OKLAHOMA GEOLOGICAL SURVEY.

Governor Robert L. Williams, State Superintendent R. H. Wilson, President Stratton D. Brooks, Commission.

C. W. Shannon, Director.

BULLETIN NO. 19.

PETROLEUM AND NATURAL GAS IN OKLAHOMA

PART II.

A DISCUSSION OF THE OIL AND GAS FIELDS, AND UNDEVELOPED AREAS OF THE STATE, BY COUNTIES.

BY

OKLAHOMA GEOLOGICAL SURVEY.

NORMAN

April, 1917.

SCIENTIFIC STAFF.

C. W. Shannon	Director
Geo. E. Burton	Assistant Director
Fritz Aurin	Field Geologist
C. W. Honess	Assistant Geologist
V. V. Waite	Chemist
Frank Gahrtz	Draftsman

Co-Operative Publishing Co., Guthrie, Okla.

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INTRODUCTION.

PURPOSE OF REPORT.

This report on petroleum and natural gas in Oklahoma is published in two parts. Part I, deals with the general phases of the oil and gas industry, and a discussion of the geology of the State. Part II, gives a detailed discussion of the oil and gas fields of the State by counties, and includes the result of recent investigations in the field, covering untested and undeveloped parts of the State.

By this plan of issuing the report in two parts, a saving in printing is gained. Many requests come in for general information concerning the oil and gas business, or in regard to the geology of some part of the State. These wants can be supplied by Part I, without sending out a full report on the subject of oil and gas. On the other hand, requests for detailed information covering various fields may be supplied by Part II. Libraries, organizations, and offices on the exchange list are furnished with both parts of the report.

It is the purpose of this report to give to the public as much general information as possible concerning the oil and gas industry in Oklahoma. In the preparation of the report consideration was given to the oil industry from the beginning of work in the Oklahoma fields, down to the present time. The oil fields of the State have been studied, and a discussion of each given, including past and present development, and possibilities of future development. New areas were investigated in detail and encouraging discoveries made. The new areas which have been studied and mapped were in some cases covered by the independent work of the Oklahoma Geological Survey, and in other parts by cooperation between the State Survey and the United States Geological Survey. Arrangements were made in regard to cooperative work whereby the state might publish such parts of cooperative reports as would be of special value to this publication, use was made, also of information secured through cooperative work in advance of the complete report to be published by the Federal Survey. A large amount of valuable information reaches the office of the Survey through the oil and gas companies and other geologists. The data thus secured were also of much value in the preparation of this report.

During the past four years several new fields have been discovered and extensions to the old pools developed. The Newkirk, Bixby, Cushing, Headlton, Adair, Boynton, Blackwell, and Stone Bluff fields are those of most importance brought in since the beginning of 1912. Oklahoma ranked second among the oil states in production, and first in the value of production during the years 1912, 1913, and 1914. For the years 1915 and 1916, the state has held first place in both production and value. In 1912 the production amounted to 51,427,071 barrels, valued at $34,672,604; and in 1913 it amounted to 58,203,740 barrels, valued at $55,018,541. For 1914 the total production was approximately 102,800,000 barrels, while that of 1915 was higher, being approximately 123,000,000 barrels.

The estimated production for 1916 is 106,190,240 barrels, or an average daily production of 290,658 barrels. The average price was higher than that for the preceding year.

PUBLICATIONS.

The following publications concerning oil and gas have been published by the Oklahoma Geological Survey:

Bulletin No. 2, Preliminary report on the rock asphalt, asphaltite, petroleum, and natural gas in Oklahoma (1911) (Exhausted); Bulletin No. 16, The Ponca City oil and gas field (1912); Bulletin No. 17, Geology of east-central Oklahoma (1914); (Exhausted); Bulletin No. 18, The Cushing oil and gas field (1914); Bulletin No. 19, Part I, Petroleum and natural gas in Oklahoma (1915.)

ACKNOWLEDGMENTS.

When Part I of Bulletin No. 19 was prepared for publication by C. W. Shannon and L. E. Trout, the same persons began the preparation of Part II of Bulletin No. 19 as a discussion of the entire state by counties, from an oil and gas standpoint. Arrangements were made for the publication of this report. However, it was found that in order to properly discuss the developed fields and to give proper consideration to the undeveloped areas of the state a much larger publication would be required than was at first anticipated. Printing funds were not then available for the publication of such a report.

Part I of this bulletin was published in December, 1915. A complete rewriting of the manuscript of Part II was begun and use made of all data available concerning the oil fields and undeveloped areas of the State. All the members of the staff of the Geological Survey contributed to this report. In the preparation of this report G. E. Burton, assitant director, Fritz Aurin, field geologist, and C. W. Honess assistant geologist, contributed largely to the report. L. E. Trout, now chief geologist for the Marland Oil Company, prepared a structural map of Kay County. This work consisted in part of a revision of the Ponca City-Newkirk anticline and the mapping of several minor pieces of structure over the county. The structural work in the Blackwell region was begun when Mr. Trout was still connected with the Geological Survey. The work as completed appears on the published map of

Kay County along with the other structural features. Credit is also given Mr. Trout for his work in the preparation of the original manuscript, much of which is included in this report.

Several pieces of cooperative work which had been done since 1912 and the results recently published in bulletin form by the U. S. Geological Survey were also included in whole or in part in the present report, proper credit being given to the authors in each case. In addition to the published work two articles are included by A. E. Fath, which are the results of cooperative work. Special arrangements were made so that advance reports on these areas might be included. These reports cover the Paden district, in Okfuskee County, and certain areas in the vicinity of Beggs, in Okmulgee County.

All or a part of the following reports are included in the publication:

Reconnaissance of the Grandfield district, by M. J. Munn; Anticlinal structure in parts of Cotton and Jefferson counties by C. H. Wegemann; The Lawton oil and gas field, by C. H. Wegemann and Ralph W. Howell; The Loco gas field, by C. H. Wegemann; The Glenn oil and gas pool and vicinity, by C. D. Smith; The Duncan gas field, by C. H. Wegemann; A structural reconnaissance in the vicinity of Beggs, by A. E. Fath, assisted by Wilson B. Emery; Faulted structure in the vicinity of the recent oil and gas development near Paden, by A. E. Fath, assisted by K. C. Heald.

D. W. Ohern and Frank Buttram, geologists for the Fortuna Oil Company, furnished much valuable information concerning the geology and structural features in Payne and Pawnee counties, and other miscellaneous areas. L. C. Snider, formerly assistant director of the Survey, gave many useful suggestions pertaining to geologic conditions in the State, and offered helpful criticism during the preparation of the report. G. D. Vanwyk, manager of the southern division of the Roxanna Petroleum Company furnished much valuable data concerning the development in the Healdton field.

V. W. Waite, Chemist and field assistant carried on field work in Pontotoc County under the direction of George E. Burton and the information gathered is included in this report. The maps for the entire report were prepared by Frank Gahrtz, draftsman, and Walter Berger, assistant draftsman.

C. W. SHANNON, Director.

OKLAHOMA GEOLOGICAL SURVEY.

Norman, May 1. 1917.

A DISCUSSION OF THE OIL AND GAS FIELDS, AND UNDEVELOPED AREAS OF THE STATE, BY COUNTIES.

ADAIR COUNTY.

LOCATION.

Adair County is situated in northeastern Oklahoma and is the third county from the northern boundary of the State. The eastern boundary is the Oklahoma-Arkansas line. The territory included in the county embraces Tps. 14 N. to 19 N. inclusive; Rs. 24 E. to 26 E., inclusive; and about 4 sections in T. 14 N., which are in R. 27 E. From the northeastern corner of T. 14 N., R. 26 E., the State line runs in a diagonal direction to the northeastern corner of the county so that about half of the area included in Tps. 15 to 19 inclusive, R. 26 E., is included in the Oklahoma side. The county thus includes all of 13 townships and a part of 5 others. The total area is 545 square miles.

TOPOGRAPHY.

The county, with the exception of the southern and southeastern parts, is in the Ozark uplift. The weathering of the cherty limestone and flint has produced broad, level tracts between the main drainage lines. From these level tracts flat-topped ridges extend out between the subordinate drainage channels to the narrow, steep-sided valleys of the larger streams. The valleys produced are of two kinds, which may be characterized as canyons and trough valleys. The former are produced by the larger streams, while the latter are produced along the smaller streams and the sides of the canyon valleys. The elevation in the Ozark uplift portion of the county ranges from 750 feet above sea level along the streams to 1,500 feet on the highest points.

The southern part of the county lies in the Sandstone Hills region, comprising the areas of Pennsylvanian rocks. The area is in the declining portion of the Boston Mountains in Arkansas. The elevation at the Oklahoma-Arkansas line is almost 1,500 feet, while the general level of the area falls to about 1,000 feet. The entire area is dissected by streams which flow out in all directions from the remnants of the high elevation, and the valleys have been cut to a depth of 300 to 800 feet. The intervening country is intricately dissected and the tributary streams, many of which flow only during abundant rainfall, descend into steep, sharp valleys.

GEOLOGY.

The surface rocks of the county belong chiefly to the Mississippian and Pennsylvanian series. There are a few scattered areas of Ordovician, Silurian, and Devonian rocks.

The rocks of the Mississippian series comprise the greater part of the county. The principal formation of the series is the Boone chert, which consists of interstratified chert and cherty limestone. At some localities near the base there are some thin limestones free from chert, while in other localities the cherty beds rest directly on the Chattanooga shale of the Silurian system. The thickness of the Boone is from 100 to 300 feet. This formation is the "Mississippi lime" of the drillers.

The southern and southeastern part of the county contains large areas covered by rocks of the Pennsylvanian series, and scattered areas small in extent are found over the southern half of the county. The principal formation of the series is the Winslow formation. The Winslow consists of sandstones and shales. The beds vary from massive sandstone and compact shales to shaly, thin-bedded sandstones and shales with quartz conglomerate. At the base of the formation coal-bearing shales occur. The more massive and resistant beds of sandstone occur in the upper part of the formation. These beds occupy the higher ridges of the region.

The Morrow, Pitkin, and Fayetteville formations are composed of resistant beds of limestone and sandstone with some beds of soft shale. These formations produce distinct benches and give terraced forms of topography. The crests of the hills and ridges are usually flat.

STRUCTURE.

The Ozark uplift has the form of an elongated dome. The axial part trends approximately S. 70° W., through the St. Francis Mountains in eastern Missouri to the vicinity of Tahlequah in Oklahoma. Thus the area under consideration lies in the southwestern end of this structural dome. The axis of the Ouachita uplift is not marked by a definite crest such as is usually the case in smaller folds. For a long distance across the axial part the strata are slightly folded and are broken by small faults. The strata pitch at low angles along the axis to the northeast and southeast. Locally the rocks are folded, producing slopes toward the southwest. The pitch is increased by faulting in the strong southwestern-dipping monocline.

The undulations in an east-west direction are very slight, with the exception of a small basin southwest of Westville. Toward the southwest the inclination increases and the beds descend 500 feet from near Westville to near the western boundary of the area. In T. 15 N., R. 24 E. a fold along Barren Fork of Illinois River for a distance of 4 miles brings the Tyner formation of Ordovician age to the surface. In T. 15 N., R. 4 E. the St. Clair marble of Silurian age is exposed over a small area in secs. 4, 5, and 9 as a result of folding and faulting.

Numerous minor folds are known to extend throughout the region, and two or three, occurring in the southern part of the county, extend over a distance of several miles.

SUMMARY.

Insofar as the structural conditions are concerned a considerable part of the county might be said to lie in probable oil and gas territory. The Bergen sandstone is of such character that it would be a good reservoir for oil and gas, and the shales of the Tyner and Chattanooga formations consist of heavy, impervious layers which would furnish good cap rocks. However, this region has not produced oil or gas, although the anticlinal and synclinal structure can readily be detected. In locations where these rocks have been penetrated strong flows of salt water have been encountered. It thus appears that the Bergen sandstone and other rocks of the region do not contain organic matter sufficient to produce oil or gas, and the rocks are filled with salt water in the anticlines as well as in the synclines. From all data collected in the region it is very doubtful if the county is to be recommended at all for oil and gas prospecting.

Near Stilwell, in the central part of the county, a well has been drilled to a depth of 2,275 feet, but operations are now at a standstill and the well will probably be abandoned.

ALFALFA COUNTY.

LOCATION.

Alfalfa County is situated in northwestern Oklahoma in the northernmost tier of counties. The north boundary is the Oklahoma-Kansas line. It includes the area extending from the middle line of T. 23 N., to the north side of the fourth row of sections in T. 29 N., Rs. 9 W. to 12 W., inclusive. The total area is 854 square miles.

TOPOGRAPHY.

The surface of the county consists of shales, soft sandstones, and disintegrated sands. In general the topography is level to slightly rolling, in some places becoming hilly. In addition to the sand flats along the Salt Fork of Arkansas River considerable stretches and areas of salt plains occur, the largest of which covers several square miles east of Cherokee.

GEOLOGY.

Alfalfa County lies entirely within the Redbeds region and at such distance from the border of the region that the thickness of the Redbeds would probably be at least 1,000 feet. The surface rocks belong to the Enid formation, which includes all of the rocks from the base of the Permian to the lowermost of the gypsum ledges in the Gypsum Hills region. In the area of this county this formation consists of red shales and sandstones with some inter-bedded ledges of lighter colored shales and sandstones.

Tertiary gravel and sand deposits are found, and along the north side of Salt Fork of Arkansas River sand hills cover a large area.

SUMMARY.

The Permian rocks, which are the chief surface formation, reach a thickness of several hundred feet, and this condition, together with the nature of the rocks, makes the finding of oil or gas in paying quantities very uncertain.

A well drilled several years ago by the Saline Oil and Mining Company at Jet reached a depth of 975 feet. The well passed through red and blue shales all the way, with the exception of about 8 feet of sand at a depth of 280 feet. It is said that this sand showed some oil.

A test well is being drilled in northeastern Alfalfa County. It is located on the line between sections 28 and 29, T. 29 N., R. 9 W. The test has now reached a depth of more than 2,000 feet.

Plans are being made to drill another test in the vicinity of Jet, and a location has been made on the Alfalfa County line in sec. 29, T. 27 N., R. 8 W., in the locality of Florence.

Surface conditions are not such that definite locations can be made for the drilling of test wells.

ATOKA COUNTY.

LOCATION.

Atoka County is one of the southeastern counties of the State. It may be described as having an extent from T. 2 N. to T. 4 S. inclusive, and from R. 9 E. to R. 15 E. inclusive, a total area of 900 square miles, or 27½ townships.

TOPOGRAPHY.

Lying at the junction of four physiographic provinces and embracing a considerable portion of each, Atoka County may well be said to have a variable topography. The four provinces are the Sandstone Hills region, the Ouachita Mountain region, the Arbuckle Mountain region, and the Coastal Plains region. These regions will be discussed briefly in the order given.

The region of the Sandstone Hills lies in the northwest quarter of the county between the Ouachita Mountain and Arbuckle Mountain region or, in other words, it is the area west, north and northeast of the town of Atoka, or west of the Missouri, Kansas & Texas Railway. Sandstones and shales are the typical rocks outcropping over this area and they weather into rather extensive flat lands or broad valleys, and form hills or ridges wherever a hard layer comes to the surface, with one exception. These hills are not prominent west of Atoka but to the north and northeast the sandstone ridges and hills become gradually higher, until the most prominent elevations are nearly 200 feet above the general level of the valleys in T. 1 S., R. 11 E., T. 1 N., R. 12 E. and in T. 2 N., R. 12 E.

The rocks governing the type of topography in this region belong to the Carboniferous system and are chiefly sandstones and shales which alternate to form the hard and soft layers, and upon weathering produce the ridges and valleys, respectively.

The structure is that of a great basin about which the border sandstones outcrop in concentric ridges with their steep slopes facing east on the east side, north of Atoka, and west on the west side, west of Atoka. The center of this basin is located in the neighborhood of Lehigh, northwest of Atoka, in Coal County, but the western part of the bowl is not so steeply upturned as is the eastern side.

The topography of the Ouachita Mountain region is represented by the large area of rugged, hilly country lying east of the Missouri, Kansas & Texas Railway, and north of a line drawn from Atoka southeast to Antlers, Pushmataha County. These hills are the western ends of mountainous ridges which gradually rise higher and higher to the east and develop into Rich and Kiamichi mountains in the central part of the range in Pushmataha County.

The ridges are made up of hard, flinty rocks and owe their origin chiefly to their superior hardness. Between the principal ridges and mountains there are flat valleys, and these invariably are located upon the softer shaly formations, and are limited to that kind of rock.

The ridge ends abruptly in a line of hills, extending northeast from Atoka, where a flinty formation is terminated by faulting. To the south the termination is not so abrupt. The crests of the high ridges lie in a plain slightly inclined toward the south. Southward this plain passes beneath the Cretaceous strata and forms the eroded surface of the older rocks upon which the Cretaceous lies. It is the plain of marine gradations made by the early Cretaceous sea. As the Cretaceous border is approached going south, the hills and ridges become lower in elevation, and the valleys shallower until they merge into one another and disappear beneath the thin edge of the Cretaceous deposits.

The strata are tilted at high angles over most of the region; timber grows sparsely on the rocky slopes and in the valleys; and the streams are in general shallow and rather swift-flowing.

Only a small area in Atoka County, namely, west of Boggy Depot lying wholly within the township, T. 3 S., R. 9 E. can be said properly to belong to the province of the Arbuckle Mountains.

This area of granite and Paleozoic rocks is the extreme eastward end of the Arbuckle uplift which increases in height and breadth westward through Johnston and Murray counties.

The rocks involved in these mountains are generally hard, and with long exposure weather in relief above the softer Carboniferous and Cretaceous sediments to the north and south respectively, but the surface of both hard and soft strata of the Arbuckle uplift in Atoka County lies in a smooth plain, which is the uplifted marine erosion plain of the Cretaceous sea, and which, west of Boggy Depot, has been only partially uncovered. This erosion plain continues westward throughout the Arbuckle region with Cretaceous sediments resting upon its southern slope as far west as the Washita River in Carter County.

The region is not deeply dissected owing to the fact that the old erosion plain has only recently been uncovered in this part of the range. The fourth physiographic province occupies the remaining, southern portion of the county and belongs to the Gulf Coastal Plains region, or what is locally called the Red River plain.

The formations outcropping over this area are the four lowermost Cretaceous formations, namely, the Trinity sand, and the Goodland, Kiamichi, and Caddo limestones. Each of these produces characteristic, minor, topographic features depending upon the character and structure of the rock but the limestones together cover an area of only about 25 square miles in the southwestern corner of the county, and are therefore only of minor importance as compared with the area of Trinity sand which covers approximately 10 townships or 360 square miles. The Trinity formation is a homogeneous, compact, siliceous sand, white to pink in color and upon weathering produces a nearly flat or rolling land gently inclined toward the south. Near the larger creeks the process of gullying is usually very much in evidence producing ravines with precipitous sides from 10 to 40 feet high. The growth of these ravines causes much damage to bridges and railroads, and ruins the lands for farming purposes. A dense forest of scrub oak and some ash is found over much of this territory.

The Goodland limestone is a thin, but relatively hard, formation which is continuously exposed forming flat table lands or benches with accompanying, steep escarpments overlooking the Trinity sands to the north. The Kiamichi formation consists of clay and thin limestones which weather into black prairie lands and form gentle slopes leading up to the Caddo limestone. The Caddo is again a harder limestone and forms a second cliff or escarpment visible nowhere in Atoka County but present just south of the county line.

GEOLOGY.

The geology of the county is discussed in a general way in connection with the above discussion on "Topography."

The Choctaw fault runs diagonally across the county from the northeastern corner in a southwesterly direction to the south side, dividing the county almost equally. To the east and south of this line the surface rocks of the northern part and the subsurface rocks of the eastern and southeast are those of the Ouachita Mountain uplift, including the Stringtown shale, Talihina chert, Standley shale, and Jackfork sandstone, which is the mountain-making sandstone of the Ouachita Mountain region. To the west and northwest of the main fault line the rock formations range in age from Silurian to Upper Pennsylvanian, and the surface formations of the entire southern part of the county belong to the Cretaceous and consist of the Trinity sand with some outcrops of the Goodland limestone along the southern border.

The reader is referred to "Coal County" for a description of the Pennsylvanian rocks; to "Pushmataha County" for a more complete discussion of the rocks of the Ouachita Mountain uplift; and to "Bryan County" for an account of the Cretaceous.

STRUCTURE.

The geology of Atoka County, as above described, involves both Paleozoic and Mesozoic sediments, the former covering the northern two-thirds and the latter the southern one-third of the total area of the county. The Paleozoic formations have been folded into anticlines and synclines and locally faulted and turned up sharply on edge so that the dip in numerous localities east and northeast of Atoka and southeast of Wapanucka is from 45° to 85°. In the extreme northwestern corner of the county, about Wardville and south to Stringtown and Atoka, west of the Missouri, Kansas & Texas Railway, thence west to the county line the Carboniferous sandstone and shales are everywhere the surface rocks and are here folded into synclines and anticlines whose limbs have a variable dip from 5° to 60°, and whose axes pitch generally northeast or southwest. A small anticline extends in a NE.-SW. direction across the center of T. 2 N., R. 12 E., with limbs dipping from 20° to 55°. To the north and to the south of this anticline and parallel to it are small synclines.

The area lying in the NW. ¼ of T. 1 N., R. 12 E. is synclinal in structure, the southeastern limbs turning up abruptly along the Choctaw fault which extends in a NE.-SW. direction from an unknown distance south of Atoka northeasterly to the county line and beyond. The entire area north and west of Atoka, to the county line in both directions, lies in a great syncline whose limbs dip from 4° to 15° or 20°. Three miles south and 2 1/2 miles east of Wapanucka the Paleozoic strata are in contact with an intrusion of granite. They dip at high angles here and are badly faulted. The same structure prevails to the south and is continuous beneath the flat lying Trinity sands an unknown distance. The area south and southwest of Atoka in T. 3 S., R. 10 E. and in the NW. 1/4 of T. 3 S., R. 11 E. is undoubtedly synclinal beneath the Trinity cap which conceals it from view.

East of the Choctaw fault, i. e., east of, and including the long line of hills east and northeast of Atoka, is an area of pre-Carboniferous sediments extending probably to the eastern county line. The structure in T. 2 S., R. 12 E. and in the SE. ¼ of T. 1 S., R. 12 E. consists of a southeasterly dip of from 20° to 70°, the higher dips occurring to the west of this area along the fault. Farther east the structure is not known in detail.

Over the southern third of the county the Paleozoic sediments are covered by a cap of Cretaceous sediments which lie unconformably upon the older, wrinkled, and faulted Carboniferous and older rocks. The dip of the Cretaceous sands and limestones is south approximately one or two degrees, and reveals only slight evidences of crumpling, the details of which have not been worked out. These formations in order from oldest to youngest are: Trinity sand, Goodland limestone, Kiamichi formation, and Caddo limestone. The Trinity sand area is 12 or 15 miles broad (north and south) and extends beyond the south county line everywhere south and southeast of Atoka. The overlying Cretaceous limestones above mentioined, together occupy a belt only 2 to 4 miles broad (north and south) and occur only in the southwestern corner of the county in the southern parts of the three townships or ranges: T. 4 S., Rs. 9 E., 10 E., and 11 E. The younger Cretaceous deposits all lie south beyond the county limits which here bury the Paleozoics to a still greater depth.

DEVELOPMENT.

At the present time there is no production whatever in Atoka County, but leasing is very active in several localities and many tests are being made, the majority of them, however, shallow. Among the companies interested are: The Gypsy Oil Company, the United States Oil Company, the Gulf Pipe Line Company, the Carter Oil and Gas Company, and a number of private individuals.

The oldest well perhaps in the region under discussion is the one drilled in sec. 8, T. 2 S., R. 9 E. by Dr. Faucett of St. Louis in 1888. During the drilling of this well a showing of oil amounting to six or seven barrels per day was reported at various depths, but it is said that no oil or gas in any quantity was encountered. The log of this well is given below:

Log of Faucett well in sec. 8, T. 2 S., R. 9 E.

Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*
Slate. blue (troubled with mud)	168	168
Sandstone and shale	201	369
Sandstone and slate (troubled with mud)	10	379
Slate	45	424
Sandstone	30	454
Sandstone and slate small oil indications)	70	524
Sandy	80	604
Sandstone	10	614
Shale and hard sand	45	659
Shells	25	684
Slate and shells	40	724
More sand than slate	68	702
Sandstone (807 ft. casing	29	821
Sandstone and slate (Sand at 833 feet)	12	833
Sandstone (oil at 917 ft. tubed and tested much salt water)	120	953
Slate	20	973
Slate and sand	50	1,023
Slate, clean	35	1,058
Slate and shells	105	1,162
Sandstone (salt water and good show of oil)	73	1,235
Slate	13	1,248
Slate and shells	11	1,259

Log of Faucett Well—(*Continued.*)

Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*
Slate and shells	18	1,277
Sand shell,s and slate (900 feet water in hole)	19	1,296
Sandstone (1,200 feet water in hole, small oil show at 1,302 ft	12	1,308
Slate	27	1,335
Sandstone (oil show at 1,347 feet, oil and gas at 1,391 feet)	79	1,414
Still in sand and drilling July 23, 1888.		

Drilling has recently been resumed in this region in the NE. 1/4 of the NE. 1/4 of sec. 3, T. 2 S., R. 9 E., and has now progressed to a depth of 1,000 feet. There is no production thus far in the new well and the log of the old Faucett well is essentially duplicated in this boring, according to reports available.

In the SW. 1/4 of sec. 13, T. 2 S., R. 11 E., a well was drilled by Bowen and O'Day of Tulsa to a depth of 1,100 feet, which yielded a showing of oil, only, at a depth of 600 feet. This hole was abandoned.

While drilling for water in the NE. 1/4 sec. 16, T. 3 S., R. 11 E. oil was found at a depth of 85 feet but as the owners were not interested in oil the well was not deepened. Another shallow well was drilled in the NE. 1/4 sec. 7, T. 2 S., R. 11 E., and still another in the SE. 1/4 sec. 35, T. 2 S., R. 12 E. Oil was discovered in both wells at about 100 feet and operations discontinued because of its presence.

These seepages have created some excitement in this general region and recently a location has been made for deep drilling in sec. 32, T. 2 S., R. 12 E. The work has not yet been begun.

At Stringtown in the center of sec. 17, T. 1 S., R. 12 E., is a dry hole 1,600 feet deep, and in the SW. 1/4 sec. 16 of the same township and range is another hole, likewise dry but only 700 feet deep.

In the SW. 1/4 sec. 32, T. 2 N., R. 12 E. is a well 2,505 feet deep drilled by the Great Southern Oil Company and in the SE. 1/4 sec. 13, T. 2 N., R. 12 E., is a boring 2,480 feet deep drilled by C. E. Douglass. They are both dry and abandoned.

North of Wardville in the NE. 1/4 sec. 10, T. 2 N., R. 12 E. is still another hole, dry and abandoned. It is 1,100 feet deep and is said to have been drilled by Mr. Albert.

In the SW. 1/4 sec. 12, T. 1 S., R. 13 E. what is said to be a crooked hole has yielded a showing of oil. It was drilled by C. E. Douglass of Okmulgee and is 1,520 feet deep.

In the center of sec. 21, T. 1 N., R. 13 E. oil was obtained at 448 feet while drilling for water, and again in the NE. 1/4 sec. 3, T. 2 N., R. 13 E., while engaged in drilling for water the drillers encountered oil at a depth of 125 feet, but nothing has been done in either case to deepen these borings.

In the NW. 1/4 sec. 4, T. 1 S., R. 14 E. a well was drilled by McGlaughin to a depth of 405 feet which yielded a high grade oil of 42° Baume at a depth of 210 feet. The oil was not sufficient in amount, however, to justify pumping and the well was abandoned. This well has recently been deepened by the Carter Oil & Gas Company.

In the SW. 1/4 sec. 8, T. 1 S., R. 14 E., a well was drilled to a depth of 605 feet by the Olive Oil Company, (Well No. 2) which yielded approximately 5 barrels of oil at a depth of 312 feet, but this amount was not considered as worth while and the well has been abandoned. The log is as follows:

Log of well in SW. ¼ sec. 8, T. 1 S., R. 14 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	20	20	Chocolate sand (oil bearing)	104	514
Brown sandstone	140	160	Sandy shale (showing oil)	10	524
Blue shale (Gas at 290 feet)	147	307	Brown lime (hard)	8	542
Gray sand (oil-bearing)	55	362	Blue shale	73	605
Blue shale	48	410			

In the SE. 1/4 sec. 23, T. 1 N., R. 14 E., Bailey and MacDonell are drilling, but at present are fishing for tools at a depth of 600 or 700 feet.

Again, in the SW. 1/4 sec. 5, T. 1 N., R. 15 E., is another shallow well, originally intended as a water well, but was abandoned when oil seeped into the boring.

A well has been begun in sec. 23, T. 2 S., R. 14 E., which has already given a showing of oil amounting to a production of about ten barrels per day at a depth of 280 feet. The well was deepened, however, to 600 feet and at present the drillers are fishing for tools. The producing sand was 160 feet thick. It is being drilled by Bailey and MacDonell.

The Bison Oil Company's test in sec. 34, T. 2 S., R. 10 E., has reached a depth of 2,050 feet, at which depth 10 feet of sand was encountered, giving a small production of oil. Drilling will continue to a greater depth.

With the exception of a few other shallow water wells, showing oil seepage, there is no further development in this county. The drillers and leasors, however, are confident despite the unfavorable geologic structure that a large pool of oil is somewhere present in the general region, and are determined to locate it. No doubt the area will be thoroughly tested out by further drilling before the year is at an end.

It will be noted that little or no prospecting for oil has been carried on in Ts. 3 and 4 S., with the exception of the water well showing oil seepage in sec. 16, T. 3 S., R. 11 E. Being an untried area, being south of the great syncline, and being an area considerably removed from the sharper folding and faulting, it seems that the southern part of the county should prove a likely field for investigation.

SUMMARY.

Although there has been considerable drilling in Atoka County, no encouraging results have been obtained. Most of the drilling has been confined to the northern and northeastern parts of the county near the Choctaw fault, where the folding has been quite severe. It is doubtful whether favorable structure can be found which will prove productive. Conditions are more favorable in the extreme southeastern part of the county, in the area of Cretaceous rocks, and in the western part which is farther removed from the influence of the Choctaw fault region.

In exploring for oil and gas in the southern part of Atoka County it should be remembered first, that favorable structure found in the surface Cretaceous may or may not extend down into the older rocks, and second, that there may be favorable structure in the underlying rocks which is not apparent in the surface Cretaceous formations. If favorable structure can be detected in the Cretaceous rocks of the surface the chances for the occurrence of structure below are greater, hence the study of the surface conditions is essential. Structural features which may be found in the older rocks but concealed by the Cretaceous overlap can be determined only by drilling. The showing of oil found in drillings to the east and southeast of the Choctaw fault does not lend much encouragement to prospecting. The occurrence of asphalt and oil seepages is common, but these probably represent the base of oils which have escaped ages ago from the broken rocks.

BEAVER COUNTY.

LOCATION.

Beaver County is the easternmost of the three counties comprising the western extension of Oklahoma known as the "Panhandle". The region of the Panhandle was formerly known as "No man's land" or the "Neutral strip." The entire strip was formerly designated as Beaver County.

The county is rectangular in shape and includes all of 40 townships and 4 miles off of the northern tier of 9 townships, and from 4 to 5 miles of the eastern tier of 6 townships. The territory embraces T. 1 N. and includes 4 miles of T. 6 N., from latitude 36° 30′, Rs. 20 to 28 inclusive, east from the Cimarron meridian. The north boundary of the county is the Oklahoma-Kansas line. The eastern line is the 100th meridian. The area is 1,798 square miles.

TOPOGRAPHY.

This region is a typical part of the High Plains and is apparently flat and level but slopes gradually from an elevation of 4,500 feet at the New Mexico line to about 2,000 feet at the eastern border of the county.

Beaver Creek flows from west to east through the center of the county and Cimarron River cuts across the northeast corner of the county. The valleys along the main streams are from 1 to 3 miles wide. During much of the year there is very little water in the streams except from such tributaries as rise in Teritiary springs.

GEOLOGY.

The surface rocks of the county are chiefly Tertiary sands and clay. In some places these surface rocks reach a maximum thickness of 400 feet. The Tertiary is underlain by the Redbeds which are exposed along the streams and canyons. Near the streams sand hills occur as a result of the weathering of the Tertiary rocks. The character of the Tertiary rocks is shown by the log of the Optima well which is given under "Texas County."

SUMMARY.

The Tertiary rocks which cover the surface are comparatively thin. The Redbeds attain very great thickness. Any drilling which should pass through the Redbeds would be almost prohibitive, and there is very little indication that production would be found at a shallower depth.

A well is now being drilled in this county near the town of Gate, and has reached a depth of 2,840 feet. Operations are now at a standstill, but the well will probably be deepened, in order that a good test may be made at this location.

BECKHAM COUNTY.

LOCATION.

Beckham County lies in southwestern Oklahoma. The western boundary is the Oklahoma-Texas line. The county embraces T. 7 N., Rs. 24 to 26 W. inclusive; Tps. 8, 9, and 10, Rs. 21 to 26 W. inclusive; the S. ½ of T. 11 N., Rs. 23 to 26 W. inclusive; all of T. 11 N., Rs. 21 and 22 W.; and the S. ½ of T. 12 N., Rs. 21 and 22 W. A row of 12 sections additional extends along the west side of the southern half of the county due to the offset caused by the land survey correction lines. The total area is 948 square miles.

TOPOGRAPHY.

The surface of the county varies from level and gently rolling areas to very rough and broken topography. The chief irregularities of the surface are due to the rise of gypsum and sandstone hills and the sand hills and dunes. Many isolated peaks and ridges are scattered over the level tracts. The surface elevations range from 1,800 feet to about 2,250 feet. The elevation at Elk City is 1,912 feet; Sayre, 1,810 feet; and Texola, near the western boundary, 2,148 feet.

The surface is in part barren and in part grass-covered. Along the streams is a narrow strip of trees and shrubs. On the uplands dwarf plums, sumac, and mesquite occur, while in the sandy areas are thousands of acres with a low growth of dwarf chestnut or chaparral oak.

All the drainage of the county is into North Fork of Red River, through its numerous tributaries.

GEOLOGY.

The surface rocks of the county belong entirely to the Permian Redbeds, except a superficial covering of Tertiary sands and gravels in the northwestern part of the county.

North Fork of Red River flows from the northwest corner of the county in an irregular course somewhat diagonally across the county to the southeast corner. To the south and west of the stream the surface rocks belong to the Greer formation, while to the north and east of the stream they belong to the Quartermaster formation. These rocks are briefly described below. For a description of the sub-surface rocks of the region belonging to the Redbeds series the reader is referred to the discussion of geology under "Blaine County."

GREER FORMATION.

The Greer formation is composed of red clays, shales, sandstones, gypsum beds, and magnesian or dolomitic limestones. The total thickness is on the average about 300 feet. The stratification of the rocks is so variable that a section which would be found in one locality would not be suited to conditions a short distance away, since it often happens that a gypsum bed or a sandstone may change laterally into a bed of shale, or other material of different quality. However, in order to give an idea of the general occurrence of the rocks found in this formation the following sections are given. The first is a section as exposed in a well along a small stream tributary to Elm Fork of Red River, 3 miles south of Texola.

Section of well 3 miles south of Texola.

	Feet.
Gypsum and shale beginning in valley	20
Red shale	15
Massive gypsum	10
Red shale	5
Massive white gypsum	15
Red shale	20
Weathered limestone (honey-combed dolomite)	3-5

Another section about 30 miles to the east of the above is given for comparison.

Section of bluff on North Fork of Red River 5 miles south of Carter, Oklahoma.

	Feet.
Red and green clay shales	30
Greenish gypsum and gypsum-bearing shale	5
Red and green shales	24
Massive white gypsum interstratified with occasional thin-bedded sandstones	25
Red and green clay shales	15
Massive white gypsum	18
Red and green shales	6
Massive white gypsum	23
Red and green shales	24
Weathered dolomite	3

QUARTERMASTER FORMATION.

The Quartermaster formation, which lies above the Greer, consists of about 300 feet of soft red sandstone, clays, and shales, with some thin-bedded gypsum layers and selenite veins in the clays and shales. There are no gypsum beds of importance in this formation. The Quartermaster is the highest, geologically, of any of the Permian rocks in Oklahoma.

STRUCTURE.

The rock formations of the area have in general the normal dip of the surface formations of the western section of the State, i. e., a dip to the eastward of. from 20 to 30 feet per mile. This usual dip is interrupted in several localities by slight folding and change of direction. There are, however, no extensive anticlinal and synclinal folds in the region, so far as surface indications point out.

The character of the surface is chiefly due to the work of erosion. The rocks have not been upheaved, folded, or faulted. While the general dip of the formation is in an eastward direction, it is common to find the dip changed to another direction or angle within a few rods. Such conditions are more readily observed in the area of the Quartermaster formation and in the area of the Greer formation where gypsum beds are exposed along the streams. Often in the isolated hills the rocks are found dipping in every direction. In many places the hills have been produced by the fact that a hard capping of limestone was present and protected the underlying shales and gypsum from weathering conditions. After the overlying rocks were sufficiently weathered, or the underlying material had been under cut by the weathering the rocks were broken and toppled about so that in a very small area the rocks apparently dip in all directions. Along the streams where the gypsums occur, as stated above, the dips are often marked and vary much in direction. The angles are from 2° to 40°. In the region of the Quartermaster rocks these apparent structural features and the irregularity in the dip are probably caused by the solution and undermining of deepseated rocks, very likely the underlying gypsum.

This phenomenon above mentioned shows the appearance of structure, but it is very evident that all the conditions are merely local and do not present conditions at all favorable for the accumulation of oil and gas.

SUMMARY.

Structural conditions which may be observed in the rocks of this county are not to be considered more than local conditions and do not warrant prospecting for oil and gas. Insofar as surface appearances are concerned, indications are not favorable for accumulation of oil and gas.

Oil and gas have not been found in the Redbeds proper in paying quantities, except in a few localities and then only in the basal members of the formation, in which cases it is very probable that the oil and gas found have worked their way upward from the Pennsylvanian rocks. It cannot be said that oil and gas will not be found in the upper part of the Redbeds, but conditions are not favorable for the occurrence of such.

In order to reach the basal members of the Redbeds in this region it would be necessary to drill through the Quartermaster and Greer formations, above described, into the Woodward, Blaine, and Enid formations, which in this region would have a total thickness of approximately 2,500 feet.

Any drilling which would be undertaken in this part of the country would be strictly a wildcat proposition, and in order to reach the Pennsylvanian rocks where production, if any, would be expected, the drilling should extend to a depth of 2,500 to 3,500 feet. While it is not impossible, it is very improbable that even if structure exists, which is not apparent at the surface, oil and gas would not be found in paying quantities except at great depth, as indicated. However, extensive folding in the Pennsylvanian rocks may bring this series somewhat nearer the surface, but only the drill can prove such conditions.

In making investigations in this section of the State the writer's attention was called to numerous places where oil appeared on the water in the streams and in some places where gas escaped from ponds and was known to occur in shallow wells. The oily substance found on the streams is not petroleum but is due in some cases to recent vegetable origin and in other cases to the suspension of irony dust particles in the water. The reported escaping gas is in no way an index to conditions existing below the surface rocks. During the year 1914 a well was drilled near Erick, but gave no encouragement to further prospecting in the region.

BLAINE COUNTY.

LOCATION.

Blaine County is located a little north and somewhat west of the center of the State. It extends from T. 13 N. to T. 19 N. inclusive, and from R. 10 W. to R. 13 W. inclusive. It includes 26 entire townships. The area is approximately 936 square miles.

TOPOGRAPHY.

The northeastern part of Blaine County lies within the Redbeds Plains. The topography of this part of the county is that of a rolling prairie plain. The southwestern part of the county is in the Gypsum Hills. This part of the county is rough, gypsum escarpments being of common occurrence. Cimarron River touches the northeast corner of the county. Tributaries to Cimarron River drain about 9 townships in the northeastern part of the county. The North Fork Canadian River and its tributaries drain a narrow belt running in a northwest-southeast direction through the center of the county. Canadian River and streams tributary to it drain the southwestern part of the county.

GEOLOGY.

The surface rocks in Blaine County are Permian except along the large streams where are found Recent sands and gravels, and on the top of hills where are found probable Tertiary gravels. This county is centrally located in the Permian or "Redbeds" region. For this reason it is advisable to include under this county a brief discussion of the geology of the Redbeds. Other counties in the region are referred to the discussion included under "Blaine County."

The general attitude of the Permian strata is that of a gentle dipping monocline. No detailed work has been done in the county, and therefore variations in this general dip of the monocline cannot be pointed out. The Permian is considered to be conformable with the Pennsylvanian.

GEOLOGY OF THE REDBEDS.*

*This description of the geology of the Redbeds is in part summarized from the discussion of the subject by L. C. Snider, in Bulletin No. 11, Oklahoma Geological Survey, and in part the report is reprinted in full. The reader is referred to this bulletin for a full discussion of the Redbeds region.

DISTRIBUTION.

The Redbeds area of Oklahoma forms a part of the larger area which extends from southwestern Kansas almost to the Pecos River in southwest Texas. The outcrop at the north end is narrow, but widens rapidly to the south and includes most of the western half of Oklahoma. From Red River south the belt narrows until on Colorado River it is about one-half as wide as it is in Oklahoma. The narrowing of the outcrops in both directions from Oklahoma is accounted for in large measure by the covering of the Redbeds by younger formations, and in part by the thinning of the beds. To the west, south, and north the beds disappear under younger formations—Lower or Upper Cretaceous or Tertiary. They are continuous beneath these younger formations to the west and reappear in a belt along the base of the Rocky Mountains in New Mexico. A narrow strip along Canadian River connects the New Mexico and Oklahoma areas across the Panhandle of Texas. Areas of red rocks in the eastern part of Colorado and Wyoming probably belong to the same great body of Redbeds.

CHARACTER OF THE ROCKS.

The Redbeds consist entirely of red shales and sandstones. The red color varies greatly in shade in different horizons and from place to place in the same horizon. All gradations from vermillion to maroon or very deep red brown can be observed in short distances where good exposures are common. In general, however, the vermillion and brick reds seem to be more common in the lower formation in which shales predominate and the deeper reds in the upper formations in which sandstones are more abundant. The sandstones are usually composed of very fine, rounded grains, and are cross-bedded and lenticular to a pronounced degree. They often grade into shales in a very short distance, but probably more often they pinch out very quickly and are replaced abruptly by shales which contain very little sand. Locally the sandstones are quite coarse and in a few instances are conglomeratic.

The shales are usually very fine-grained, slightly consolidated, and very plastic, with high shrinkage in drying. They usually contain considerable quantities of soluble salts. The color of the clay shales is usually a brighter brick red or vermillion than that of the sandy shales or the sandstones.

The gypsums, although they occur in ledges of up to 60 or more feet in thickness and cover considerable areas, are relatively unimportant when considered as a part of the Redbeds as a whole. Closely associated with the gypsums are white to greenish sandstones and shales, which, on account of their color, are often very striking in fresh exposures. The stratification of these whitish or greenish rocks is very irregular. A greenish band may appear, thicken to 5 or 6 feet, and pinch out in a few rods. The stratification of these light-colored bands is probably no more irregular than that of the minor variations in the red rocks, but is much more noticeable on account of the contrast in colors. Two or three ledges of dolomite, usually less than 5 feet in thickness, are the only carbonate rocks.

THICKNESS.

The character of the Redbeds as noted in the preceding paragraphs renders it impossible to make an accurate determination of their thickness by measuring across the outcrop. The stratification is so irregular that a section taken at one place cannot be duplicated even in its larger features at a distance of a mile. In detailed sections great variation is found in the distance of a few rods. The lenticular nature of the sandstones and shales and the cross-bedding of the sandstones make it almost impossible to determine the dip of the rocks from observation of short exposures. In the upper portion of the beds some general horizons can be followed and the thickness between them can be rather closely approximated. The only way of obtaining the thickness of the lower portion of the beds is from the logs of the few deep wells which have been drilled in this region.

Williston and Case* estimate the Redbeds in Kansas, Oklahoma, Texas, and eastern New Mexico, as "thicker than those of northern New Mexico (1,600 feet), probably reaching 2,000 feet in their totality." This estimate, however, is manifestly too small for the thickness of these beds in central Oklahoma. At Alva, near the Kansas line, a well passed through 1,100 feet of Redbeds. The well started some distance below the lowest gypsum and the mouth was consequently at least 750 feet below the top of the Redbeds as exposed in Oklahoma. To the south of the latitude of Alva the Redbeds thicken downward rapidly to the center of the State. At Shawnee a well which was started near the Pennsylvania-Permian contact shows over 1,000 feet of red rocks. When it is remembered that much of the Permian and all of the Pennsylvanian in the latitude of Alva is non-red and that in the latitude of Shawnee these lower Permian rocks are red and that in addition 1,000 feet or more of the uppermost Pennsylvanian rocks are red, we obtain a total thickness of over 3,000 feet. (The thickness of 750 feet above the mouth of well + 1,100 feet in well at Alva + 500 feet Permian rocks non-red at Alva but red at Shawnee, + 1,000 feet red Pennsylvanian in well at Shawnee=3,350 feet.) The estimate of 500 feet for the Permian rocks which are non-red at Alva but red at Shawnee is from the thicknesses near the Kansas line. The thickness at Shawnee is probably greater.

In the deep well recently completed at El Reno the rocks were red and reddish brown to a depth of 2,050 feet. The thickness of the Redbeds formations occurring to the west and lying at a level above the mouth of this well is certainly not less than 900 feet and is probably greater. This well indicates a thickness of 3,000 feet or more for the Redbeds.

*Williston, S. W., and Case, E. C., The Permo-Carboniferous of New Mexico: Jour. Geol. vol. 9, 1911, p. 4.

Gould* gives the thickness of each formation of the Permian and the sum of these thicknesses gives a minimum of 2,250 feet for the Permian Redbeds. The maximum is probably 500 feet more. This with 1,000 feet or more of red Pennsylvanian gives between 3,000 and 4,000 feet of Redbeds in the central part of the State. The writer regards 3,000 to 3,500 feet as a very conservative estimate of the thickness of the Redbeds as exposed from the center or east of the center of the State to the west line.

AGE.

The Redbeds of the area under discussion were studied in Kansas and Texas several years before they were in what is now Oklahoma. Before 1893 the Kansas beds had been usually referred to the Jura-Trias or definitely to the Triassic**, although some of the earliest observers had ascribed them to the Upper Carboniferous and some to the Lower Cretaceous. All these correlations were made on lithologic or stratigraphic grounds.

RELATIONS OF THE REDBEDS.

As has been shown in the preceding paragraphs, the greater part of the Redbeds is generally regarded as of Permian age. In Kansas, only the upper portion of the Permian rocks is red, but near the Kansas-Oklahoma line the limestones and non-red shales of the lower part of the system grade southward into red shales and sandstones so that the line between the red and non-red rocks descends lower in the system and the line between the outcrops swings to the east. As a result there is only a small area of non-red Permian rocks in Oklahoma, most of Kay County and portions of Osage, Noble, and Pawnee counties. The same change takes place in the rocks in the upper part of the Pennsylvanian system, i. e., the limestones in Kansas give way to shales and sandstones in Oklahoma, with most of the sandstones dying out before they reach Arkansas River. To the south of the Arkansas the shales, and farther south the sandstones, take on the red color and become part of the Redbeds. The line between the red and non-red beds passes about midway between Pawnee and Stillwater and southeastward to Stroud, where it swings to the west of south and passes around the west end of the Arbuckle Mountains. The line between the Pennsylvanian and Permian enters the State a few miles east of the northeast corner of Osage County and bears a little to the west of south to the west side of the Arbuckle Mountains. The Pennsylvanian and Permian rocks, then, occur in the following areas: (1) A large area of red Permian rocks in the central and western part of the State, (2) a small triangular area of non-red Permian rocks in Kay

*Gould, Chas. N., Geology water resources of Oklahoma: Water-Supply Paper U. S. Geol. Survey, No. 148, 1904.

**Hay, Robert, The Trisassic rock of Kansas: Trans. Kans. Acad. Sci., vol. 6, 1889, p. 36; and Cragin, F. W., Geological notes on the region south of the great bend of the Arkansas: Bull. Washburn Col. Lab. of Nat. Hist., vol. 2, 1889; and A geological reconnaissance in southwestern Kansas: U. S. Geol. Survey, No. 57, 1890, pp. 20-21; Williston, S. W., Geol. Map of Kansas, 1892.

County and adjoining parts of Osage, Noble, and Pawnee counties, (3) a small area of red Pennsylvanian rocks between the two lines mentioned above, and (4) the non-red Pennsylvanian rocks covering most of the eastern half of the State.

The relations of the red and non-red rocks in Texas and in Kansas have been shown* to be similar. The Permian in central Texas is white (Albany), but becomes red to the north (Wichita), and limestones give way to sandstones and shales from south to north in the same way that the limestones of Kansas do from north to south.

The upper limit of the Redbeds in Oklahoma is irregular and is always one of unconformity. Limestone of lower Cretaceous (Comanchean) age occurs in small areas in Woods, Woodward, Dewey, Custer, and Washita counties. The patches seldom exceed a few acres in extent and are on top of the hills or broad divides between the streams. The limestone is seldom over 3 or 4 feet thick and usually seems to have been let down from above as the shales and soft sandstones worked out from beneath it. In the rest of the area in Oklahoma the Redbeds pass under the Tertiary or Quaternary sands. In Texas the Dockum beds, Redbeds of Triassic age, occur unconformably above the Permian Redbeds, but this formation is not present in Oklahoma.

CLASSIFICATION.

The classifications of the Redbeds of Kansas and Oklahoma have been discussed at some length by Cragin**, Gould***, and Snider****. The changes which have been made in the divisions and terms used give the classification as follows:

Quartermaster formation.	
	Mangum dolomite member.
	Collingsworth gypsum member.
	Cedartop gypsum member.
Greer formation	Haystack gypsum member.
	Kiser gypsum member.
	Chaney gypsum member.
	Day Creek dolomite member.
Woodward formation	Whitehorse sandstone member.
	Dog Creek shales member.

*Cummins, W. F., The Texas Permian: Tex. Acad. Sci., vol. 2, 1897, pp. 93-98; Adams, George I., Stratigraphic relations of the Red Beds to Carboniferous and Permian in northern Texas: Bull. Geol. Soc. America, vol. 14, 1903, pp. 191-200; Gordon, C. H., Jour. Geol., vol. 19, 1911, pp. 110-125.

**Cragin, F. W., The Permian system in Kansas: Colorado Col. Studies, vol. 6, 1896, p. 3.

***Gould, C. N., Water-Supply Paper U. S. Geol. Survey No. 154, 1906, pp. 23-24.

****Snider, L. C., The Gypsum and Salt of Oklahoma: Bull. Okla. Geol. Survey No. 11, 1913, pp. 114-115.

	Shimer gypsum member.
Blaine formation	Medicine Lodge gypsum member.
	Ferguson gypsum member.
Enid formation.	

ENID FORMATION.

The Enid formation includes the rocks from the base of the Permian Redbeds to the lowest heavy gypsum ledge. The Pennsylvanian-Permian contact has been taken as a line crossing the Oklahoma-Kansas state line north of Pawnee, and extending south to that town, then west of south to Purcell, and south to the west end of the Arbuckles. The most recent work* has shown that the line should be drawn more nearly south from Pawnee. The upper limit of the formation is the base of the lowest gypsum of the Blaine formation. Owing to the lenticular nature of the gypsum this is not an exact limit, but is still a well defined horizon.

The line between the Enid and Woodward to the south or southeast of El Reno is very indefinite. The Enid formation occupies all or part of the following counties: Grant, Alfalfa, Woods, Major, Garfield, Noble, Payne, Lincoln, Logan, Kingfisher, Blaine, Canadian, Oklahoma, Cleveland, and McClain. The Redbeds in western Garvin and Carter counties may belong to part of this formation.

The Enid consists almost entirely of red shales with soft, lenticular, red sandstones. The lower portion contains relatively more sandstone than the upper, but the shales predominate throughout and comprise practically all of the upper part. Throughout the Enid there are veins of white sandy material. These sometimes occur as lenses having considerable thickness at the center but pinching out rapidly. Lentils as much as 3 feet thick in the center have been observed to pinch out in a very few (10 or 12) rods. Some of the beds of white sand are four feet, or even more, thick and cover areas of several acres. In a few cases of exceptionally good exposures layers of this white sand less than an inch thick can be traced for about one-fourth mile. The grains of the ordinary red sandstones as well as those of the white layers, are very fine—a large percentage passing a 200-mesh sieve. The shales grade from very sandy to clay shales. The latter are very fine-grained, very plastic when wet, and have great drying shrinkage.

The red color of both the sandstone and the shales is due to iron (ferric) oxide, which forms a thin coating over the grains of sand in the sandstones and presumably over the clay particles in the shales. In the uppermost 100 feet some of the shales have a green color. This color is probably due to some form of iron, but since these green shales are largely gypsiferous the color may be due to a compound of iron and calcium. The green color is often mistaken for copper stain.

At about 100 feet below the top of the formation the shales locally are very salty and give rise to salt springs at Ferguson in Blaine County,

*Beede, J. W., The Neva Limestone in northern Oklahoma: Bull. Okla. Geol. Survey No. 21, 1914, p. 22.

at the Big and Little Salt Plains on the Cimarron near the Kansas-Oklahoma state line, and at the Salt Plain near Cherokee. It is not to be understood that the salt occurs in these different localities at exactly the same horizon. The water carrying the salt at Cherokee is probably from a horizon considerably lower than that from which the salt water of the springs at Ferguson comes, while the salt horizon at the Salt Plains on the Cimarron is probably somewhat higher.

The shales for 25 to 30 feet below the gypsum ledge are very gypsiferous and the exposures show many veins of satinspar and selenite. This vein material has almost certainly been derived from the solution of gypsum by water passing through the ledges above and has been deposited near the surface of the exposure by the evaporation of the water. Near the bottom of the strongly gypsiferous layer is a persistent layer 1 to 2 feet thick of greenish selenite, the crystals of which are usually about an inch long, and a single layer of concretions of pure white, fine-grained gypsum. The concretions are in the shape of flattened ellipsoids and all lie with the long axis horizontal. The short or vertical diameter is usually about 2 inches and the long diameter 3 to 6 inches. These concretions lie almost or quite touching each other, forming a layer in the shale. On account of the persistence and uniformity of this double layer it is believed that it is the result of original deposition.

The surface of the territory underlain by the Enid is in general a plain into which the streams have cut shallow valleys. The eastern portion of the outcrop is somewhat hilly on account of the sandstones in the lower part of the formation. This portion is covered by oak trees but the greater part of the area is prairie and only a few cottonwoods and elms occur along the streams. The thickness of the Enid was estimated by Gould at 1,200 to 1,500 feet.

BLAINE FORMATION.

The Blaine is the great gypsum-bearing formation of the northwestern part of the State. In this connection only a brief notice will be given to the character of the formation and its relations.

The Blaine formation consists typically of three gypsum members separated by shales. The formation always forms a pronounced escarpment, as the soft, easily eroded shales of the Enid are eroded much more rapidly than the gypsums. This escarpment and the outliers have been known since early times as the "Gyp Hills." The hills enter the State from Kansas on the south side of the Salt Fork of Arkansas River, follow down that stream a few miles, swing back northwest up the Cimarron, cross the Cimarron just north of the Kansas-Oklahoma state line, and follow down the south bank of that river gradually getting farther from it. The formation is well developed as far southeast as Watonga, but from that point on the gypsums become lenticular and the formation plays out about 5 miles north of El Reno. The formation ranges from 75 to 100 feet thick.

WOODWARD FORMATION.

This formation is well described by Gould and since the field work for this report dealt very little with the formation and determined nothing new concerning it, his description is given in its entirety.*

Dog Creek shales member.—The Dog Creek member is composed mainly of clays, containing occasional thin ledges of magnesian limestone, which in places grade into a fair qualiity of dolomite.

The ledges, however, are usually thin and rarely sufficiently conspicuous to be worthy of more than passing notice. Professor Cragin's original description of this member is as follows:**

'The Dog Creek * * * consists of some 30 feet, or locally of a less or greater thickness, of dull-red argillaceous shales, with laminae in the basal part and one or two ledges of unevenly lithified dolomite in the upper. The color of these shales resembles that which prevails in most of the divisions below rather than of the terranes above the Dog Creek.'

In his second paper he modifies his description in this way:

'In central Oklahoma it is a great dolomite formation, laminated dolomite occupying a considerable part of the thickness.***'

In his second paper he suggests that the name Dog Creek be changed to Stony Hills. The writer agrees that the name Dog Creek is, perhaps, not the best that could be used, but in view of the fact that the dolomites which make up the Stone Hills in eastern Blaine County belong to the Blaine formation and do not belong to the Dog Creek, there seems to be no good reason for using the name Stony Hills to designate this member.

"Studies made during the last three years have demonstrated that in many parts of Oklahoma the thickness of the Dog Creek is much greater than that given by Professor Cragin. Near Quinlan, in eastern Woodward County, the aneriod readings indicate 225 feet as the thickness of these beds, measured from the top of the underlying gypsums of the Blaine formation to the sandstones of the next higher formation of this member, the Whitehorse, and in a number of localities 150 and 175 feet were recorded. Exposures are common along the top of the Gypsum Hills from Canadian County to the Kansas line and beyond.

Whitehorse sandstone member.—The Whitehorse sandstone was also described (under the name Red Bluff sandstone) by Professor Cragin in his first paper, as follows:****

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*Gould, C. N., Water-Supply Paper, U. S. Geol. Survey No. 148, 1904, pp. 15-59.

**Cragin, F. W., the Permian system in Kansas: Colorado Col. Studies, vol. 6, 1896, p. 32.

***Cragin, F. W., Observations on the Cimarron series: Am. Geologist vol. 19, 1897, p. 358.

****Cragin, F. W., The Permian system in Kansas: Colorado Col. Studies, vol. 6, 1896, p. 40.

'This formation consists of some 175 or 200 feet of light-red sandstones and shales. * * * Viewed as a whole it is very irregularly stratified, being in some cases considerably inclined, in others curved, and this oblique and irregular bedding, being on a much larger scale than that of the ordinary cross-bedding, at first glance gives the impression of dips, anticlines, synclines, etc., that have been produced by lateral pressure, the dips, however, being in various directions. * * * The Red Bluff beds exhibit the most intense coloration of any of the rocks of the series. When the outcrops are wet with recent rains their vividness of color is still greater, and the contrast of their almost vermillion redness with other colors of the landscape is most striking. Spots and streaks of bluish or greenish gray sometimes occur in these rocks, but not to nearly so great an extent as in the lower beds. The sandstones of the Red Bluffs are generally too friable for building stone, but in some instances selected portions have proved hard enough for such use and are fairly durable.'

In Oklahoma the Whitehorse member often weathers into conspicuous buttes and mesas. For instance, in eastern Woodward and western Woods counties a row of these buttes, which rise 100 to 200 feet above the surrounding country, extends from the vicinity of Whitehorse Springs, whence the name, southwest across the Cimarron, to the high divides beyond. To some of these buttes characteristic names have been given, as Lone Butte, Potato Hill, Watersign Hill, Wild Cat Butte, and the like. The noted Red Hill between Watonga and Geary in southern Blaine County, is composed chiefly of the Whitehorse formation. South of Canadian River this sandstone thickens and on weathering often forms conspicuous bluffs, such as the famous Caddo County Buttes, southwest of Bridgeport. The Whitehorse sandstone is exposed along the Washita near Chickasha, continuing westward, where in the vicinity of Anadarko it forms bold bluffs both north and south of the river, and extends as far west as Mountain View. Ledges which probably belong to the same general horizon outcrop north of the Wichita Mountains in the vicinity of Hobart and Harrison, and it is not impossible that further studies may demonstrate that the same beds extend under the upper gypsums, across Greer County.

'*Day Creek dolomite.*—Resting upon the upper part of the Whitehorse sandstone in Kansas and Oklahoma is a conspicuous ledge of hard, white dolomite, first described by Professor Cragin from exposures in southern Kansas, as follows*:

'Upon the latest of the Red Bluff rests a persistent stratum of dolomite varying in thickness from less than a foot to 5 feet or more. * * * It is true dolomite, containing with the carbonate of lime an equal or even greater percentage of carbonate of magnesia. Though not of great thickness, it is an important member of the upper Permian of southern Kansas and northern Oklahoma, owing to its persistence, which makes it a convenient horizon of reference. * * * The stone is nearly white in fresh

*Op. cit. p. 44.

fracture, weathering gray, and often has a streaked and gnarly grain resembling that of fossil wood. * * * Its cherty hardness and fracture are not due to the presence of silica, as one is tempted to infer, but are characters belonging to it as a dolomite. It is a durable building stone.

In his second paper on the Permian rocks, in describing a typical Oklahoma locality, Professor Cragin says:

'The brow of the Red Hills near Watonga, Okla., is capped with the Day Creek Dolomite, which here presents itself as a compact stratum of gray, somewhat pinkish or reddish tinged cherty-hard rock, little different from the typical ledge that skirts the flanks of Mount Lookout in Clark County, Kans. The stratum here has a thickness of 3 feet.'

The line of outcrop of the Day Creek in Oklahoma is not continuous; nevertheless, it is found in numerous localities, and on account of its distinctive lithological appearance it is always easily recognized. It is displayed on many of the hills of Woodward County, not only north of the Cimarron, but also between the Cimarron and the North Canadian and south of the latter stream. In Blaine County it forms the caps of a number of the prominent hills, notably the Red Hills between Geary and Watonga. South of Canadian River in Caddo County the dolomite covers the White-horse buttes southwest of Bridgeport and outcrops southwestward as far as the headwaters of Cobb Creek and on the west side of that creek past Colony. In the vicinity of Mountain View, in the valley of Washita River, a ledge of dolomite appears at the same general level as that occupied by Day Creek, and another dolomite ledge in the hills north of Harrison may provisionally be referred to this horizon.

The composition of this material in Oklahoma may be understood by reference to the following analysis:

Analysis of dolomite from the summit of the Red Hills 6 *miles northwest of Geary, Okla.*

	Per. cent.
Calcium carbonate	42.47
Magnesium carbonate	52.86
Water	1.82
Oxides of iron and aluminum	1.35
Silica and insoluble residue	1.82
Total	100.32

GREER FORMATION.

The Greer formation outcrops in two areas. The eastern one begins in the southeast corner of Woodward County and extends east of south in a widening belt through the central part of Dewey and Custer counties and eastern Washita County. In the southeastern part of Washita the belt divides, one branch swinging more to the east through the southwestern parts of Caddo and Grady counties into northwestern Stephens County. The other swings west along the south line of Washita County and is thought to connect with the western area in Beckham and Greer counties, although the connection cannot be made out on account of the covering of alluvium and sand in the valley of North Fork of Red River. The western area of the Greer occupies all of Harmon, southern Beckham, western Greer, and western Jackson counties.

The Greer formation is made up of sandstones, shales, and gypsums, with a ledge of dolomite, having a total thickness of about 150 to 300 feet. The stratification in the eastern area is extremely erratic and no horizon can be traced sufficiently far to be used as a basis for separating the formation into members. The gypsums are lenticular and in the northern part of the area are few in number and not very thick; to the south the gypsum lentils become more numerous and thicker, reaching their maximum in eastern Washita County. Farther southeast the ledges thin out.

In the western area the stratification is more regular and five distinct beds of gypsum and one of dolomite can be traced for considerable distances and are classed as members of the formation.

QUARTERMASTER FORMATION.

As is the case with the Woodward formation, the Quartermaster contains no important deposits of gypsum in Oklahoma and little attention was paid to it in the field work for this report, and the writer has no facts concerning the formation to add to those already published by Gould.* Consequently his description is given in full.

Above the Greer are 300 feet or more of soft, red sandstones, and arenaceous clays and shales to which the name Quartermaster has been applied. So far as known this is the highest formation of the Redbeds in Oklahoma.

In the lower part of the formation the rocks are chiefly shales, typically red, but sometimes containing greenish bands and layers. The shales become more arenaceous above, and in places form a strong, consolidated sandstone, which is rather thin-bedded and prone to break into small rectangular blocks, and weather queerly into long and narrow buttresses or rounded, conical, or nipple-shaped mounds from 10 to 50 feet or more high. These mounds may be solitary, but in some areas hundreds of them occur in a single quarter-section. The sandstone is further characterized by the marked and very peculiar dip of the rocks in certain directions. The strata often dip at angles of from 20° to 40° to all points of the compass, even in a small area. These dips often produce escarpments that have the appearance of those formed by regularly bedded dipping strata. The most plausible explanation of this phenomenon is that the erratic dipping is caused by the undermining of deepseated rocks, probably some of the various gypsum members of the Greer.

In this sandstone, particularly in its upper part, there are many springs of soft water, which usually issue as seeps at the head of deep canyons or beneath bluffs of red sandstone. While few of them have large flows, many are large enough to supply farmhouses, or, in some cases, to furnish stock

*Gould, C. N., Op. cit., pp. 72-73.

water for ranches. Wells in these sandstones frequently yield good water at moderate depths. In fact, with the exception of the eastern area of the Enid, the Quartermaster is the only Redbeds formation in which any large amount of good water is found.

Except where covered by younger rocks, the Quartermaster outcrops over practically all of Day and Roger Mills counties (Ellis and Roger Mills), and is also extensively developed in the western part of Dewey, Custer, and Washita counties. To the south and east it is underlain by the Greer, while to the west and north it disappears beneath the sands of the Tertiary. Streams tributary to the South Canadian, Washita, and the North Fork of Red River in the region form canyons in this rock and are fed by springs issuing from it. The name is from Quartermaster Creek, which flows from Day County through the extreme northwestern corner of Roger Mills County and empties into Washita River in Washita County. Along this creek both the lower shales and the sandstones higher up in the formation are well exposed. The peculiarities of structure and weathering are also well exemplified along this stream. In the present state of our knowledge it is not deemed advisable to attempt to subdivide the Quartermaster formation.

DEVELOPMENT.

In sec. 20, T. 19 N., R. 11 W. a well was put down to a depth of about 1,400 feet. This hole was stopped before it reached the horizon of productive strata.

In the NW. corner of the NW. 1/4 of the SW. 1/4 of sec. 10, T. 16 N., R. 11 W., the Watonga Oil Company drilled a well to a depth of 1,024 feet. This well caved so much that it had to be abandoned. Another well was started 30 feet east of the old location. A rotary drill was used and a depth of 400 feet was reached when operations ceased.

In the southeast corner of sec. 5, T. 15 N., R. 12 W., the Watonga Oil Company drilled a well to a depth of 2,440 feet. They had so much trouble with caving that the hole was abandoned. No production was found in this well.

SUMMARY.

The productive strata probably underlie Blaine County, though so deep as to make exploration too expensive at the present time. The deepest well drilled to date was only 2,440 feet. This well probably did not reach the horizon of the shallowest productive stratum.

BRYAN COUNTY.

LOCATION.

Bryan, one of the southernmost counties of Oklahoma, is bounded on the north by Johnston and Atoka counties, on the east by Choctaw

County, on the south by the state of Texas, and on the west by Marshall County. It extends from T. 5 S. to T. 9 S., and from R. 7 E. to R. 13 E. inclusive, and comprises an area of about 924 square miles. The county seat is Durant, located in the center of the county.

TOPOGRAPHY.

The whole region of Bryan County lies within the Red River Plain, which is a part of the larger physiographic province known as the Gulf Coastal Plain. The Gulf Coastal Plain extends almost entirely around the Gulf of Mexico as a broad belt of sands, clays, and thin limestones, having a gentle slope toward the sea. The belt covers a large area in Mexico, the southeastern half of Texas, the southeastern counties of Oklahoma, all of Louisiana and Mississippi, the southeastern half of Arkansas, the southern halves of Alabama and Georgia, all of Florida, and merges into the Atlantic Coastal Plain province which borders the Atlantic Ocean from Florida to New Jersey.

The Red River Plain is an essential part of the Gulf Coastal Plain but in no wise differs, either in structure or with regard to surface features, from the Coastal Plain.

The strata bordering the Gulf of Mexico all dip gently toward the Gulf. The youngest, or those most recently deposited, occur at the waters edge; the oldest, namely the Trinity sands, are found outcropping farthest north; all intermediate formations from the youngest to the oldest may be found in their proper order farther and farther north from the waters edge, outcropping as concentric belts about the Gulf.

The Red River Plain embraces the territory adjacent to the river, some 25 or 30 miles north and south; it extends as far west as western Love County, and east to its junction with Mississippi River.

GEOLOGY.

The whole of Marshall, Bryan, and Choctaw counties, together with large areas also of Love, Johnston, Atoka, and McCurtain counties, lie within the Red River Plains region, and the sediments exposed in this section of Oklahoma are the oldest deposits of the Coastal Plain region, namely the Cretaceous.

TRINITY SAND.

The Trinity sand is the basal formation of the Cretaceous and is found exposed at the surface in all of the counties of Oklahoma above mentioned. It reaches a maximum thickness of about 400 feet. It is a loosely consolidated, friable sandstone or compact sand, usually white or pink in color, and upon weathering forms flat or gently rolling lands. Close to the river (Red River) and near the larger creeks within the areas of the Trinity sand this formation is given to gullying, and precipices from 10 to 40 feet high are not infrequently seen standing at the heads of the small tributaries. This process goes on very rapidly during the wet seasons when the streams are high and the ground saturated with water, causing great damage to roads, railroads, and bridges, and moreover, practically ruins all such lands for farming or for any other purpose. The soils weathering from this formation are thin and poor and of a red color, but timber, chiefly scrub-oak, together with some ash and elm, grows abundantly, as a rule, over such areas. The timbered areas are rapidly being converted into arable lands in Love, Marshall, and Bryan counties.

GOODLAND LIMESTONE.

The Goodland limestone, though thin, is relatively hard, and wherever it comes to the surface it projects as a ledge or bluff forming a table land with a steep escarpment to the north. It forms mesas or buttes where it occurs as outliers and its escarpments then overlook the flat Trinity sands in all directions. It outcrops all the way across the county from east to west in a narrow, sinuous strip.

KIAMICHI FORMATION.

The Kiamichi formation lies above the Goodland and outcrops to the south of the Goodland exposure, and stretches across the county in a hill about a mile wide. This formation consists of thin limestones and friable clay forming gently rolling slopes leading up to the Caddo limestone. The weathered product is a heavy, black, clay soil and is much used for farming.

CADDO FORMATION.

The Caddo formation is composed of interstratified clays, marls, and limestones, together with some siliceous material. The limestones are usually hard and occur in the upper part of the formation. They make broad, rolling uplands, and are bordered by low escarpments, and slopes descending over the lower and softer beds. The belt stretches across the country and averages about 4 miles in width.

BOKCHITO FORMATION.

The Bokchito formation, like the Caddo, consists of alternating clays, sands, and hard, siliceous limestones, the last mentioned being thin and occurring chiefly in the upper part of the formation. The limestones usually project from the slopes to form terraces or ledges overlooking the country underlain by the Caddo limestone. The lower part of the formation forms a gently rolling or smooth surface.

BENNINGTON LIMESTONE.

The Bennington limestone is a thin, hard, resistant formation, and forms low bluffs or benches. It is about 25 feet in thickness.

SILO SANDSTONE.

Unconformably upon the Bennington limestone lies the Silo sandstone, a partially consolidated brown sandstone and shale 250 feet thick which extends south several miles but whose southern limit has not as yet been determined. The weathering of the surface produces an undulating topography.

OTHER FORMATIONS.

The Eagle Ford, 150 feet thick and the Austin chalk, 400 feet thick, are the formations next succeeding the Silo sandstone and should be found in the southern portion of Bryan County, but just what their distribution is cannot be stated at the present time as no detailed work has been carried out within this particular area.

STRUCTURE.

Bryan County lies wholly within the area of Cretaceous sedimentation, whose formations outcrop in more or less parallel belts extending across the county in a general east-west direction. The Trinity sands, the basal formation of the Cretaceous system, appear at the surface in the northeastern corner of the county only, but they are continuous beneath the overlying limestone, sandstones, and clays everywhere, and must be pierced by the drill in every well before the Paleozoic sediments can be reached.

This formation is about 400 feet thick and has been a source of much trouble to the driller in Marshall County and other adjacent areas where it has been encountered by the drill. It is an unconsolidated white or pink "pack sand" which is given to caving and when pyritiferous layers are encountered in it the sands cave away from beneath and large boulders of the pyrite roll down against the casing, causing much trouble and sometimes crushing the casing, as resulted in the Lebanon well in Marshall County. The Cretaceous rocks dip generally to the south at the rate of about 40 feet per mile. The Trinity sands therefore, while lying exposed at the surface in the northeastern part of the county, would occur at a depth of 1,400 feet in the southernmost section of the county south of Kemp, and at correspondingly shallower depths in more northerly localities.

The structure of these beds is therefore like so many shingles lapping one upon the other the lowermost projecting farthest north and the uppermost extending farthest south and all tilted south so as to catch and conduct the surface waters beneath ground to the sea. This slope to the Gulf is very slight, 40 feet per mile, as stated above, but there may be local monoclines; although at the present writing no detailed work has been done to locate them if there be any.

That the structure beneath the Cretaceous sediments, in the Paleozoic rocks, is entirely different from that just described as occurring with the Cretaceous may be guessed from the conditions and relationship of the rocks observed to the north in Atoka County. These older rocks are, no doubt, folded and faulted and probably locally are associated with granite, but it is not possible to describe their structure in detail in Bryan County owing to their inaccessability for study.

DEVELOPMENT.

While leasing is very active in Bryan County at the present time, only four wells have thus far been drilled and no oil of any consequence has been reported. One of these wells is in the E. 1/2 of sec. 21, T. 6 S., R. 8 E. It has a depth of 1,060 feet but produced only a showing of oil and gas, and has been abandoned.

In the center of section 9, T. 7 S., R. 9 E., a well has been drilled to a depth of 1,185 feet with a showing of oil at a depth of 735 feet. This is known as the S. B. Longfellow well and at the present time is being deepened.

A third well has been drilled in the SE. 1/4 of the NE. 1/4 of sec. 32, T. 5 S., R. 13 E. At the present writing it is 1,260 feet deep, and will be drilled to greater depth.

The only other test made in the county is the dry and abandoned hole put down in the NE. 1/4 sec. 28, T. 6 S., R. 12 E., which has a depth of 1,000 feet, the bottom of which is in shale.

SUMMARY.

Although some wells have been drilled in Bryan County, no very encouraging results have been obtained. It is, however, within possible oil and gas territory, but it must be remembered that exploration in a region like this is a more difficult problem than it is in the area of Pennsylvanian and Permian outcrops in the northern and east-central parts of the State. If, as is generally believed, the Pennsylvanian is the source of oil and gas in Oklahoma, the fact that the Cretaceous lies unconformably on the Pennsylvanian makes the problem of locating favorable structure from surface indications very difficult. Folding, indications of which are found in the surface Cretaceous, will in most cases extend down into the Pennsylvanian, but there may be structure in the Pennsylvanian which does not show at the surface.

From a study of well logs of Bryan County it appears that the Choctaw fault is continuous through this county from near the town of Atoka, where its southern extension is concealed by the Cretaceous formations. From Atoka this fault, which involves pre-Cretaceous formations only, probably continues in a southern, slightly eastern direction through Bryan County. The data are insufficient to make a definite determination as to the exact course of this fault, but it probably passes through some point between Durant and Bennington. The log of a well near Durant shows a limestone very similar to the Arbuckle limestone, and that of a well near Bennington shows the Ouachita uplift formations. Then, on the west side of the fault, the Arbuckle Mountain series of formations, and on the east side, the Ouachita uplift series would be expected.

It is not known then, whether the Pennsylvanian of the Arbuckle Mountain series would be encountered on the west side of the fault, and even if it should be encountered, there would be some question as to whether structural conditions in it would be favorable for the accumulation of oil and gas. On the east side of the fault, in the region of the Ouachita uplift, no Pennsylvanian has been determined, the highest formation being of Mississippian age which is stratigraphically below the

Pennsylvanian. To say, then, that the Pennsylvanian occurs east of the Choctaw fault in this area covered by the Cretaceous is very problematical. The asphalt deposits in the Ouachita Mountains indicate that some of these formations have at some time contained oil, and that it has escaped on account of the upturned oil-bearing strata being exposed, leaving the asphaltic residue. If such conditions exist east of the Choctaw fault in Bryan County, then the chances for the accumulation of oil in pre-Cretaceous formation would be very slight. However, if after the Cretaceous sediments were deposited oil and gas continued to escape, then there is a possible chance for accumulation in the Trinity sand of the Cretaceous.

Considering the pre-Cretaceous formations as a source of oil and gas, the most likely territory is in the southwestern part of the county, and considering the Cretaceous area, in which drilling would be shallow, the most likely territory is in the southern part of the county.

CADDO COUNTY.

LOCATION.

Caddo County is located in the southwestern part of the State. It extends from T. 5 N. to T. 12 N. inclusive, and from R. 9 W. to R. 13 W. inclusive. It includes 36 whole townships. The entire area is approximately 1,296 square miles.

TOPOGRAPHY.

Most of Caddo County is within the Gypsum Hills region. The extreme northwestern part of the county is in the Wichita Mountains. Immediately northeast of the Wichita Mountains, and extending in a northwest-southeast direction is a strip of Redbeds Plains which is about 8 miles wide. The formation in the Gypsum Hills region slopes in general to the northeast. The topography is rough, the prominent feature being sandstone-capped and gypsum-capped hills and escarpments.

That part of the Wichita Mountain region which is in Caddo County belongs to the Limestone Hills group of the region. This group is a collection of limestone and porphyry hills, and low mountains. The hills and low mountains in this region are rounded and smooth.

Some of the crests of the hills and mountains are 400 to 600 feet above the surrounding Redbeds Plains. The Redbeds Plains region is a gently rolling prairie plain. Most of Caddo County drains into Washita River. The extreme northern part of the county is drained by tributaries to Canadian River. The southern part of the country drains into tributaries of Red River.

GEOLOGY.

Most of the outcropping rocks in Caddo County are Permian. In the extreme southwestern part are found granite-porphyry, Reagan sandstone, and Arbuckle limestone.

The granite-porphyry appears to be rather coarse-grained. It varies in color from brick red to shades of light pink. The rock contains spherulitic aggregates of feldspar and micropegmatite, a little quartz, and a very little altered hornblende.

The Reagan sandstone rests on the eroded uneven surface of the granite-porphyry. It is approximately 300 feet thick and is composed of hard and soft sandstone, grit, conglomerate, shales, and siliceous shell limestones.

The Arbuckle limestone lies conformable on the Reagan sandstone. It is composed of a continuous succession of limestone beds usually less than 5 feet in thickness and aggregating 4,000 to 6,000 feet. The individual beds vary from dense fine-grained white limestones to cream-colored dolomitic limestones interstratified with slightly argillaceous and siliceous lime beds.

The Permian* rocks consist of shales, sandstones, and gypsum. The shales are usually very fine-grained slightly consolidated and very plastic, though some of them are siliceous. The sandstones are usually composed of fine, round grains, and are usually cross-bedded and lenticular. A sandstone often grades horizontally into shales within a very short distance. The gypsum occurs as both rock gypsum and gypsite-dirt gypsum. The gypsum is usually not pure white, but either pinkish or dark-colored.

STRUCTURE.

In the southern part of Caddo County the Permian strata are known to lie unconformable on the older Cambrian and Ordovician strata. The distance north to which the Wichita uplift has influenced these older strata is not definitely known though some geologists place the limit of influence at the Canadian River. If this be true then the Permian strata are unconformable with the older Cambrian, Ordovician, and Pennsylvanian strata through Caddo County, though the difference in dip and strike in the northern part of the county is slight. Observed dips on the Arbuckle limestone in the southwestern part of the county are as high as 20°. If, as Taff supposes, the limestone hills in the southwestern part of the county occupy the middle of the Arbuckle formation, taking the average thickness of the older rocks as exposed in the Arbuckle region and averaging the northeast dip between 20° and 0° at the Canadian River, then the base of the Pennsylvanian rocks would be expected to underlie the Permian at approximately 8½ miles northeast of the limestone hills.

The general dip of the Permian strata is to the west. There are a few local variation in the general west dip, but we have not done

*The reader is referred to the discussion of the Permian under "Blaine County."

sufficient detailed work to permit pointing them out. In looking for structure favorable for the accumulation of oil and gas under geological conditions such as there are in Caddo County it is well to keep in mind these facts: (1) Whatever folding occurs in the surface Permian, if severe enough will influence the underlying older rocks. If the folding occurs in a locality where the Permian is conformable with the underlying rocks the folding in these older rocks will be similar to the folding at the surface. If unconformable then the folds in the older rocks will be dissimilar, the amount of dissimilarity depending on the amount of difference in strike and dip between the unconformable strata. (2) There may be folding in the underlying older strata that does not show in the surface Permian. (3) Though oil and gas might migrate at great distances along the unconformable contact between the Permian and the older rocks, thereby accumulating in up-bends in this contact, or in up-folds in the Permian, the maximum accumulation would be expected at the up-fold of the Permian or up-bend of the unconformity nearest the contact between the Permian, and the underlying oil or gas bearing strata. If, as is generally supposed, the Pennsylvanian strata are the source of oil and gas in Oklahoma, then the maximum accumulation in Caddo County would be expected more than 8½ miles northeast from the Limestone Hills.

DEVELOPMENT.

Several wells have been drilled in this county and in adjacent areas in the bordering counties, but encouraging results were not obtained until showings of oil and gas were encountered in the well now being drilled by the Kiechi Oil and Gas Company in sec. 32, T. 6 N., R. 9 W., near the town of Cement. Both oil and gas have been reported from this location. The gas production is stated in varying amounts from a few thousand cubic feet to several million, and the oil productions are reported at 25 to 50 barrels per day. All of these productions were reported from shallow depths.

A few years ago a well known as the "Funk Well" was drilled east of Cement. It was reported that the drill passed through three oil sands, one of which gave about 10 barrels initial daily production, and another a yield of 1,000,000 cubic feet of gas.

SUMMARY.

While conditions may be favorable for the accumulation of oil or gas in the older strata underlying the Permian or along the unconformity near the contact between the Permian and these older oil and gas bearing strata, these productive horizons lie so deep as to make explorations too expensive at the present time. Some small deposits may be found at shallow depths in the southern part of the county near the Wichita Mountains.

The showings of oil and gas encountered in the wells near Cement have added a stimulus to development in that part of the county. These showings were found at a shallow depth, and conditions may be similar to the general conditions at Gotebo, where a small production is obtained at the base of the Redbeds. Without available data it is not known whether the reported production at Cement is at the same horizon. A study of the logs of these wells when available should give valuable information about the formations encountered.

It is thought that in a northern direction from the Wichita Mountains the Redbeds become thicker. If this is true, a productive horizon which would probably be near the base of the Redbeds, or in the Pennsylvanian rocks below, would be encountered at a shallower depth in the southern part of the county than in the northern part. In the extreme southwestern corner of the county the Arbuckle limestone of the Wichita Mountains and the Redbeds are in contact, while the log of a well drilled near El Reno shows at least 1,800 feet of Redbeds.

CANADIAN COUNTY.

LOCATION.

Canadian County is located a short distance west of the center of the State. It extends from T. 10 N. to T. 14 N. inclusive, and from R. 5 W. to R. 10 W. inclusive. It includes 24 entire townships and parts of 4 others. The entire area is approximately 927 square miles.

TOPOGRAPHY.

The eastern part of the county is in the Redbeds Plains. The topography is that of a rolling prairie plain, broken by the valleys of the North and South Canadian rivers. About 7 townships in the western part of the county are within the Gypsum Hills. Locally the topography is fairly rough—gypsum escarpments are not uncommon. The small streams have made deep and narrow canyons. The county is drained by North and South Canadian rivers, and tributaries to them, and by tributaries to Cimarron River.

GEOLOGY.

The surface rocks in Canadian County are Permian, except along the large streams there are Recent sands and gravels, and capping some of the hills are Tertiary gravels. The Permian rocks in most of the county are red shales and red sandstones, the shales predominating. The following Permian formations outcrop in Canadian County: the Woodward, Blaine, and Enid. The Enid formation occupies about two-thirds of the surface of the county, and is located in the northeastern part. The Blaine formation, which occupies a very narrow strip, enters the county about 6 miles east of the northwest corner and extends in a southeastern direction to a point about 6 miles due north of El Reno, where it pinches out. The remainder of the surface of Canadian County is occupied by the Woodward formation. For a full discussion of the geology the reader is referred to this subject under "Blaine County." The following log of a well located in the S. ½ of the SE. ¼ of sec. 3, T. 12 N., R. 7 W., will give a general idea of the underground strata:

Log of El Reno Well, in sec. 3, T. 12 N., R. 7 W.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Black gumbo soil	3	3	Blue shale	10	1,830
Coarse gray sand	50	53	Brown shale	20	1,850
Red shale	1,048	1,095	Blue shale	15	1,865
Coarse red shale	127	1,222	Brown shale	5	1,870
Fine red sand	6	1,228	Brown shale	15	1,885
Red shale	17	1,245	Brown sand	5	1,890
Fine red sand	5	1,250	Brown sand	15	1,905
Red shale	25	1,275	Brown shale	25	1,930
Coarse red sand with			Blue shale	10	1,940
clay nodules	7	1,282	Brown shale	10	1,950
Red shale	60	1,342	Blue shale	10	1,960
Red sand	6	1,348	Brown shale	40	2,000
Shale	7	1,355	Blue to brown shale	10	2,010
Fine red sand	47	1,402	Brown to blue shale	20	2,030
Red shale	10	1,412	Blue shale	10	2,040
Red sand	15	1,427	Brown shale	10	2,050
Red shale	8	1,435	Blue slate	65	2,315
Red sand	40	1,475	Coarse brown shale	5	2,320
Red shale (with nod-			Blue shale	50	2,370
ular grains)	20	1,495	Brown shale	100	2,470
Fine red sand	49	1,544	Blue nodular shale	145	2,615
Coarse red shale	8	1,552		12	2,627
Fine red sand	8	1,560	Blue shale	218	2,845
Red shale	8	1,568	Brown shale	35	2,880
Fine red sand	11	1,579	Blue shale	20	2,900
Red shale	6	1,585	Limestone	2	2,902
Fine red sand	15	1,600	Brown shale	83	2,985
Red shale	60	1,660	Blue shale	17	3,002
Fine brown sand	12	1,672	Blue shale	46	3,048
Red shale	8	1,680	Sand and lime con-		
Fine red to white sand	3	1,683	glomerate	30	3,078
Red shale	62	1,745	Coarse brownish shale	107	3,185
Brown sand	5	1,750	Brown sand	5	3,190
Red shale with nodules	20	1,770	Coarse brownish shale	30	3,220
Coarse brown shale	50	1,820	Brown shale	95	3,315

STRUCTURE.

The rocks of Canadian County belong to the Prairie Plains monocline. They dip at a rather low angle to the southwest. The surface rocks of the Enid formation within Canadian County are for the most part shales. The surface is, therefore, almost level with few or no surface indications of the underground structure.

In the area occupied by the Blaine and Woodward formations there are ledges of gypsum in the former, and of dolomite in the latter, that are of sufficient horizontal extent to be used as "key" strata in determining underground structure.

DEVELOPMENT.

Two wells were drilled near El Reno by that city. One, located in the S. ½ of the SE. ¼ of sec. 3, T. 12 N., R. 7 W., was drilled to a depth of about 3,500 feet, the other located in the SE. corner of the N. ½ of SE. ¼ of sec. 7, T. 12 N., R. 7 W., was drilled to a depth of 1,200 feet. A log of the former is given under "Geology" of Canadian County. Both of these wells were dry. No other development has been reported for Canadian County.

SUMMARY.

Canadian County is in probable oil and gas territory, but the great depth to probable production makes explorations at the present time too expensive. The northeastern two-thirds of the county, where the Enid formation is at the surface, is a level plain with few or no surface indications of the underground structure. Areas of this sort will have to be explored either by "wild catting," or by diamond drilling for structure.

The areas occupied by the Blaine and Woodward formations where there are surface indications of underground structure are so far to the westward that the productive sands are probably so deep that the cost of development is at the present time prohibitive.

CARTER COUNTY.

LOCATION.

Carter County is located in central southern Oklahoma. The county includes all of 20 townships and parts of 5 others. The territory embraced is in T. 1 S. to T. 5 S., inclusive, R. 1 E. to 3 E. and R. 1. W., to R. 3 W., inclusive. The area is 832 square miles.

Ardmore is the county seat. The principal towns of the oil field region are: Ringling, Wilson, Wirt, Dundee, and Healdton.

TOPOGRAPHY.

Carter County includes a part of four physiographic regions: The Arbuckle Mountains region, which includes the eastern two-thirds of the north side; the Sandstone Hills or Pennsylvanian region occupies the southern two-thirds of the area south of the Arbuckle Mountains; the western one-third is covered by the Sandstone Hills region; and in the central-southern part is an irregular area occupied by the Coastal Plains or Cretaceous region.

The surface topography varies from level plains to rough, mountainous areas, such as are found in the Arbuckle Mountains, on the north side, and the Criner Hills, in the south-central part of the county. The elevation of the county ranges from 850 feet to 1,050 feet above sea level.

The drainage is into the Washita, which flows across the northeast corner of the county, and its chief tributaries Caddo Creek, flowing entirely across the county from west to east, and Wild Horse Creek flowing through the northwestern part of the county; and into Red River through its numerous southward-flowing tributaries.

GEOLOGY.

The surface rocks of the county range in age from Cambrian to Cretaceous, and in some scattered areas Recent sands and gravels are found. The geologic divisions correspond very closely to the topographic and physiographic regions mentioned above.

The Arbuckle Mountains lie along the north boundary of the county. The geology of the Arbuckle Mountain region is discussed to considerable extent under both "Murray County," and "Johnson County," and only brief mention will be made of the character of the region in the discussion dealing with Carter County.

The Arbuckle Mountains consist of a moderately elevated region varying in elevation from 1,300 feet above sea level to 900 and even as low as 750 feet above sea level toward the eastern end, where the uplift coalesces with the bordering plains. These mountains consist of a great series of rocks composed chiefly of limestone, which range in age from middle Cambrian to Devonian. Some sandstones and shales of great thickness also occur in the uplift. The formations comprising the uplift are succeeded on the borders by great thicknesses of carboniferous conglomerate, shales, sandstones, and limestones. In the central or axial portion of the mountains is mass of pre-Cambrian, granite, granite porphyry, diabase, and associated crystalline rocks.

The rocks exposed in the region are as follows, beginning with the oldest: Granite, Reagan sandstone; Arbuckle limestone; Simpson formation, Viola limestone; Sylvan shale; Hunton formation; and Woodford chert.

Lying to the south and southwest of the region the surface rocks of the county, with the exception of the Criner Hills area, consist of Pennsylvanian, Permian, and Cretaceous sediments.

The Criner Hills, which are the Arbuckle Mountains in miniature, lie 15 miles south of the Mountains and 6 miles southwest of Ardmore. All the formations occurring in the Arbuckle uplift except the igneous rocks, the Reagan sandstone, and the lower part of the Arbuckle limestone, are exposed in the Criner Hills. These hills rise only a few feet above the surrounding country.

The topography of both the Arbuckle uplift and Criner Hills is due to the character of the rocks exposed. The Arbuckle limestone is a massive, fairly homogeneous formation, making rugged, stony, hills; while the Viola and Hunton limestones are composed of thin, hard beds, and make smooth, oval-topped hills and ridges. The Sylvan shale occurs in the valleys and is wooded, while the other areas are chiefly without trees. The Simpson consists of soft sands and shales, with some limestone and occurs in the valleys and hill- slopes.

The region between the two uplifts consists of rocks of Carboniferous age, which have been strongly folded. They consist of sands, shales, limestones, and limestone conglomerate. The trend of the folds is northwest-southwest, being practically parallel with the Arbuckle and Criner Hill axes.

The Arbuckle uplift and the basin between the uplifts is concealed toward the west and northwest by Permian Redbeds, and on the south-west by Cretaceous sediments. West of the Criner Hills and through-out the southwestern part of the county the Carboniferous rocks are covered by the Cretaceous sands and conglomerates. Some scattering areas of these Cretaceous materials are found throughout the central and western parts of the county.

STRUCTURE.

Structural features are very marked in a large part of the county and in areas where the younger rocks conceal the structural conditions there is much evidence that the underlying rocks are folded and in many places faulted and broken. The rocks of the Arbuckle Mountain uplift dip at high angles to the points where concealed by later sedi-ments.

The following* paragraphs indicate the character of the folding in the Arbuckle Mountain region which produced the structural fea-tures now present:

From Cambrian time up to middle Carboniferous the stratigraphic succession is regularly conformable, showing that the rock beds remained practically flat during successive periods. There were probably oscilla-tions which brought the sediments to the surface of the water at times, and gave occasion for slight erosion, which will be described in the dis-cussion of stratigraphy. About the middle of the Carboniferous period, near the beginning of Mississippian time, the rocks of the Arbuckle Mountain region were uplifted and folded, and mountainous conditions resulted. During and following the uplift, and before the end of Carboni-ferous times the mountains, so far as can be observed, were worn down to moderate relief. During this time thick deposits of limestone con-glomerates, derived from the Silurian, Ordovician, and Cambrian rocks toward the heart of the uplift, were laid down in the bordering Carboni-ferous seas. As erosion progressed, during late Carboniferous time folding

*Taff, Joseph A., Geology of Arbuckle and Wichita mountains: Prof. Paper U. S. Geol. Survey No. 31, 1904 pp. 15-16.

and faulting occurred, as is shown by the infolding and faulting of some of the earlier Carboniferous conglomerates with older Paleozoic strata. Remnants of this Carboniferous conglomerate occur in the present Arbuckle Plateau in a number of places and conceal the whole northwestern extension of the uplift. The nearly flat limestone conglomerate, grits, and clays of the bassal portion of the "Redbeds" rest unconformably upon the Coal Measures conglomerate and across the extreme western end of the Arbuckle Mountains. Between the Permian and the Cretaceous there is no record of sedimentation, and it is presumed that land conditions prevailed.

The basal formation of the lower Cretaceous lies across the southeastern side of the Arbuckle uplift, on a nearly smooth floor, composed of granite and interstratified with thick and hard limestone and thinner limestone, sandstone, and shale formations. This formation, which is slightly inclined toward the southeast, is composed of the beach and near-shore deposits of the Cretaceous sea, which transgressed northward and most likely beyond the region of the Arbuckle Mountains. The nature of these deposits of the Cretaceous and of the flat floor upon which they rest suggests strongly that the land upon which the Cretaceous sea advanced had been reduced to a low peneplain. Whatever the condition of the pre-Cretaceous land, it appears that the Cretaceous degradation reduced all the rocks from the soft shales of the Carboniferous to the massive hard limestones of the Cambro-Ordovician and the granite to a nearly flat plain. The basal Cretaceous formation was rapidly eroded toward the south, in the direction of the drainage and of the dip of the strata. After the sands were removed from the rock floor of varying hardness on which they had been deposited, differential erosion produced the topographic forms of the Arbuckle Mountains and the bordering parallel hills and valleys and etched plateau. The plain of the Arbuckle Mountains when projected southward passes beneath the Cretaceous sediments, approximately in the Cretaceous floor.

The Criner Hills are included almost entirely in Carter County. The lower southern extremity of the uplift extends into Love County. The following* discussion gives the structural conditions of this region, and from these descriptions conclusions may be drawn concerning the conditions which will be found in the areas surrounding the Criner Hills, but having a surface covering of younger and practically undisturbed rocks.

The relations of the Pennsylvanian beds to the older rocks are essentially the same as in the Arbuckle Mountains, so far as could be determined by a general survey. The Sycamore limestone and Caney shale of the Mississippian occur infolded with the older rocks, and it seems evident that in this area, as elsewhere in the Arbuckle Mountain region, active disturbances of the rocks did not occur until about mid-Carboniferous time.

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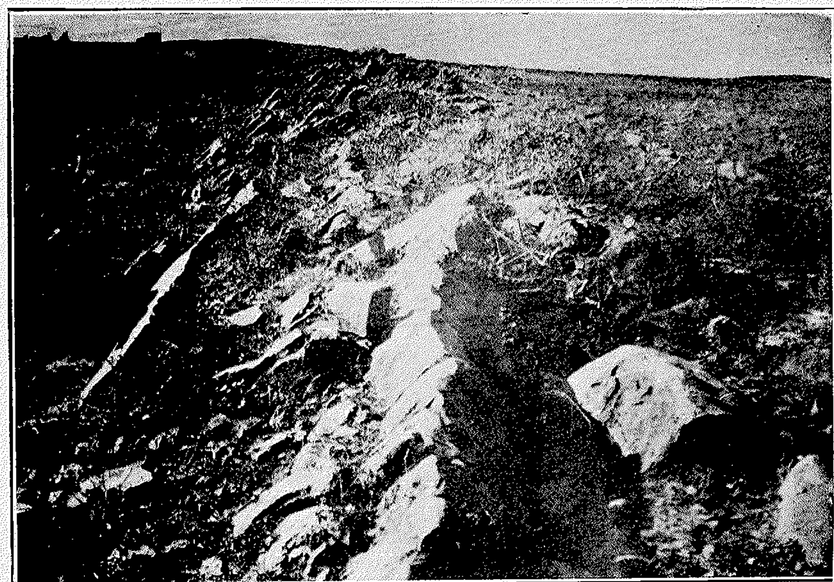
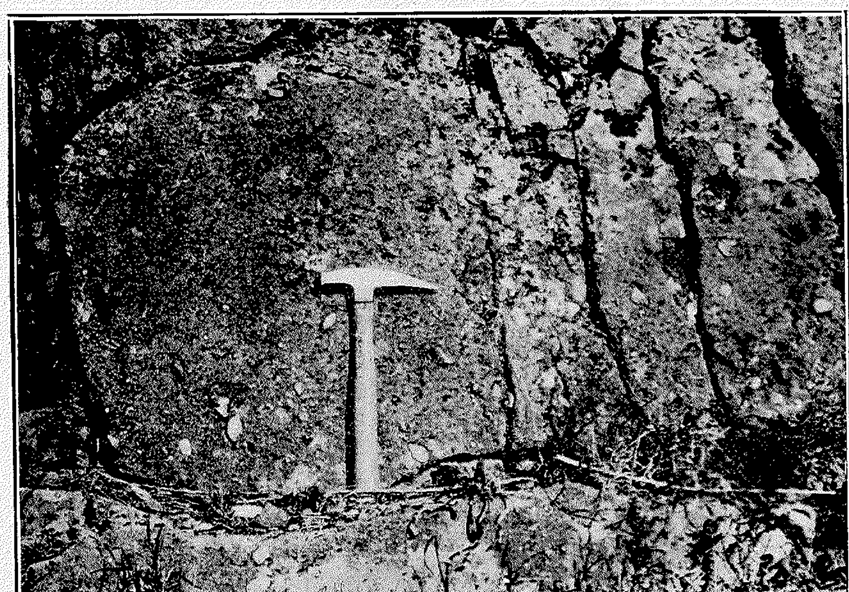
*Taff, Joseph A., Geology of the Arbuckle and Wichita mountains: Prof. Paper U. S. Geol. Survey No. 31, 1904, pp. 48-50.



A. STEEPLY TILTED BEDS OF LIMESTONE OF CARBONIFEROUS AGE IN THE REGION BETWEEN THE ARBUCKLE MOUNTAINS AND THE CRINER HILLS UPLIFT, 4 MILES WEST OF ARDMORE.



B. STEEPLY TILTED BEDS OF CARBONIFEROUS LIMESTONE SHOWING INCLUDED PEBBLES. IT IS PROBABLE THAT THIS CONGLOMERATE LIMESTONE IS THE SOURCE OF SOME OF THE PEBBLES FOUND IN THE CRETACEOUS CONGLOMERATES.

Sufficient fossils, however, were not obtained to determine the position of the lowest Pennsylvanian beds exposed in the district.

There is a pronounced unconformity at the base of the Coal Measures strata across the northwestern end, in a large portion of the northeastern side, and at the southeastern end of the hills. The lowest exposed beds of the Coal Measures consist of gritty siliceous limestone, sandstone, and shale interbedded, and coarse limestone conglomerates. The entire southwestern side, however, and a part of the northeastern side are marked by faults. The extent of displacement on the southeastern side is not determinable. The older rocks of the hills end abruptly in a definite but low escarpment, at the base of which a number of large springs issue. As shown by the exposures, the rocks in contact at the base of the escarpment consists of Coal Measures shale, calcareous, grits, and sandstones, and dip toward the southwest. In the area west of Hickory Creek, except that part bordering the stream, a flat, fertile plain extends to the base of the escarpment.

The rocks of the Criner Hills structurally compose parts of four folds. All these folds are intersected by faults and are bounded on one or more sides by an overlap of Carboniferous deposits.

The larger of these folds includes the northwestern half of the hills and is a northeastward-dipping monocline or the broken southern limb of a syncline. Along and near the southwestern side the lowest exposed beds of the Arbuckle limestone are nearly flat and are locally deflected downward at low angles toward the fault which bounds the hills. It is interpreted that this local southwestward deflection of the rocks is due to the drag in the downward displacement on the opposite side of the fault. There are no means by which the extent of displacement of the strata along the southwest side of this fold can be determined. It is reasonable, however, to consider that the throw is not so great as the discordance in strata now in contact at the fault would indicate, but that it is, in part at least, due to an unconformable overlap of Carboniferous upon the folded and eroded older rocks before the faulting occurred.

A fault also bounds the northeastern side of this fold. It bears S. 25° to 30° E. from the northwest corner of the hills, oblique to the strike of the rocks and to the trend of the hills. The strata on the east side of the fault have been thrown down with respect to those on the west side. The axial part of a syncline occurs east of this fault, near the north end of the hills. The lowest rocks exposed here are Devonian (Woodford) cherty shales, which occur in contact with Ordovician (Viola) limestone on the opposite side of the fault. Near the north side of sec. 22, T. 5 S., R. 1 E., the fault crosses the axis of this syncline, and toward the southeast successively lower formations approach the fault on each side. This fault joins that in the southern boundary of the hills near the crossing of Hickory Creek. The downward displacements of these faults are in opposite directions, and it is evident that in the latter fault the displacement is greater, since it continues downward toward the southwest, beyond the junction of the faults, and to the southeast end of the hills. From Hickory Creek southeastward the inclination of the older rocks of the hills is 45° to 50° NE., while the Carboniferous rocks dip 25° to 30° SW.

East of the above-described fault ,which cuts the hills diagonally, the older rocks comprise a remnant of an anticlinal fold, which trends approximately N. 20° W. The upper part of the Simpson formation is exposed in places both east and west of Hickory Creek, and the succeeding Viola limestone outcrops in large bodies on each side, making the southeastern part of the Criner Hills. Still higher formations, the Sylvan shale and the Hunton limestone, occur at the northwestern and southwestern ends of this broken fold. In the northwestern end they are terminated by faulting and overlap of the Carboniferous conglomerate, and at the opposite end apparently only by overlap. Faulting has occurred in the axial part of this fold also. At the crossing of Hickory Creek, in the SW. ¼ sec. 35, T. 6 S., R. 2 E., the Simpson formation is exposed only in the southern limb of the fold. It appears that the fault follows approximately the strike of the fold, and that the eastern limb has been thrown down with respect to the other. The dip of the rocks in the Simpson formation here is 80° SW., while on the opposite side the Viola limestone is nearly as steeply inclined in the opposite direction. In the eastern half of sec. 36, T. 5 S., R. 2 E., there is a small area of Silurian, Devonian, and Mississipian rocks, surrounded unconformably by Coal Measures strata. It appears to be a part of the northern limb of the anticline above described. The rocks dip toward the northeast, and are nearly in strike with the same formations at the southeastern end of the Criner Hills.

The Carboniferous rocks on the northeast side of this anticline have suffered folding, and near the contact with the older rocks are generally steeply inclined and dip toward the northeast. East of Hickory Creek dips of Carboniferous rocks at and near the contact vary from 25° to 40°, while the older rocks dip at greater angles and in places in different or opposite directions, indicating a great unconformity. Immediately east of the road at its crossing of Hickory Creek near the west side of sec. 35, T. 5 S., R. 2 E., the contact is evidently upon a fault. At this place the Simpson formation dips toward the southwest, while the dip of the Carboniferous is 40° in the opposite direction. Farther southeast, and in the opposite side of the axis of the fold, the Viola, Sylvan, and Hunton formation dip northeast, in the same direction as, but at higher angles than, do the overlying Carboniferous strata. West of Hickory Creek, at the base of the Coal Measures deposits, is a strong unconformity which is probably in part due to faulting. The beds near the base are variable in character along this contact. In some places they appear to be chiefly shale, while in others, especially in sections 22 and 27, are coarse limestone conglomerates consisting of pebbles of the same nature as the limestones of the Criner Hills.

DEVELOPMENT.

GENERAL STATEMENT.

The occurrence of oil seepages and asphalt deposits over the county has been known for years. Many of these led to local prospecting and many excavations were made, which resulted in the opening of several good deposits of asphalt, and eventually led to the finding of oil and gas in paying quantities. The first actual drilling was done by the Santa Fe Railway Company in May 1904, after they had secured 2,000 acres of land in fee. Three or four shallow wells were drilled before a successful well was finally completed in October, 1905. This was the opening of the Wheeler field.

In addition to the discoveries in the Wheeler district a few wells were drilled at various places over the county, but no production of value was encountered until in August, 1913, when the first well was drilled in the Healdton field.

The Wheeler and Healdton fields, and the miscellaneous drilling over the county since the discovery of these fields are discussed under the corresponding headings in the following pages.

WHEELER FIELD.

LOCATION.

The Wheeler oil and gas field is located in the west central part of Carter County, about 18 miles northwest of Ardmore. The developed area is included in sections 16, 17, 18, 19, 20, 21, 22, 23, 26, 27, 28, 29, 30, 32, 33, 35, T. 3 S., R. 2 W.

Oil City is the name of the town in the field, Wheeler being only a townsite with no buildings except a school house. Wilson, about 10 miles distant, is the nearest railroad station.

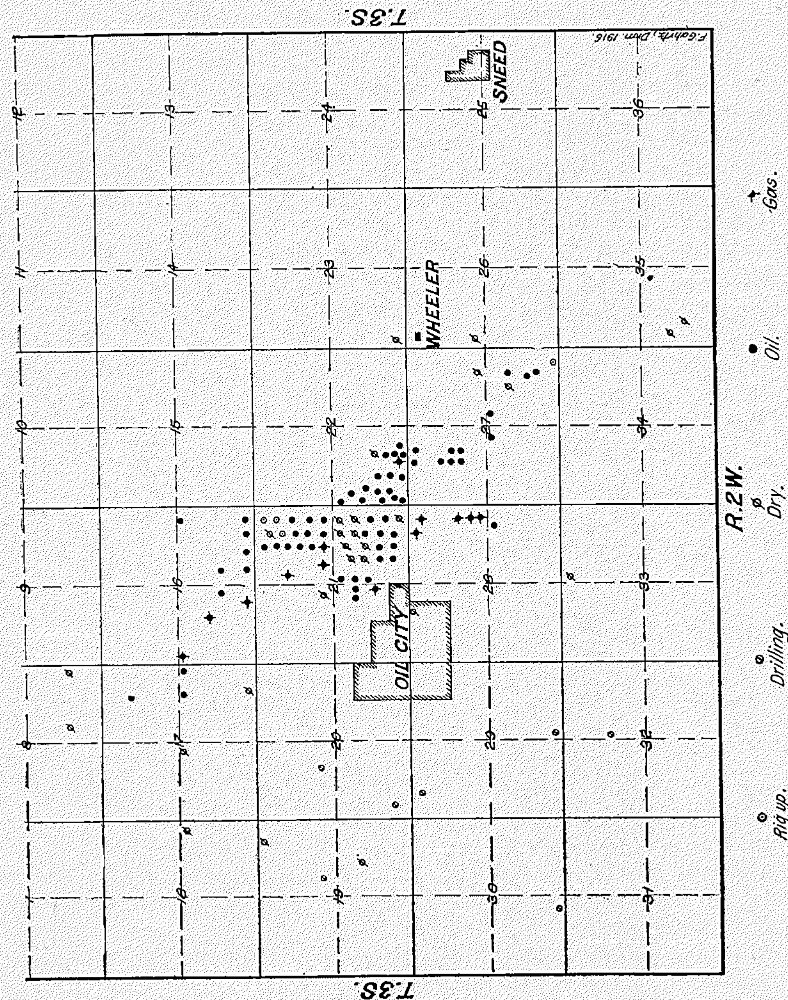
TOPOGRAPHY.

The area of development lies within 15 miles of the southern exposed part of the Arbuckle Mountains, and is on the uplands between Caddo and Walnut Creeks. There are no marked irregularities in the surface and the elevation is about 900 feet above sea level.

GEOLOGY.

The rocks encountered in the region consist of probable Cretaceous sands, Permian Redbeds, and Pennsylvanian rocks. Of the latter group, only the Glenn formation is to be considered in the discussion of the Wheeler field. This formation consists of alternating sandstones and shales, which are bituminous in many places. Some lentils of limestone occur. The Glenn is the asphalt-bearing horizon at Overbrook, south of Ardmore, and at Woodford, a few miles west of the Wheeler field. The Permian Redbeds are the surface rocks over most of the immediate vicinity of the field. The basal members of the Permian

WHEELER OIL AND GAS FIELD.



seem to yield the oil and gas of the region and lie unconformably upon the Glenn. Some of the wells in the field begin on the surface sands which are highly impregnated with asphalt.

STRUCTURE.

As stated in the general discussion of geology of this county, the region between the Arbuckle Mountains and the Criner Hills represents a structural trough or syncline, composed almost entirely of the rocks of the Glenn formation. The outcropping rocks in the base of the syncline are nearly vertical. The Permian sediments encroach from the northwest and are deposited in a nearly level-lying position across the upturned edges of the Carboniferous rocks.

Occasional irregularities are found in the Redbeds but on account of the nature of deposition and the character of the soft shales and sandstones, structural features cannot readily be determined.

The folding in the Wheeler district has been very slight, but the area has been mapped structurally by different geologists and the outlines of the field as determined by the drilling of dry wells, have shown that there is some relation between the surface structure and the underground structure.

Within the large trough minor folding has taken place and it is probably due to these conditions that the producing areas found in the area owe their importance. It is believed that Caddo Creek and Walnut Creek are both synclinal streams.

DEVELOPMENT.

Development of the Wheeler field was begun by the Santa Fe Railway Company in May, 1904, after they had secured nearly 2,000 acres of land in fee. The first well was undertaken with a Columbian drilling machine on the NE. 1/4 SE. 1/4 sec. 21, T. 3 S., R. 2 W., but it was soon discovered that the formations caved badly and the hole was abandoned. The second attempt resulted in a flow of gas at about 150 feet which supplied fuel for operating purposes for about two months, when the gas was cut off by a cave. The hole was then continued to 516 feet and converted into a water well. The third attempt resulted in the loss of nearly all the tools in the field at a depth of about 500 feet. It was not until October, 1905 that a strike was made which seemed to assure success. The company had found the work so heavy that they began the use of the standard drilling outfit and carried their fourth well to a depth of 860 feet where a flow of 6,000,000 cubic feet of gas was struck. Deeper drilling developed a pay of oil, and an attempt was made to take the gas off through an eight inch casing and the oil through a four inch tubing, but the casing was not down to the gas sand and the shale caved and stopped the flow of gas. In 1906 it was discovered in the sixth well drilled in the pool, that there were two pays, one of gas, the other of oil, separated by a few feet of shale, the oil being below. Since that discovery many of the wells have been finished as combination oil and gas wells. In such the gas is taken from the higher sand through the outside casing while the oil is procured through a smaller casing or tubing.

The paying production both of oil and gas comes from a depth of 860 to 1,000 feet, depending, it appears, on the present surface irregularities and the unevenness of the old pre-Permian land surface upon which the Redbeds lie. Some of the wells produce gas only, and others oil alone, but as a rule both gas and oil are encountered and occasionally one or the other is present in appreciable amounts in every sandstone penetrated by the drill. Although the Santa Fe Company has completed a considerable number of wells in the field, only a few in the immediate area have been dry. Production in gas has ranged from three and three-fourths million cubic feet per day to 13,500,000 cubic feet, while oil tests have shown from 5 to 68 barrels per day of a heavy black asphaltic oil from 20° to 23° Baume.

For some time the marketing of oil was not attempted as the amount available did not warrant the construction of transportation facilities. Two of the wells were put to a pumping test for one year and were found to produce as much oil on the last day as on the first. This seems to be a remarkable showing for wells of heavy oil, and probably indicates a long life for the field.

Two deep wells have been drilled in the field—one to 2,427 feet, the other to nearly 4,000 feet, but no pay was found below the 1,000-foot sand. The records indicate that the horizon of the Redbeds is passed at from 860 to 1,000 feet and the Pennsylvanian entered. From the vast thickness of shale and limestone recorded and the difficulty of keeping the hole straight, the formations seem to be dipping at high angles.

Other companies have taken leases surrounding the field and from time to time have drilled wells, but none have developed paying properties, either in oil or gas.

PROBABLE SOURCES OF THE OIL.

The conditions under which the oil or gas, or both, occur at Granite, Gotebo, Lawton, Hope, and Wheeler seem to be similar in all essential respects; that is, they occur near the base of the Redbeds close to the unconformity between the Permian rocks and the older Paleozoic formations, so that what is said concerning the source of supply of the Wheeler oil is equally applicable to the other four mentioned.

The Redbeds formations contain asphaltic bitumen in the Wheeler field, and at numerous places in nearly every direction from the developed area. The same is true in northern Texas in the region of Petrolia and Wichita Falls. So far as has yet been determined the Redbeds are at least several hundred feet thick at all places where these asphaltic deposits occur, and since the high state of oxidation in the Redbeds is due to the absence of organic matter at the time of formation of the rocks it does not seem possible that the oil and gas could have originated within the Redbeds.

In Carter, Jefferson, and Love counties, Okla., and in that portion of Texas immediately south, thick deposits of Pennsylvanian rocks that contain either oil or oil residuum (asphalt) where exposed, pass under the Permian Redbeds. In Oklahoma the Pennsylvanian beds are so tilted and broken that the Permian formations lie in immediate contact with their upturned edges. If those Carboniferous rocks which lie buried had remained exposed there would now be nothing left but the heavy non-volatile residuum; but since the Permian rocks were deposited before the petroliferous strata of the older rocks had been exposed long enough for the volatile oils to escape they had a tendency to seal up the leaks. Deposition, however, is slow, so that the petroleum and gas became disseminated through the strata. Furthermore there is no reason to believe that transportation of the hydrocarbons from one formation to the other should cease with deposition, especially when the deposited members are as porous as the Redbeds. Thus, in the course of time, any oil in the Carboniferous beds below the Permian would be conveyed upward and would either collect in the Redbeds or escape through them. It seems that for a long period of time the latter was true in the Wheeler field for, it contains one of the largest deposits of brea known in the United States, and even yet gas is escaping on the SW. 1/4 SE. 1/4 sec. 21, about three quarters of a mile southwest of the place where the first well was drilled. In the light of present data the underlying Paleozoic rocks seem to be the only reasonable source from which the Wheeler Oil and gas could have come.

Owing to the fact that deep drilling has failed to locate the source of supply in the Pennsylvanian rocks immediately below the Wheeler field, it is suggested that the oil and gas may have been transported along the line of unconformity and the original deposit may be encountered at greater depths at some other place in the general region. There are, however, no data at present available on which to base this probability.

SUMMARY.

About 125 wells have been drilled in the general region about the Wheeler field and Oil City. Eighty or more of these have produced oil or gas in paying quantities. Between forty and fifty wells have been drilled in the immediate area of production here and in the surrounding sections, and have proved dry, or at least of such small consequence that the drillings were abandoned and classed as dry holes.

The trend of the producing area is in a northwest-southeast direction,

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The history of the early development and the discussion concerning the origin of the oil is from Okla. Geol. Survey Bull. No. 2 by L. L. Hutchison, 1911, pp. 245 and 250.

beginning in the northeast 1/4 of sec. 17 and extending to the center of sec. 35; the greatest amount of development and the best production being in the S. 1/2 of sec. 11, E. 1/2 of sec. 21, and SW. 1/4 of sec. 22. Very few of the scattering wells have given much encouragement to miscellaneous prospecting. However, most of the scattering drillings have been shallow, and little or no attention was given to geologic conditions.

As above stated, the oil found in this region is of a heavy grade and has been used chiefly as a fuel oil. It is not probable that the immediate region will give additional production which will be much greater than the production at the present time.

A pipe line was laid from the Wheeler field to Ardmore several years ago, and the oil was transported through this line to railroad cars at loading racks. Gas was also supplied to Ardmore. After the discovery of the Healdton field a line was run from this field to connect with the line from Wheeler, and oil from both places was transported through the line.

HEALDTON FIELD.

LOCATION.

The Healdton oil and gas field is located in the western part of Carter County, bordering Jefferson and Stephens counties. The principal part of the field lies in the central part of the N. 1/2 of T. 4 S., R. 3 W., and the south side of secs. 31, 32, and 33, T. 3 S., R. 3 W., and the SE. 1/4 of sec. 36, T. 3 S., R. 4 W. The field was named from the village of Healdton, a few miles east of the location of the first well drilled in the area.

Since the opening of the field Healdton has made some growth and the new towns of Dundee and Wirt (Ragtown) sprang up and soon grew to have a population of a thousand or more each. Ringling and Wilson are the nearest railroad towns, each of these towns being about 5 miles distant from the field. Both of these towns owe their origin to the discovery of the oil field and the building of the Oklahoma, New Mexico & Pacific Railroad from Ardmore to Ringling. The Healdton field is 20 miles west and a little north of Ardmore, and 25 miles east and a little north of Waurika. When development first began in the field and for several months afterwards it was necessary to haul all material from Ardmore by teams. Since the completion of the new line of railroad the material is supplied from Wilson and Ringling.

TOPOGRAPHY.

The Healdton field lies within the physiographic province known as the Redbeds Plains. This area consists of sands, soft sandstones, and shale which produce a rolling surface. The elevation ranges from about 850 to 1,000 feet above sea level.

The area is drained by the east fork of Mud Creek, on the west; by Walnut Creek, on the east; and Simon Creek to the south.

GEOLOGY.

The general geologic conditions have been discussed in the preceeding pages. However, further details of the geology and stratigraphy are given in this connection. This information is in part the result of field work of the Oklahoma Geological Survey, and in part of the United States Geological Survey.

Geological work was begun in the region by the Oklahoma Geological Survey in September, 1913, directly after the drilling of the first well in the region. Work was done in the general region and south to Red River. Further work was carried on during 1914. The results of the field work of the State Survey were not published in bulletin form, but were given to the public through short articles in the newspapers and from the offices of the Survey in such a manner as seemed best suited to the occasion.

In 1913 a field party in charge of Carroll H. Wegemann, doing cooperative work between the Oklahoma Geological Survey and the United States Geological Survey in the Loco district and adjoining territory, also did some preliminary work in the Healdton field. During 1914 Mr. Wegemann and assistants carried on work for the Federal Survey making a detailed study of the region, and the results of the work were published as United States Geological Survey Bulletin No. 621-B.

A considerable part of this report* is quoted in the following pages.

STRATIGRAPHY.

The surface rocks in the Healdton field consist of alternating beds of red and gray shale, brown, white, and red sandstone, and thin beds of conglomerate the pebbles of which are principally quartz. They belong to the series of strata known as the "Red beds" and are of Permian age. The precise nature of the conditions under which the Permian beds were formed is not clear. To the south, in Texas, they were put down, in part at least, in an ocean, as is shown by the presence of limestones which bear marine shells; but farther north, in the area under discussion, which lay nearer to the old shore line, the conditions of sedimentation appear to have been rather fluviatile or estuarine. The beds are at least in part of fresh-water origin. The bones of animals that were probably land forms are found among them, and plant remains occur at certain localities.

Some of the sandstone beds are very irregular in thickness and are replaced laterally by shale, but others, such as the sandstone that forms the escarpment in the Duncan gas field, 20 miles north of Healdton, can be traced for 50 to 75 miles, showing that they must have been put down under conditions which allowed considerable regularity of deposition. How-

*Wegemann, C. H. and Heald, K. C., The Healdton oil field, Carter County, Oklahoma, Bulletin U. S. Geol. Survey No. 621-B, 1915, pages 14-22.

ever, although certain groups of sandy beds persist over great areas, the individual beds of sandstone that compose the groups are in themselves irregular. The broad extent of such deposits does not preclude the possibility of their deposition by rivers.

The origin of the red color of certain of the Permian beds is a question that has been much discussed. It seems probable that the red color of the beds does not necessarily imply aridity of climate during their deposition. That the beds were red when originally deposited is presumably to be conceded, although it must be admitted that in certain beds the red color has been changed to blue or bluish gray, and vice versa. At the present day red soils are formed as a rule in warm, moist climates, where vegetation is abundant and surface weathering deep, and it seems reasonable to suppose that similar conditions of climate and weathering prevailed at the time of the formation of the "Red Beds," at least in the region from which the sediments were derived. If, however, vegetation had been abundant in the waters in which the red sediments were deposited, it is probable that the carbonaceous matter would have acted as a deoxidizing agent, changing the color of the sediments with which it was mingled from red to blue. The whole problem of the deposition of the "Red Beds" is not well understood.

The red color of the Permian extends to depths of 200 to 300 feet below the surface on the Healdton dome, but, as is abundantly proved by the logs of the wells, the lower limit of the red color is by no means at a constant horizon. Shale beds which are in one well blue are in another red, and vice versa, the color changing from place to place.

How many feet of Permian beds have been removed by erosion from this area can only be surmised. In the present work the general relations of the strata at Healdton and those in the Loco, Duncan, and Lawton fiields have been determined with a fair degree of certainty, and if, as stated by Taff,* the highest peaks of the Wichita Mountains were in all probability never covered by the Permian sea, there must have been less than 1,500 feet of Permian beds removed by erosion in the Lawton area. The rocks at the surface in the productive area at Lawton are probably about 500 feet stratigraphically above those at the surface in the Healdton field. It may be inferred, therefore, that from 1,500 to 2,000 feet of Permian beds have been removed by erosion from the central part of the Healdton dome, and as the plain on the crest of the Arbuckle Mountains, which was formed in pre-Cretaceous time, is only 400 feet higher than the surface at Healdton, it is evident that the greater part of the erosion of the Permian was accomplished prior to the Cretaceous period. As is shown in what follows, the Permian probably extends to a depth of 800 or 900 feet below the surface

*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, pp. 74-75, 1904.

in the Healdton field, so that the thickness of the formation as originally deposited was probably about 2,500 feet.

As exposed along the Arbuckle Mountains, the contact of the Permian with the underlying beds is unconformable, the flat-lying Permian strata overlapping the edges of the steeply dipping Ordovician, Devonian, and Carboniferous rocks.*

Similar unconformable relations prevail along the Wichita Mountains, and there is evidence that the older rocks were rather deeply trenched by erosion before the Permian was deposited over them. The unconformity appears to be comparatively local in extent and to owe its origin to the Wichita-Arbuckle uplift, inasmuch as it does not appear in Clay County, Tex., where the contact of the Permian and the underlying Pennsylvanian is exposed. In the Texas region the Cisco, which is the uppermost formation of the Pennsylvanian, is as far as appearances go, conformable with the Wichita, the lowest formation of the Permian, and it is, in fact, difficult to recognize the boundary between the two formations.** In the region between Clay County and the Wichita-Arbuckle uplift the base of the Permian is nowhere exposed.

In the Healdton field, which is about 12 miles distant from the Arbuckle Mountains, the well logs afford considerable evidence that the unconformity so conspicuous along the mountains is present. Limestone is practically absent from the first 800 or 900 feet of strata below the surface, but at greater depth in certain wells thick beds of limestone are encountered. The sandstone beds in the non limestone-bearing series can be correlated from well to well throughout the field by making due allowance for errors in recording the strata passed through in drilling. No break or unconformity in the series is apparent. Where, however, thick beds of limestone are encountered they appear to be at different horizons in different wells and bear no definite relation to the sandstone beds, as if separated from them by unconformity. Under these conditions it appears reasonable to assume that the shale and sandstone beds predominantly red near the surface and gray or blue at depth, are of one age, the Permian, and that the thick limestone beds below, which alternate with light or dark gray shales and which seem to be separated from the overlying series by an unconformity, are older and presumably of Pennsylvanian age. The principal oil and gas bearing beds are, according to the above classification, near the base of the Permian.

A tentative correlation between the strata of the Healdton and Loco fields seems to show that the gas-bearing sands at Loco are several hundred feet stratigraphically above the oil sands at Healdton. The facts on which this correlation is based are as follows: A little east of the center of sec. 21, T. 4 S., R. 3 W., is an outcrop of asphaltic sandstone similar in character

*Taff, J. A., op. cit., p. 72.

**Gordon, C. H., Geology and underground waters of the Wichita region, north-central Texas: U. S. Geol. Survey Water-Supply Paper 317, p. 19, 1913.

to a rock which is exposed at numerous places in the Loco field, particularly in sec. 25, T. 3 S., R. 5 W., where it was at one time mined. The probable equivalent of the sandstone in sec. 25 is encountered at a depth of 40 feet in well No. 4 of the Oklahoma Diamond Oil & Gas Co., drilled in the SE. 1-4 sec. 10, T. 3 S., R. 5 W. A comparison of the log of this well with that of well No. 1, drilled by the Red River Oil Co. on the Clydie Ingram farm, a little over half a mile west of the outcrop of asphaltic sandstone in sec. 21, T. 4 S., R. 3 W., shows considerable similarity, and it therefore appears possible that the asphaltic sandstone in sec. 21, T. 4 S., R. 3 W., represents the same bed that is exposed in the Loco field. This sandstone seems to have been encountered at a depth of 12 feet in the Clydie Ingram well.

The Clydie Ingram well is a dry hole, almost 2 miles southwest of the productive area at Healdton, and it is impossible to make accurate correlations between it and the Healdton wells. It seems probable, however, from a comparison of the logs, the known dip of the rocks from the Healdton dome toward the well in sec. 21 being taken into account, that the probable equivalent of one of the gas-bearing strata in the Loco field which was encountered in the Ingram well at 670 feet lies within 100 or 200 feet of the surface on the crest of the Healdton fold.

A general correlation of the beds exposed in the Healdton field with those appearing at the surface near Loco and also in the Duncan and Lawton fields may be made on the basis of a series of sandstones that constitute the surface rocks in the sandy wooded area northeast of the Healdton field. The same beds are found southwest of the field, where also they are timber covered. They appear to be the same as the sandstone beds that constitute the surface rocks from Loco north to the grahamite mines in sec. 6, T. 2 S., R. 4 W., and form the timbered ridge which runs from the vicinity of the grahamite mines northwestward to a point 4 miles southeast of the Duncan gas wells. It appears probable that the sandstone hills that lie just east of the Lawton oil and gas field are formed by this same sandstone, inasmuch as the next higher ridge-forming sandstone in the Lawton region is the same as the sandstone which forms the escarpment or rim rock of the Duncan gas field and which is the first prominent bed above the timbered sandstone series of the grahamite mines.

Except for a few plant remains the Permian beds in the Healdton field are unfossiliferous. Two small collections of leaves were obtained. They have been examined by David White, and his descriptions are given below.

SE. 1/4 SW. 1/4 sec. 4, T. 4 S., R. 3 W. Surface fragment of ferruginous sandstone containing plant remains. The fragment is filled with miscellaneous drifted and waterworn plant vestiges, many of which are small fragments belonging perhaps to the genus Walchia. Obscure remains of seeds are also present. This rock does not appear to contain conclusive evidence as to its age, though it is probably Paleozoic.

A number of small fragments obtained by breaking up a piece of reddish sandstone, rather coarse grained, contain drifted and somewhat waterworn bits of vegetation. The plant debris consists of very small pieces and is mostly so macerated or abraded as to render specific identification impossible.

The material includes fragments of a lobed pinnule which, from its form and nervation, probably belongs to Callipteris, a distinctly Permian genus. Several fragments of gymnospermous twigs apparently represent a species of Walchia, nearly related to if not identical with *Walchia gracilis* Daws. A very small fernlike fragment, with decurrent lamina, may be either Callipteris or Pecopteris. A peculiar fragment of a scale probably belongs to a fructification found in the Permian of the Southwest. It is very closely related to Noeggerathia. Two specimens containing portions of neuropteroid pinnules are comparable to *Neuropteris gleichenioides*. Portions of two seeds are recognized, one of them being probably referable to the genus Cardiocarpon.

There is scarcely room for doubt as to the Paleozoic age of the sandstone which contains this material, and, notwithstanding the extremely fragmentary character of the debris and the very small number of specimens, I do not hesitate to regard the beds as Paleozoic. The specific evidence indicates that the sandstone is probably Permian.

Two other fragments of sandstone accompany the collection just described. The larger fragment is strewn with comminuted plant debris, none of which is generically determinable, although it is probable that a number of megaspores are present. The small fragment contains a seed of the type referred to the genus Walchia. This seed is evidence of the Permian or latest Pennsylvanian age of the bed from which the specimens were obtained.

Fragments of sandstone the grains of which are cemented with chalcedony were seen at several places on the northwest flank of the Healdton dome. This sandstone resembles in every respect certain beds that are found in the Trinity sand, of Cretaceous age, where that formation is exposed along Red River, about 30 miles south of the Healdton field. Nowhere in Healdton was this sandstone noted in place, but about halfway between Hewitt and Ardmore numerous blocks of it were found on a wooded knoll just north of the road. The blocks are only 4 or 5 inches in thickness and appear to be practically in place. The underlying shale is oxidized for a depth of about 2 feet, being rusty brown in color. It is possible that this sandstone is in reality of Cretaceous age and is the last remnant of a comparatively thin sheet of Cretaceous beds which were at one time spread over this country.

It is believed that prior to the deposition of the Cretaceous strata the land areas were reduced by erosion almost to a plain, which is now represented by the flat surface forming the crest of the Arbuckle Mountains. The sandstone outcrop on the Hewitt-Ardmore road, above mentioned, is about 200 feet below this plain on the Arbuckle Mountains, so that if these beds are in reality Cretaceous the plain must have been somewhat irregular in order to allow their deposition at a level considerably lower than that of the mountain area. The supposition that the beds are Cretaceous is supported only by lithologic similarity, which, however, in a rock of so peculiar a character should have considerable weight.

GEOLOGIC HISTORY.

As is evident from the nature of the Paleozoic rocks exposed in the Arbuckle Mountain uplift, conditions of sedimentation were almost continuous from the Cambrian to the close of the Mississippian. Slight oscillations of the sea floor probably took place, but were not of sufficient magnitude to produce any pronounced unconformity. At the close of Mississippian time an uplift of the mountain mass now represented by the Arbuckle Mountains occurred and a great lens of conglomerate of Pennsylvanian age, known as the Franks conglomerate, was laid down. Marine conditions were re-established and continued during Pennsylvanian time, at the close of which the mountains were again uplifted and their surface was eroded into deep valleys. Once more the land subsided and was submerged, and the Permian deposits were laid down on this irregular surface.

At the close of the Permian epoch the whole region was uplifted with comparatively little folding, and apparently it remained a land area through Triassic and Jurassic time, the surface being reduced by erosion to a lowlying, comparatively level plain in which hard and soft rocks alike were removed and brought to one general level. At the beginning of the Cretaceous period this broad flat plain was tilted toward the southeast and the Cretaceous sea advanced upon it, spreading its deposits of sand, shale, and limestone over what had formerly been land. As the southeastern part of the plain subsided the northwestern part of it rose, and when conditions of stability were restored and erosion continued to act upon that part of the surface which remained above the ocean, the softer rocks of the ancient plain were reduced to lower levels, leaving the harder rocks, such as those that form the Arbuckle uplift, rising above the newly formed surface and preserving in their flat summits the former base-level. Erosion continued until a new plain was formed, and this plain is the notable feature of the present physiography of the greater part of Oklahoma. Over the surface of this plain rivers deposited thin sheets of gravel, and it is stated by Taff* that these gravel deposits, which lie in terraces along the courses of the present rivers, may be traced southeastward into the Tertiary area, where they merge with the Tertiary gravels of the Coastal Plain, showing that the gravel deposits and the ancient plain on which they were formed are probably of Tertiary age. The correlation of the gravel deposit of the plain with those of the coastal sediments may, however, be open to question, and the formation of the plain may be more recent than Tertiary. Since the formation of this plain a slight uplift of the region has occurred, and now the rivers are once more cutting their valleys below the plain which they formerly made. This cycle of erosion has not progressed far, and the new base-level that is slowly being formed is represented only by the flood plains of the larger streams.

*Taff, J. A., op. cit., p. 17.

INFORMATION AFFORDED BY WELL LOGS AND METHODS OF FIELD WORK

In an oil field like that of Healdton, in which exposures of rock are very few, the outline of the structure must be determined in large measure from the data afforded by the logs of the wells drilled in the field. A clear appreciation of the nature of the data afforded by well logs is necessary in order to understand the degree of accuracy of the statements which follow and of the structure as outlined on the accompanying map.

In deep wells depths as usually measured are, because of the stretching of the drilling cable, accurate only within 5 or 6 feet. The change from shale to sandstone is not necessarily abrupt, and the sandstone may not be recognized until it has been penetrated for several feet. Very fine grained sandstone is easily mistaken for shale by one who is not accustomed to distinguish between the two, and certain drillers habitually call fine-grained sandstone shale or slate. Hard sandstone may be referred to as "lime," and limestone, if it is oil bearing, is sometimes mistaken for sandstone. Alternating beds of sandstone and shale may be regarded as unbroken sandstone. Certain drillers note only those sandstones that carry water, oil, or gas, and, as a consequence, the thickness of sandstone beds is often underestimated. In these circumstances accurate correlations between the strata recorded in the logs of adjacent wells are difficult, and sometimes impossible, but by a careful comparison of all the logs available in a given field, it is usually possible to determine what beds are continuous over the area and to decide which of the records are inaccurate. Where exact correlation between wells is impossible, the geologist must rely on his judgment in representing the form of structure that is most likely to exist, and his results are of course subject to error.

In the field work the locations and elevations of all wells in the field were determined by means of a plane table and telescopic alidade.

STRUCTURE.

The principal production of the Healdton field and adjoining pools comes from underlying Pennsylvanian rocks. What the structural conditions of these rocks are cannot be stated in advance of drilling. Some of the production is in the Permian Redbeds, but it is very probable that any oil or gas here encountered has migrated into the rocks from the underlying Pennsylvanian. The surface conditions in the Healdton area are such that the working out of the structure in advance of drilling was very difficult and uncertain. However, some structural features are evident throughout this general region. The streams are chiefly synclinal. The larger streams, such as Mud Creek, Walnut Creek, and Simon Creek, lie in the major synclines, and many of the small streams lie in minor basins or synclines, and, in fact, a few of the small streams are anticlinal. Thus the divides are more or less in the nature of anticlines, producing structural features which extend in some cases for several miles, but it is only on the highest structural points that production is encountered. On account of the scarcity of rocks outcrops it is very difficult to determine these highest points. In a few places conditions are such that certain sandstone outcrops may be taken as key rocks for the working out of definite structure. However, the structure which has been mapped by different persons doing work in the Healdton field has been chiefly upon information furnished by the logs of wells drilled. After a few wells had been drilled it was possible for the geologist to determine the trend of the underground structure and thus give considerable aid to the prospector. In United States Geological Survey Bulletin No. 621-B. previously referred to, Wegemann has made use of a sterogram which shows in an excellent manner the nature of the principal folds with the superimposed minor folds.

The following paragraphs* give further detailed information concerning structural features of the area.

The accumulation of oil at Healdton is situated on an irregular structural dome or anticline about 4 1-2 miles in length by 2 miles in breadth, the long axis trending N. 62° W. The presence of the dome is not indicated by the topography. Superimposed on the fold are twelve or thirteen minor folds, the long axes of which appear to trend in general at right angles to the trend of the major fold. In the east half of the dome there are among the minor folds at least two oval depressions, which may be considered to be the reverse of the minor dome structures.

The extreme difference of elevation in the main dome, indicated by the altitude of the oil sands on its flanks and on the highest of the minor domes, amounts to about 400 feet, but the height of the entire dome, could it be measured at a greater distance from its central part, is probably considerably more than this. The amount of dip in different parts of the field varies greatly, ranging from 100 to 400 feet in a mile.

Near the corner of secs. 4, 5, 8, and 9, T. 4 S., R. 3 W., a fault trending in general parallel to the long axis of the major dome appears to be present. Its downthrow is to the north. It is possible that this structure may be an abrupt fold rather than a fault, but from the relations of the strata recorded in wells on both sides of it, as well as from the presence of the dry hole in the SE. ¼ SW. ¼ SE. ¼ sec. 5, the presence of a true fault is regarded as very probable. The abrupt fold shown in the south-central part of sec. 32 may be a fault rather than a fold and this probability is strengthened by the presence of two dry holes in the NW. ¼ NE.¼ sec. 5.

As has already been stated, the Healdton pool lies about 12 miles southwest of the west end of the Arbuckle Mountain uplift. At a distance of 65 miles N. 72° W. from the Arbuckle Mountains lies the Wichita Mountain uplift, which is believed to be of the same age. Between these two uplifts the Permian beds are bent into a broad, low arch which is outlined on its north side by an escarpment of sandstone. This escarpment may be traced from a point north of Foster post office, which is northwest of the Arbuckle Mountains, to the Duncan gas field, thence north of the town of Duncan in

*Wegemann, C. H., and Heald, K. C., Op. cit., pp. 22-26.

a northwesterly direction to the north flank of the Wichita Mountains. The position of the south limb of the low arch between the two mountain uplifts has never been determined, as the rock exposures in the broad plains of this region are very few.

About 10 miles northwest of the Healdton dome is the Loco gas field, and 15 miles north and a little west of Loco is the gas field known as the Duncan field, which lies 10 miles northeast of the town of Duncan. The three fields lie along a curve which appears to encircle the west end of the Arbuckle Mountains, forming, so to speak, a cross fold to the low arch which lies between the Arbuckle and Wichita uplifts. It is not meant to imply that the Healdton, Loco, and Duncan fields are situated on one long anticline. They are in fact three separate domes, but they lie in such a relation to one another as to suggest that they are more intimately connected in origin with the Arbuckle uplift than with the Wichita. The Duncan field lies north of the low arch between the two mountain uplifts, and the Loco and Healdton fields lie south of it.

Midway between the Healdton field and the Arbuckle Mountains is the dome or anticline on which is situated the Wheeler oil field, the axis of which appears to parallel that of the Healdton dome.* About 30 miles west and 8 miles south of the Healdton dome is an anticline exposed in the east bank of Red River, about 6 miles southwest of Waurika.** This structure is an alignment with the Devol anticline mapped and described by Munn*** in the Grandfield district, farther west. The axis of this fold lies about 30 miles south of the Wichita Mountains and is in general parallel to the axis of that uplift. South of the line of the Devol anticline and the anticline which lies southwest of Waurika are the Burkburnett and Petrolia oil and gas fields, which are situated on domal or anticlinal structures.

It is apparent, therefore, on considering the structure of this general region as a whole, that the Permian beds have been thrown into a series of waves or undulations such as might have been caused by stresses acting between the rigid mass of the Arbuckle and Wichita mountains and the strata of the plains region. That subsequent stresses have acted in directions oblique or at right angles to those which produced the major folds is indicated by the relations of the axes of minor domes, such as those which occur in the Healdton field, to the axes of the larger structures on which they are superimposed. It is possible that the time of the formation of the folds that are now occupied by oil and gas pools was coincident with the uplift of the region which followed the formation of the supposed Tertiary plain. In Cotton County, southwest of the Healdton field, the

*Snider, L. C., Petroleum and natural gas in Oklahoma, p. 144, 1913.

**Wegemann, C. H., Anticlinal structure in parts of Cotton and Jefferson counties, Okla.: U. S. Geol. Survey Bull. 602, pl. 5, 1915.

***Munn, M. J., Reconnaissance of the Grandfield district, Okla.: U. S. Geol. Survey Bull. 547, 1914.

adjustment of the minor streams to folds is very exact, and it is probable that the time of folding has been comparatively recent.*

OCCURRENCE OF OIL AND GAS.

Oil and gas in the Healdton field are found in many sandstone strata of the "Red Beds," but the principal deposits from which they are obtained lie in three or more sandstone beds which form, together with the interbedded shale, an oil-bearing zone about 250 feet in thickness. The top of this zone is found from 600 to 950 feet below the surface. In general the highest of the sandstone beds is the gas-bearing sand, although gas occurs in considerable amount in the lower sands, and the gas sand in certain wells produces a considerable amount of oil. From this sand also, on the flanks of the fold, below the oil and gas horizon, salt water is reported. The next sand below the gas sand is that on the surface of which the structure contours of the map are drawn. The oil in this sand is often, though not invariably, lighter than that of the lowest sand. This lowest oil sand is not reached in all the wells but appears to be as rich in oil as the second. Certain wells that have been drilled to considerable depths have encountered below this sand thick beds of limestone which alternate with dark shale, and which are probably of Pennsylvanian age.

Oil, when found in the beds above the principal oil and gas zone, is of high specific gravity, containing considerable amounts of asphalt. Salt water is rarely, if ever, recorded from the strata above the principal oil-bearing zone, but it is found in the strata of that zone on the flanks of the fold below the oil pool, and in some wells—as, for example, Woodward No. 4 of the 1911 Oil Co., in sec. 32, T. 3 S., R. 3 W.—it is reported from strata below those which carry the oil.

The lower limit of the oil pool is by no means at the same elevation with reference to sea level on all sides of the dome. In the SE. ¼ SE. ¼ sec. 36, T. 3 S., R. 4 W., oil is encountered at sea level, and in the SE. ¼ SE. ¼ sec. 6, T. 4 S., R. 3 W., the oil-bearing zone was found barren at 190 feet above sea level. In the shallowest part of the Healdton pool on the crest of the dome, oil is obtained at 380 feet above sea level, or 600 feet below the surface. The wells which show the greatest quantity of gas are, as a rule, situated on the crests of the minor domes. This does not appear to be true of the wells just northeast of the center of sec. 5. It should be stated, however, that logs of the Wrightsman and Foster wells, just northeast of the wells mentioned, were not obtained, so that the details of the structure in this particular area are not known and the mapping may be somewhat inaccurate.

The general character and fractional composition of the Healdton crude oils are indicated in the accompanying tables, which are extracted from a report on "Conditions in the Healdton oil field," submitted by Jos. E. Davies, Commissioner of Corporations, to the Department of Commerce, March 15,

*Wegemann, C. H., op. cit., p. 34.

and published by the department under that date. According to this report the Healdton oils range in gravity from 29.27° to 33.93° Baume. The variation does not appear to have any direct relation to the structure. Oils of different gravity that are obtained from adjacent wells come, as a rule, from different sands. In general, the oil in the Healdton pool is darker in color than oil of the same gravity in other fields.

The largest production from single wells, amounting in one well to 5,700 barrels a day, is obtained on the minor dome in the N. ½ sec. 6, T. 4 S., R. 3 W. This dome is not the highest one in the field, but it appears to be one of the most regular, and the question may here arise as to whether the more intense folding that has taken place in certain parts of the Healdton dome has tended to close the pores between the sand grains, making the sands less porous and reducing their capacity to hold oil. The two dry holes in the NW. ¼ NE. ¼ sec. 5, T. 4 S., R. 3 W., may perhaps be accounted for in this manner or on the possibility of a fault existing at this locality. The dry hole in the SW. ¼ SE. ¼ sec. 5 is probably due to the presence of the fault indicated. A fault of this nature may interrupt an oil-bearing bed, causing an accumulation on one side of the fault, whereas the beds on the opposite side are left barren of oil.

SOURCE OF THE OIL.

The oil in the Healdton field has probably been derived from the Pennsylvanian rocks underlying the Permian, near the base of which the oil is found. There is, however, no direct proof of this assumption. It is usually admitted that the Pennsylvanian beds, which contain more plant and animal remains than the beds of the Permian are the more probable source of oil, and in the great fields of northern Oklahoma the oil is obtained from Pennsylvanian strata. It is therefore usually assumed that oil found in the beds of the Permian has been derived from the underlying Pennsylvanian.

East of the Arbuckle Mountains beds of Ordovician age are known to be asphalt-bearing in the vicinity of Atoka*. The asphalt deposits formerly mined near Woodford, 10 miles northeast of the Healdton field, however, occur in Carboniferous strata. It seems probable that the limestones underlying the Permian in the Healdton field are of Pennsylvanian age, inasmuch as the strata occupying a similar position in the Loco field have yielded Pennsylvanian fossils in the drill cuttings from the gas wells; yet there is a remote possibility that the limestone beds in the Healdton field may be older than Pennsylvanian and perhaps Ordovician.

If, as is believed by some authorities, the formation of petroleum from plant or animal remains is due to the action of bacteria, it is evident that the transformation to petroleum must take place soon after the deposition of the sediment. If the folding which produced such structure as

*Taff, J. A., Grahamite deposits of southeastern Oklahoma: U. S. Geol. Survey Bull. 380, p. 296, 1909.

that of the Healdton dome has taken place in compartively recent time, it is evident that the oil, the accumulation of which is undoubtedly due to the presence of the rock folds, has been collected in its present position since the folding, or at a time long after the formation of the oil. It must then have existed through the ages as minute globules scattered through the Pennsylvanian rocks, or collected in some fold of the Pennsylvanian from which, after subsequent erosion, deposition of the overlying beds, and folding, it migrated into the strata of the Permian.

To the writers it seems more probable that the organic compounds, whether of vegetable or animal origin, from which the oil was eventually formed, existed as minute particles in shale or limestone. Recent microscopic studies by Davis** have demonstrated the presence in the "oil shales" of Colorado of the remains of algae in great numbers, and there appears to be little doubt that the compounds in this shale, which on distillation give petroleum, are derived, in part at least, from these algal remains. The shales of the Carboniferous were probably not so highly impregnated with organic material capable of producing oil as the typical oil shales, yet their mass is so great that even with a comparatively low percentage of organic material they might be capable, under proper conditions of temperature and pressure, of generating vast stores of petroleum. Such conditions may well have been supplied by the earth movements that produced the folds in which the oil accumulated, the organic material in the shale undergoing slow distillation under conditions of high pressure and of the temperatures induced by the pressure. The product of such distillation may have been petroleum, or it may have been gas from which on condensation petroleum was formed. Gas passes through rock pores with little friction as compared with oil, and many accumulations of petroleum which are accounted for with difficulty on the supposition that petroleum as such migrated for considerable distances through the rock strata are easily explained by supposing that the petroleum reached its place of accumulation in the form of gas, which later condensed to petroleum. Whatever the method of formation of the oil and the conditions under which it was collected into pools, it is certain that in such fields as that of Healdton the presence of domal or anticlinal structure in the rock beds has been the controlling factor in determining the place of accumulation.

DEVELOPMENT.

The first well in the Healdton field was drilled by the Red River Oil Co., (Critchlow & Co.), (Dundee Oil Co.), in August, 1913, on the Wirt Franklin farm in the NE 1/4 of sec. 8, T. 4 S., R. 3 W. This was a very fortunate location for the drilling of the "Discovery well." If the location had been that of some of the nearby wells which came in as "dusters," the area would probably not have been discovered until

**Davis, C. A., On the fossil algae of the petroleum-yielding shales of the Green River formation: Science, new ser., vol. 41, No. 1059, Apr. 16, 1915.

a much later date and prospecting might have been discontinued altogether.

The initial production was about 25 barrels per day with a maximum of perhaps 50 barrels. However, the discovery of oil in this section of the State caused great excitement and many people came from all the surrounding country to see the new well. Oil companies and their representatives from all over the country came into the region to secure leases and attempt to obtain nearby locations. The Red River Oil Company drilled another well one-half mile to the northwest of their No. 1, in section 5 on the Mary McClure farm. This well came in for about 300 barrels per day. This meant that active development would commence at once, and before the year had closed there were 14 wells drilled in the region and the production of the field was estimated at 20,000 barrels for the month of December.

Some of the wells brought in were of large capacity, but most of them produced from 100 to 500 barrels.

During the next year much development took place, some wells being drilled in having an initial flow of 5,000 barrels or more.

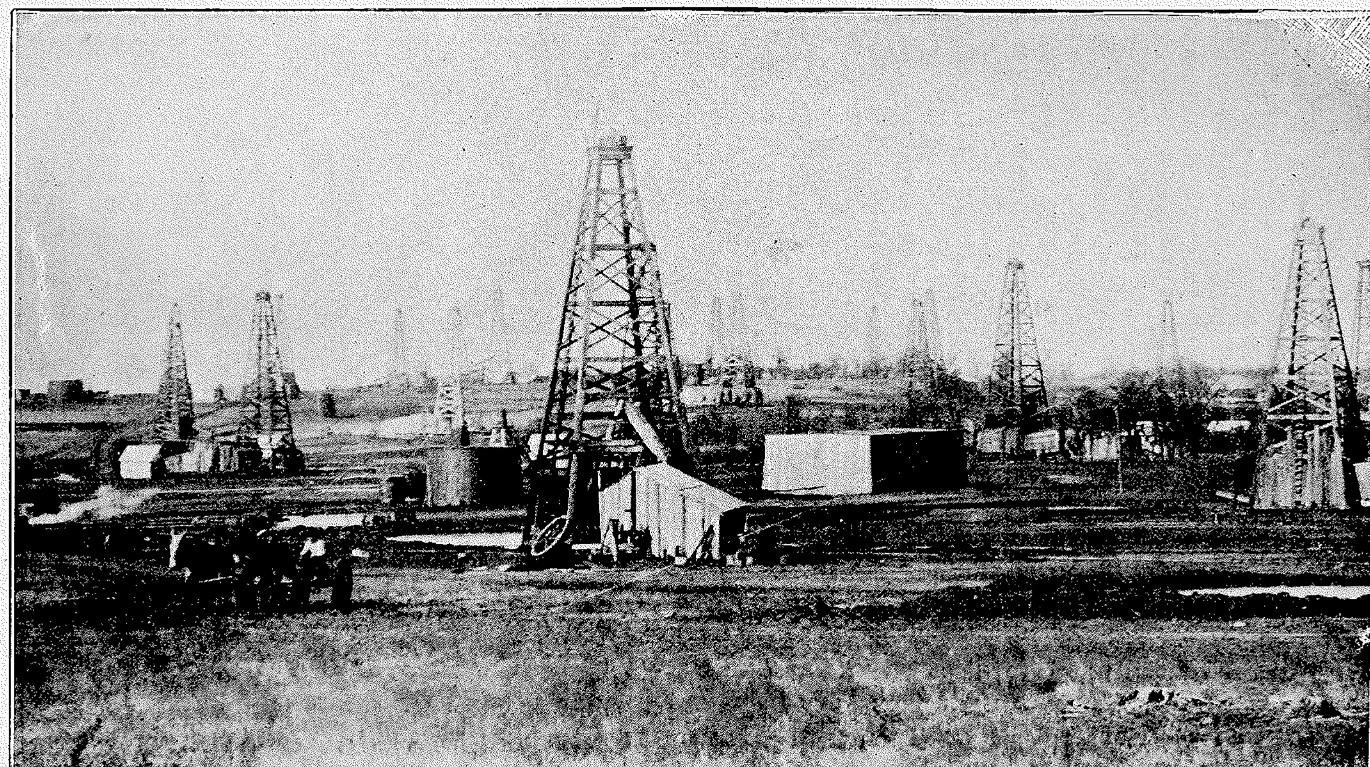
The old town of Cornish, in northeastern Jefferson County was for a while the only town near the area being developed; but after a few months an oil town grew up and was called Ragtown, because of the hastily constructed shacks and tents, but was afterwards called Wirt. This town has been practically destroyed by fire, on two different occasions, the last of which occurred in the fall of 1916. The town is now being rebuilt. The Ringling railroad (Oklahoma, N. Mexico, & Pacific R. R.) was built from Ardmore to a terminus about one mile north of Cornish. A town was platted at this location and in a few months the new town of Ringling had a population of 1,500 people.

The question of handling the oil was of great consequence in the early development of the field. The Magnolia Pipe Line Co. extended a branch line from Bowie, Tex., to the Healdton field, by way of Waurika, but this line was unable to handle the output, and it was necessary for the operators to store their oil in earthen reservoirs and steel tanks.

During the summer of 1914 several tanks were struck by lightning and a large quantity of oil was destroyed. Oil in earthen tanks lost much by evaporation of the gasoline and other volatile constituents, and on account of the heavy rains thousands of barrels of oil were lost by the breaking of the reservoirs. These heavy losses and the depression of the oil market retarded development and much activity did not again take place until about the middle of 1915. Up to this time a total of about 300 wells had been drilled.

The greatest amount of oil stored in the Healdton field was during the latter part of 1915. During this time and the first part of 1916 a large number of tanks were constructed in the field. During October

PLATE X.



SHOWING DEVELOPMENT IN THE HEALDTON FIELD, SEC. 6. T. 4 S., R. 3 W.

1915 there were 300,000 barrels of oil placed in storage and almost twice this amount in November, and a still higher amount was stored in December, so that at the close of the year it was estimated that almost 2,000,000 barrels of oil were in storage. On January 1st, 1915, the average daily production was about 90,000 barrels. At the first of 1916 the daily output of the field was about 75,000 barrels, without much change in the average production for several months. Many of the old wells were falling off, but the new production was about offsetting the decline. The deepest well drilled was the Hapgood well in sec. 21, T. 4 S. R. 3 W., which was abandoned during January as a dry hole at a depth of 2,900 feet. At 2,700 feet a barren sand 65 feet thick was encountered.

The drilling of the Gypsy Oil Company's well to an 1,800 foot gas-sand in sec. 28, T. 2 S., R. 3 W., near Fox, in the latter part of 1915, created a new demand for leases and some of the highest prices in the history of the industry in the State were paid for acreage. This well also stimulated interest in deeper drilling.

At the close of the year 1915, 100 strings of tools were working, and the production was being well maintained.

The principal sources of transportation of oil for the field was by the Producers' Refining Company to Gainesville, Tex., the Sun Oil Co., tank car shipments from Ringling by means of a 4-inch pipe line, and the Magnolia Pipe Line Company, completing its arrangements to carry approximately 50,000 barrels daily. The producing wells drilled in during 1915, yielded from 200 barrels to 1,200 barrels per day.

During 1916 development was very active, especially considering that the decline in price again seriously affected the Healdton field, but the added means of transportation and the market for the oil at the refineries permitted development to go on at a very good rate, so that by the latter part of 1916 there were more than 1,200 producing wells in the Healdton field.

The recent development of importance in the Healdton region is in the S. 1/2 of secs. 13 and 14, and the N. 1/2 of secs. 23 and 24, T. 4 S., R. 3 W. Development is extending to the southeast into T. 4 N., R. 2 W., so that the southeast extension has not been limited. The extent of the field is changing rapidly and any map showing the developed area is soon out of date. The finding of sands at new horizons where sands have not been found heretofore, or, were not productive at the depths expected, indicates that new productive sands are being found, or that the folding is sharper than is supposed and the production occurs farther down the sides of the structure.

FUTURE DEVELOPMENT.

The productive area of the Healdton oil field has already been defined in a general way by the drill, but there still remains much undeveloped territory to be explored. The drilling already done shows that the oil sands are productive in practically all parts of the dome above the 200-foot contour—that is, within the area encircled by it. In this area only one dry hole has been drilled. This was located on the line of a probable fault, and it may reasonably be inferred that when fully explored the entire area outlined by the 200-foot contour will be found productive. Greater gas pressure and consequently higher initial production will probably be encountered near the crests of the subsidiary domes than in the depressions between them.

A most promising place for an extension of the producing territory is in the NW. ¼ SE. ¼ sec. 31, T. 3 S., R. 3 W. A well has already been drilled in the southwest quarter of this 40-acre tract, but the axis of the subsidiary dome on which it is situated extends from the well in a northeasterly direction—how far has not yet been determined.

Similar conditions exist on the subsidiary dome whose highest part lies just north of the center of sec. 6, T. 4 S., R. 3 W., and on which some of the best wells in the field have been put down. The axis of this dome extends in a southwesterly direction from a point just north of the center of sec. 6, but the extent of the structure to the southwest has not been determined. The fact that dry holes were put down in the SE. ¼ SE. ¼ sec. 6, and the SE. ¼ NW. ¼ sec. 7 should not condemn the territory along the axis of this dome southwest of the center of sec. 6. In testing this territory, as well as that in sec. 31, T. 3 S., R. 3 W., wells should be drilled on the anticlinal axis at intervals of one-eighth of a mile, beginning near the productive wells.

Some areas outside of the 200-foot contour have already been proved to be productive territory. The dry hole near the center of the SE. ¼ SE. ¼ sec. 36, T. 3 S., R. 4 W., tends to condemn the territory beyond the productive wells at the northwest end of the pool, but the area east of these wells, although it is outside of the 200-foot contour, will probably prove to be oil producing.

Wells drilled near the east quarter corner of sec. 10, T. 4 S., R. 3 W., are not large but appear to indicate an extension of the pool in that direction, and the territory between them and the main dome to the west probably contains oil.

An extension of the productive territory is to be expected south of the small dome in the SW. ¼ NW. ¼ sec. 10, T. 4 S., R. 3 W., in line with its axis, and this territory may extend as far south as the productive well already drilled in the SW. ¼ SE. ¼ sec. 15. Recent development in the vicinity of this well, however, shows high gas pressure, which may indicate the presence of a subsidiary or separate dome. Should such a dome be present at this distance from the main dome there is a possibility that an oil pool accumulated in it is entirely separate from that of the main dome, in which case part of the territory between it and the main dome is probably barren.

A producing well is located near the northeast corner of sec. 16, T. 4 S.,

R. 3 W., and the territory between it and the small dome half a mile to the northwest appears promising.

At other places around the dome the limits of the oil pool are at present fairly well defined by dry holes. The producing territory will probably be extended for very short distances at many places, but prospecting should be done cautiously by wells drilled comparatively near those already producing.

The oil and gas development in the southern part of sec. 15, T. 4 S., R. 3 W., suggests the possibility of finding other oil pools in the vicinity of the Healdton pool. To judge by the steep dip to the southwest in the S. ½ sec. 8, T. 4 S., R. 3 W., and the dry holes which have been drilled in this locality, the chances of finding oil immediately southwest of the Healdton pool seem to be poor. The territory between the Healdton pool and the asphalt deposits in sec. 32, T. 3 S., R. 4 W., has been by many operators considered as favorable ground for oil prospecting, but the fact that dry holes have been put down in secs. 32 and 36 is against this view. The surface rocks between the northwest end of the Healdton field and the asphalt deposits belong to the sandy series which overlies the beds exposed on the Healdton dome, and the structure in this area is therefore probably synclinal and not favorable to oil accumulation.

In the vicinity of the Healdton field the best chances for the extension of the producing territory or the discovery of new domes appear to be in the areas mentioned above and in the Permian area for a distance of 4 or 5 miles east and southeast of the field. About 8 miles east of the field the older Paleozoic rocks reach the surface and the oil-bearing beds at Healdton are not present, having been removed by erosion.

GAS PRODUCTION.

The Healdton field is not only a large producer of oil, but also of gas. In 1913 only three gas wells were completed, with a total initial capacity of 50,000,000 cubic feet. During the next two years the total initial volume increased to 191,500,000 cubic feet in 1915. During 1915 and 1916 several large gas wells were completed in sec. 15, T. 4 S., R. 3 W. One well completed in this section had an initial volume of 40,000,000 cubic feet. The gas sand was encountered at 1,000 feet. The deepest test in the same section was also a strong gas well encountering two gas sands at 1,057 and 1,115 feet respectively. Several good gas wells were drilled in this section. Most of the wells range from 20,000,000 to 40,000,000 cubic feet.

Another heavy gas producing area is what is known as the Fox district in T. 2 S., R. 3 W. Three gas sands have been encountered at 1,450, 1,795, and 2,000 feet respectively. The Phillips and Franklin test in sec. 29 showed an initial volume of 31,000,000 cubic feet in the 1,450-foot sand, which in this well is 348 feet shallower than encountered in the Gypsy well in sec. 28.

The conservation of the natural gas resources in this field has been successfully carried out. Where commercial quantities of gas have been encountered in wells drilling through the gas horizon the mud process has been used with good results.

The Ardmore Gas Co., which supplies consumers in Ardmore, is the principal gas line carrier. Another gas line supplies the towns of Ringling and Wilson.

There is no question but that the natural gas resources of the Healdton field are large. The development along this line has been retarded on account of lack of pipe lines to markets. Many neighboring towns should take advantage of such excellent opportunities as this field affords. A gas line from this field to Oklahoma City and intervening towns would, no doubt, insure the various villages an abundant supply for many years.

Table showing the number, and estimated initial volume and pressure of gas wells in the Healdton field, 1913-1916, *by years.*

Year.	No. of gas wells.	Initial volume.	Pressure.
1913	3	50,000,000	200-350
1914	9	150,000,000	200-425
1915	14	191,500,000	200-500
1916	5	100,000,000	100-600

K. N. Hapgood, Well No. 13, *sec.* 3, *T.* 4 *S., R.* 3 *W.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Dark rock	10	10	Light sand	35	350
Red rock	35	45	Red rock	10	360
Blue limestone	20	65	Gray sand	5	365
Red rock	47	112	Blue shale	20	385
Light sand	53	165	Lime shell	7	392
Red rock	35	190	Blue soft shale	123	515
Light sand	50	240	Gas sand	25	540
Blue shale	10	250	Red rock	20	395
Red rock	15	265	Blue shale	12	437
Light sand	30	295	Red rock	23	450
Blue shale	25	320	Blue shale	354	804
Red rock	65	385	Light gas sand	4	808
Light soft sand	10	395	Blue shale	9	817
Dark soft soil	5	5	Brown oil sand	20	837
Red rock	165	170	Blue shale	80	917
Light sand	10	180	Light oil sand	8	925
Red rock	45	225	Blue shale	20	945
Light sand	25	250	Oil sand	30	975
Red rock	50	300	Blue shale	24	999
White hard lime	15	315			

Stella Keck, Well No. 11, *sec.* 5, *T.* 4 *S., R.* 3 *W.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Blue soft shale	110	650	Blue shale	50	915
Light sand	50	700	Gray sandy shale	25	940
Light gas sand	20	720	Lime shell	10	950
Blue shale	65	785	Sandy lime	15	965
Gas sand	5	790	Oil sand	50	1,015
Lime shell	30	810	Blue shale	18	1,033
Oil sand	55	865			

W. Davis Well No. 1, *sec.* 6, *T.* 4 *S., R.* 3 *W.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface	10	10	Lime shell	5	760
Red rock	115	125	Mud	10	770
Gas sand	20	145	Gas sand	8	778
Red rock	80	225	Mud	17	795
Gas sand	25	250	Gas sand	10	805
Red rock	50	300	Blue shale	60	865
Gas sand	75	375	Oil sand	5	870
Red rock	15	390	Blue shale	10	880
Oil sand	35	425	Oil sand	35	915
Blue shale	175	600	Shale	5	920
Gas sand	20	620	Lime shell	10	930
Blue shale	115	735	Blue shale	10	940
Lime shell	5	740	Oil sand	237	1,177
Blue shale	15	755			

Apple & Franklin, Well No. 1, *sec.* 8, *T.* 4 *S., R.* 3 *W.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Sand and gravel	3	18	Sand	20	380
Red rock	120	120	Blue shale	246	626
Water sand	30	150	Gas sand (no gas)	8	634
Red rock	70	220	Blue shale	210	844
Water sand	25	245	Oil sand (2 bbl. well at 844)	41	885
Red rock	35	280	Blue shale	46	931
Sand	25	305	Oil sand (oil and gas at 933)	16	947
Red rock	25	330			
Water sand	10	340			
Blue shale	20	260			

Mollie Ingram, Well No. 1, sec. 17, T. 4 S., R. 3 W.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	5	5	Sand and salt water	25	895
Red mud	65	70	Brown shale	105	1,000
Blue mud	20	90	Sand and salt water	30	1,030
Red mud	55	145	Blue slate	20	1,050
Sand and water (s. w.)	15	160	Brown shale	50	1,100
Red shale	10	170	Blue shale	35	1,135
Blue shale	20	190	Sand and salt water	20	1,155
Red shale	35	225	Blue shale	5	1,160
Sand and water (s. w.)	25	250	Red shale	20	1,180
Red shale	24	274	Sand and salt water	25	1,205
Sand and water (s. w.)	26	300	Pink shale	35	1,240
Red shale	15	315	Brown shale	20	1,260
Sand and salt water	45	360	Sand and salt water	12	1,272
Red shale	70	430	Pink shale	8	1,280
Sand and water (s. w.)	45	475	Blue shale	10	1,290
Red shale	81	556	Sand and salt water	10	1,300
Sand and salt water	21	557	Blue shale	22	1,322
Red shale	68	645	Sand and salt water	11	1,333
Sand and salt water;	30	675	Sandy lime	8	1,341
Blue shale	20	695	Dark blue shale	12	1,353
Red shale	65	760	White shale	12	1,365
White shale	15	775	Brown shale	15	1,380
Lime shell	5	780	Sand and salt water	20	1,400
Sand and salt water	65	845	Blue shale	105	1,505
Blue shale	10	855	Sand and salt water	18	1,523
Sand and salt water	10	865	Blue shale	42	1,656
Blue shale	5	870	Sand and salt water	35	1,600

R. V. Newton, Well No. 1, sec. 29, T. 4 S., R. 3 W.

Character of rock.	Thickness.	Depth	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Red clay	30	30	Red rock	22	710
Water sand	5	35	Water sand	20	730
Red rock	95	130	Red rock	70	800
Water sand	5	135	White shale	20	820
Red rock	235	370	Red rock	60	880
Gray slate	90	460	Brown shale	10	890
Water sand	5	465	Red rock	40	930
Red rock	45	510	White shale	20	950
Blue shale	120	630	Red rock	25	975
Water sand	5	635	Water sand	15	990
Blue sand-shale	45	680	Gray slate	13	1,003
Water sand	8	688			

Table showing number of wells, initial, average, and total monthly production for the Healdton field, by months, for 1916.

Month.	Wells completed.				Initial production.		Total oil production.	
	Total.	Oil.	Gas.	Dry.	Total.	Average per well.	Daily average.	Monthly.
					bbls.	bbls.	bbls.	bbls.
January	61	64	1	2	10,110	158.	65,000	2,015,000
February	68	64	1	3	8,410	131.4	53,000	1,537,000
March	95	92	1	2	13,330	144.8	54,000	1,674,000
April	75	74	0	1	9,260	125.1	55,000	1,650,000
May	88	85	1	2	10,985	129.2	60,000	1,860.000
June	69	65	0	4	11,505	177.	62,000	1,860,000
July							50,000	1,550,000
August	34	34	0	0	2,905	885.4	40,000	1,240,000
September	24	23	0	1	2,475	107.6	50,000	1,500,000
October	29	29	0	0	1,820	62.7	60,000	1,860,000
Total	549	530	5	15	71,000	121.2	54,900	16,716,000

Drilling record and production of Healdton field in 1915, by months.

Month.	Wells completed.				Initial production.		Total oil production.	
	Total.	Oil.	Gas.	Dry.	Total.	Average per well.	Daily average.	Monthly.
					bbls	bbls.	bbls.	bbls.
January	12	7	0	5	900	128.5	6,290	194,990
February	3	2	1	0	300	150.	1,070	29,988
March	24	7	6	11	1,955	279.2	1,666	51,646
April	10	7	0	3	1,450	207.1	4,500	135,000
May	7	5	2	0	350	70.	4,516	139,996
June	7	7	0	0	1,215	173.5	7,333	219,990
July	16	14	2	0	3,320	237.1	11,950	370,450
August	22	20	0	2	1,885	94.2	11,200	347,200
September	25	20	1	4	3,685	184.2	20,000	600,000
October	52	48	0	4	22,175	461.9	25,750	798,250
November	61	59	1	1	29,995	508.3	40,000	1,200,000
December	96	94	1	1	18,780	199.7	45,000	2,325,000
Total	335	290	14	31	86,010	224.4	17,439	6,412,510

Pipe line runs and storage for Healdton field, 1915, in barrels.

Magnolia Pipe Line Company	3,067,231
Pugh and Dillard Pipe Line Co.	55,800
Producers' Pipe Line Company	460,000
Croshie & Armstrong	458,000
Steel storage	3,624,827
Wooden storage	320,000
Total	7,985,759

Table showing estimated production of the Healdton field, 1913-1916 *by months, in barrels.*

Motnh.	1913.	1914.	1915.	1916.
January		54,250	194,990	2,015,000
February		120,400	29,988	1,537,000
March		499,100	51,646	1,674,000
April		495,000	135,000	1,650,000
May		759,500	139,886	1,860,000
June		900,000	219,990	1,860,000
July		1,085,000	370,450	1,550,000
August	250	1,295,800	347,200	1,340,000
September	1,000	810,000	600,000	1,300,000
October	5,000	620,000	798,250	2,000,000
November	10,000	556,200	1,200,000	1,850,000
December	10,000	589,000	2,325,000	
Total	36,250	7,784,250	6,421,510	

Well record and production in Healdton field 1913-1916, *by years.*

Year.	Wells completed.				Initial daily production.		Total production.*
	Total.	Oil.	Gas.	Dry.	Total.	Average. per well.	
					barrels.	barrels.	barrels
1913	23	15	3	5	844	56.2	36,250
1914	392	340	9	43	106,171	312.3	7,784,250
1915	335	290	14	31	86,010	296.6	6,412,510
1916							

*estimated.

SUMMARY.

Carter County is in good oil and gas territory, as has been proved by the development in the Wheeler, Healdton, and Fox districts. However, certain areas in the county are to be eliminated from the territory for oil and gas prospecting. The immediate region of the Arbuckle Mountains and Criner Hills uplift, and certain parts of the structural basin between the two uplifts would not be expected to produce oil and gas in commercial quantities. On the other hand, there are other areas in the county which appear very favorable for future development. As above stated, some miscellaneous drilling has been done over the county but in most of these cases the locations were made without reference to structure, and it is also a very noticeable fact that none of these wells were drilled to a sufficient depth to be considered tests.

In addition to the development in the western part of the county, parts of the following areas are favorable—T. 4 S., R. 1 W.; T. 4 S., R. 2 W.; the western part of T. 4 S., R. 4 E.; the western part of T. 5 S.,

R. 1 W.; and parts of T. 5 S., Rs. 2 and 3 W. These areas lie almost entirely in the region of Cretaceous overlap and the selection of locations must be made with the greatest care. Tests must be made in the most favorable localities to a depth of 2,500 to 3,000 feet.

The structure in general corresponds to the topography. The principal streams are synclinal. There is perhaps no county in the State where conditions for future drilling can be as greatly aided by carefully preserved well records as in Carter County. The character and extent of the folds in the mountain uplifts which are largely concealed can be in a large measure determined by logs of wells drilled, and a careful study of conditions thus revealed will be of the highest value in future development.

The transportation and refining problems for the county have been solved and the building of additional railroads, and improvement of public roads have made all parts of the county readily accessible so that future drilling in new areas can be carried on at much less expense than when development began in the Healdton district.

CHEROKEE COUNTY.

LOCATION.

Cherokee County is located in northeastern Oklahoma and is the third county from the north boundary of the State, in the second tier of counties from the east line. The territory included in this county embraces Tps. 14 N. to 19 N., inclusive, Rs. 21 E. to 23 E., Tps. 16 N. to 18 N., inclusive, R. 20 E., and a few sections in the same townships in R. 19 E., forming an irregular strip along Grand River. The county includes all of 21 townships and 26 square miles additional along the west side of the county. The total area is 782 square miles.

TOPOGRAPHY.

The county, with the exception of the southern and southwestern part, is in the Ozark uplift. The remainder of the county lies in the Pennsylvanian or Sandstone Hills region. In the Ozark region the weathering of the cherty limestones and flint has produced broad, level tracts between the main drainage lines. From these level tracts flat-topped ridges extend out between the subordinate drainage channels to the narrow steep-sized valleys of the larger streams. The elevations of the surface range from about 1,200 feet to 500 feet along Grand and Illinois rivers.

The southern and southwestern parts of the county lie in the rough, faulted, and broken area of the Sandstone Hills region.

The drainage of the western half of the county is directly into Grand River, while that of the eastern part is into Illinois River, which is one of the chief tributaries of the Grand.

GEOLOGY.

The surface rocks of this county belong chiefly to the Mississippian and Pennsylvanian series. Some small areas of Ordovician and Silurian rocks occur. A brief description of the surface rocks is given in "Adair County."

STRUCTURE.

There is evidence throughout the area of the county that at various periods slight and variable foldings of the rocks have taken place. Since rocks lower than the Mississippian outcrop in but a few areas little can be said of their structure, except such as is involved in the rocks of the Carboniferous period.

The discussion of structure in "Adair County" applies to this county also. Locally throughout the county are many folds which are of sufficient size to afford opportunity for the accumulation of oil and gas if present in the underlying formations. Along Illinois River at a distance of 6 or 8 miles northeast of Tahlequah the Bergen sandstone and Tyner formation of Ordovician age are exposed. These exposures show the presence of a considerable fold in the surface rocks. In the southern part of the county numerous faults of great magnitude occur.

SUMMARY.

While numerous structural features are present over the county, and the surface and underlying rocks are such that conditions necessary for the occurrence of oil and gas would be encountered, it is very doubtful if the region is to be considered as being in favorable oil and gas territory.

In 1884 the Cherokee Council passed an act by which an oil company was formed. A well was started on Illinois River, about 20 miles northeast of Tahlequah. The Council of 1885 repealed the charter and operations on the well ceased. Later in the same year the charter was reinstated and drilling was begun and continued intermittently until 1888, when the well was abandoned at a depth of 1,414 feet without encountering more than showings of either oil or gas.

During the past few years several wells have been drilled in the western portion of the county. The Portland Oil & Gas Company's Well No. 1 on the Whitlock farm in sec. 24, T. 18 N., R. 21 E. was abandoned as a dry hole after a long period of drilling. S. S. Whitford & Company's Well No. 1 on the Freeman farm in sec. 18, T. 17 N. R. 22 E. was reported to have given a light flow of gas, and a well drilled in sec. 21, T. 17 N., R. 21 E. found some oil. In sec. 21, T. 17 N., R. 20 E. a sand with a fair showing of oil was encountered at 800 feet. Other wells drilled in secs. 8, 21, and 23 of the same township and range gave only sufficient showings of oil and gas to arouse interest for the drilling of additional wells. Near Melvin a well was drilled upon the recommendation of a clairvoyant. This well was abandoned at a depth of more than 1,500 feet without a showing of either oil or gas.

CHOCTAW COUNTY.

LOCATION.

Choctaw County lies in the southeastern part of the State. It is bounded on the north by Atoka and Pushmataha counties; on the east by McCurtain County; on the south by the State of Texas; and on the west by Bryan County. It extends from T. 5 S., to T. 7 S. inclusive, and from R. 13 E. to R. 20 E. inclusive, and has a total area of approximately 800 square miles.

The chief town is Hugo which is the county seat and is centrally located at the junction of the north-south and east-west divisions of the St. Louis & San Francisco Railroad.

TOPOGRAPHY.

The surface features developed upon the Cretaceous sediments of Choctaw County constitute essentially the same type of topography as that developed in Bryan County where the same formations outcrop, a description of which may be found under the proper heading under "Bryan County."

GEOLOGY.

The geology of Bryan County is duplicated, or continuous eastward, through Choctaw County. The detailed delineation of each separate formation as it outcrops in this region has never been mapped; consequently it is possible to state only in general terms what the distribution is. In Bryan County the separate members outcrop in parallel belts which trend a little south of east. A reconnaissance shows the same to be true of Choctaw County, and the disposition of the beds and the general structure are also the same. For a general discussion, that of the geology of Bryan County may be referred to.

DEVELOPMENT.

Choctaw County has not interested capitalists to any great extent in the past but at present more interest is being taken. A number of years ago a well was drilled in the NE. 1/4 sec. 5, T. 6 S., R. 17 E. It was begun at the top of the Trinity sand just below the bluff of Goodland limestone which overlooks the little creek at a point one mile and a half north of Goodland along the St. Louis & San Francisco Railroad tracks. The depth reached was about 1,000 feet and yielded no production.

The Lusher Drilling Company, in 1914, began operations east of Hugo and drilled a well in the SW. 1/4 sec. 30, T. 6 S., R. 18 E., but their interests have since been entirely taken over by G. Earl Shaffer and the drilling at this location is still progressing. The depth at the present time is 1,960 feet. A showing of oil was reported at a depth of 728 feet and a little gas was encountered at a depth of 1,300 feet but no yield of value has occurred.

Geologists are studying the dip and strike of the strata in various localities in Choctaw County in an effort to locate any favorable structure that might be present. Consequently other wells may be begun in the near future. At present the above are the only two holes drilled.

SUMMARY.

Choctaw County is within possible oil and gas territory. Production might be found in at least two horizons: Trinity sand, and Pennsylvanian sands. The most productive part of the Trinity sand would be expected where this formation is in contact with edges of the productive sands of the Pennsylvanian, though oil and gas may have migrated long distances along the unconformable contact between the Cretaceous and the underlying older rocks. The Cretaceous formations above the Trinity sand contain a number of limestone ledges from which the underground structure could be determined in part. Folding in the Cretaceous may or may not extend down into the underlying older rocks. A study of surface indications should locate possible accumulations within the Trinity sand. Tests should be started on favorable surface structure and should extend below the Trinity. Careful logs should be kept and samples of the underlying rocks taken, as it is only by drilling that the relation of the underlying older rocks to the Cretaceous can be determined.

There may be favorable structure in the Pennsylvanian which is not apparent at the surface. The drill is the only means of locating such structure.

CIMARRON COUNTY.

LOCATION.

Cimarron County is on the extreme west end of the Panhandle of Oklahoma. It is rectangular in shape and includes all of 45 townships and 4 miles off of the northern tier of townships. It includes the territory embraced in Tps. 1, 2, 3, 4, and 5 N., and 4 miles of T. 6 N., from the base line running along the line of 36° 30′ north latitude and Rs. 1 to 9 inclusive, east from the Cimarron Meridian. The total area is 1,836 square miles. The northern boundary of the county is the Oklahoma-Colorado line. The western boundary, which is on the 103d meridian (Cimarron Meridian), is the Oklahoma-New Mexico line, and the southern line is the Oklahoma-Texas boundary.

TOPOGRAPHY.

Cimarron County lies in the highest of the High Plains, the average elevation above sea level being higher than any other elevation within the

State. In the northwest corner the elevation reaches approximately 5,000 feet above sea level, and at the northeast corner 3,700 feet. The southern half of the county varies from 4,800 to 4,000 feet.

Beaver Creek drains the southern half and eastern part of the county. The northwest part is drained by Canadian River. In the high uplands are a few small streams at work cutting into the level country. In large areas, however, the only drainage is in two broad shallow basins sometimes called "buffalo wallows." There are no trees in the county except an occasional elm, cottonwood, or willow along the streams.

GEOLOGY.

The surface rocks of the region are practically all of Cretaceous or Tertiary age. The Cretaceous rocks cover a considerable territory in the northwest part of the county. They are chiefly yellow or lime-colored clays and shales. In a few places the shales are carboniferous and become gray or blue in color. Locally loose, unconsolidated sands and thin-bedded oyster shell limestones are found. The limestones are ciliceols and lenticular.

Above the Permian Redbeds proper there is a series of strata which consists of Redbeds of uncertain relationship. The thickness of this series is not known. The Lower Cretaceous exposed in the northwestern part of the county consists of red and green shales and possibly a few sandstones and limestones near the top of the formation. There is a heavy ledge of sandstone capping the shale beds and this may be the top of the Lower Cretaceous or basal part of the Dakota sandstone of Upper Cretaceous age. At least, that which has already been classified as Dakota lies conformably on the Lower Cretaceous.

The Upper Cretaceous is represented in this area by the Dakota sandstone which consists of alternating sandstones and shales, the former predominating. The following section was made of Black Mesa, about 3 miles north of Kenton.

Section of Black Mera, about 3 miles north of Kenton, Okla.

Character	Feet.
Basalt	60
Tertiary pebbles and sand	145
Sandstones, thin-bedded and brown	25
Sandstone ,thin-bedded, gray and limy near top	10
Sandstone, massive, brown, cross-bedded	40
Sandstone, thin-bedded, limy near top, shale also present	30
Sandstone, massive, brown, cross-bedded	45
Shale slope, covered and not well exposed	30

Sandstone, massive, cross-bedded	35
Shale and sandstone alternating; shale yellow and sandstone brown	15
Shale, red for the most part, also contains white sandy streaks; amount exposed	40
Slope, wash and debris covered	125
Alluvium and Cimarron River deposits	20
Water level of Cimarron River	
Total	620

In general there are three regular, massive sandstone members of the Dakota. In some localities four separate member shave been identified. The lowest member is generally a white. massive, cross-bedded sandstone and appears to rest conformably on a red shale bed of the Lower Cretaceous. Streaks of copper ore were noted in this sandstone. In many places prospect holes have been dug in the base of it. The average thickness of the ledge is about 40 feet. The middle sandstone member is a brown, massive, often cross-bedded sandstone. The thickness is about 30 feet. The upper sandstone is very similar in character to the middle member. It caps most of the hills throughout the area and has an average thickness of about 45 feet. Between the three members there are usually shales or soft, thin-bedded sandstones, which erode easily and make the heavy, more resistant sandstones stand out as prominent ledges. The shales vary in color. The usual varieties are brown. yellow. or black.

Between the middle and upper sandstone ledges a bed of coal occurs over parts of the area. One locality where coal occurs is in secs. 19 and 20, T. 4 N., R. 1. E., about 5 miles west of Mineral. Here are two old prospect pits which are reported to have been operated by some Swedish people years ago. The coal bed appears to have about a maximum thickness of 12 inches.

The Tertiary deposits consist of loosely consolidated sands and clays of light color, and attain a thickness varying from a few feet to more than 500 feet. In the extreme northwestern corner of the county is a small area of black igneous rock known as basalt. This material is from 1 feet to 75 feet in thickness and overlies the other formations, and appears to be Tertiary or post-Tertiary in age.

STRUCTURE.

Between the Permian and Cretaceous formations there is an unconformity which means that the Permian Redbeds were deposited, later uplifted and eroded, and again submerged, during which period the Cretaceous deposits were laid down. Structure, such as folding during the uplift at theclose of the Permian might not be revealed in the Cretaceous rocks on account of covering up of the surface indications in Permian. Therefore, where there are no apparent surface indications of folding in the Cretaceous it does not necessarily indicate that no folding exists in the Permian and Pennsylvanian rocks underlying. The parts of the county in which the Cretaceous rocks are exposed at the surface are the only parts of the county where there are sufficient rocks outcrops to do structural work. The regions of special importance in this area are in the vicinity of Cimarron River north of Boise City, and in ehe vicinity of Kenton in the northwest part of the county. The general dip of the rocks is to the eastward and over most of the territory covered by Cretaceous rocks the general dip prevails, but in some localities there are apparent reversal dips and the Cimarron River along a considerable part of its course appears to be synclinal. Dips taken on the north side of the river at various localities indicate a strong southeasterly direction, while those on the south side locally have a northeast direction. It is, however, very difficult to determine structure in this regoin on account of the slumping of the rocks which has taken place on a large scale. Detailed work in the region may reveal some structure which would be favorable for drilling. However, it is doubtful if definite spots can be selected from a geologic standpoint for the location of test wells.

A test in the region should be drilled to a depth of at least 3,500 feet in order to be considered a test of the region. A location has been made in the NE. 1/4 of the SW. 1/4 of sec. 22, T. 4 N., R. 1 E., near Mineral. Another location has been determined upon in the northern part of T. 3 N., R. 1 W., near Mexhoma. Considerable investigations are being made in the region and especially in the area between Boise City and the northern limits of the county.

SUMMARY.

A large tract of land in Cimarron County has been segregated by the State School Land Department as probable oil and gas territory. This segregation probably came about as a result of the reported discovery of several small producing wells across the line in Colorado. In many places the exposed shales are highly carboniferous and locally some coal is found. In the vicinity of Mineral and to the northward in the western portion of the county coal has been mined for local use for a number of years. Reports indicate that this coal varies in thickness from a few inches to 30 inches and is of a poor quality. Where it has been mined and prospected it lies at approximately 20 feet below the general surface level.

It is probable that some oil and gas might be encountered in the vicinity of these carbonaceous rocks. However, they are not of sufficient thickness to provide a very great source of supply, and the only chances for the finding of oil or gas in paying quantities in the region are from deep drilling. The area as a whole is not to be considered very favorable oil and gas territory.

CLEVELAND COUNTY.

LOCATION.

Cleveland County is located in the central part of the State. It extends from T. 6 N. to T. 10 N. inclusive, and from R. 4 W. to R. 1 E. inclusive. It includes 12 whole townships and parts of 7 others. The total area is approximately 585 square miles.

TOPOGRAPHY.

Cleveland County lies in the Sandstone Hills region with the exception of the western part, which is in the Redbeds plains. The western and northwestern part of the county is a rolling prairie, while all of the eastern is hilly and sandy, the streams having eroded narrow and deep valleys in many instances. The hills are in part due to erosional features in the shales and sandstones, and in part to wind work, causing duning and ridging of the surface sands, especially along the north bank of the Canadian River. The range in elevation is from 960 feet on Little River in sec. 1, T. 8 N., R. 1 E. to 1,320 feet on top of a hill 3 1/2 miles northeast of Moore.

Little River and its tributaries drain the greater portion of the county, especially the northeastern part. Canadian River drains the western and southern parts of the county.

GEOLOGY.

The surface rocks over the entire northern half and a part of the southern half of the county are Permian Redbeds. The red-Pennsylvanian rocks are exposed in the southeastern corner of the county. It is very difficult to distinguish the Permian from Pennsylvanian in this section of the State. In general the rocks consist of sandstones, shales, sandy shales, and conglomerates. The sandstones vary in character from soft to hard, in color from white to red, and in texture from fine to coarsely conglomeratic, and are usually cross-bedded. They are frequently replaced by shales, or vice versa, within a short distance, making it very difficult to use them as a horizon marker in the determination of structure.

From a study of well records it appears that either the Redbeds become thicker to the southwest in Pottawatomie County, which would have a relation to the conditions in Cleveland County, or that the red-Pennsylvanian has replaced a part of the non-red portion of that series of formations. If either supposition is true the thickness of the Permian Redbeds and red-Pennsylvanian would not be as great in the northeastern as in the southwestern part of Cleveland County.

STRUCTURE.

In general the structure of the surface rocks is that of a westward-dipping monocline. Reconnaissance work of a preliminary nature has been done over the greater portion of the county. The usual westward dip is slightly interrupted in a number of places by minor local folding. There are, however, no extensive and well-defined anticlinal and synclinal folds in the area so far as surface indications point out in the light of present available data.

DEVELOPMENT.

No test well has been drilled in Cleveland County. A well was drilled several years ago near Newcastle, which is just across Canadian River, in McClain County. It is reported to have been drilled to a depth of 2,000 feet and abandoned without a showing of either oil or gas.

Recently there has been some activity in leasing in the eastern and southeastern parts of the county, and it is probable that several tests will be drilled in the near future.

The Cleveland County Development Company has made a location in sec. 31, T. 9 N., R. 1 E., and expect to begin drilling at an early date. The well will be drilled to a depth of 3,500 feet if necessary. A well is now being drilled in sec. 19, T. 10 N., R. 2 E. The depth of the well is now (Dec. 15, 1916) about 1,000 feet. This location is in Pottawatomie County, just across the line from Cleveland County. A large block of acreage has been secured in the extreme southeastern corner of the county, ~~test in sec. 29 showed an initial volume of 31,000,000 cubic feet in the~~ and plans are being made for the drilling of a test hole. The location selected for the test is near the NE. cor. sec. 26, T. 6 N., R. 1 E. According to report made for the lessors by a consulting geologist this immediate area is on favorable structure. Two locations have recently been made in the vicinity of Lexington—one in sec. 14, T. 6 N., R. 1 W., and the other in sec. 14, T. 7 N., R. 1 W. Drilling will soon begin on the latter location.

SUMMARY.

The eastern and southeastern parts of the county are in probable territory. While the surface indications are not of such a nature, over the territory which has been surveyed, that they give much weight to the value of this area, it is possible that the selection of locations in the area might lead to the finding of oil and gas in the underlying Pennsylvanian rocks which do not belong to the same period as the Permian and red-Pennsylvanian surface rocks. The non-red-Pennsylvanian, the oil and gas bearing rocks of northeastern Oklahoma, would probably be encountered from an average of about 1,200 feet in the eastern part to an average of about 1,800 in the extreme northwestern part. A well to be considered a test in this region should not be abandoned at a depth less than 3,500 feet.

COAL COUNTY.

LOCATION.

Coal County is located in the southeastern part of the State. It extends from T. 1 S. to T. 3 N., inclusive, and from R. 8 E. to R. 11 E., inclusive. It comprises 14½ townships and has an area of 522 square miles.

TOPOGRAPHY.

The greater part of Coal County is within the Sandstone Hills region. In topography it may be considered an extension of the Ouachita region, though the features are less pronounced. Broad, level valleys of shale occur between sandstone ridges.

A very small part of the county is in the Arbuckle Mountain region. The surface features vary from rolling prairie plains to rather rugged hills. The surface elevation ranges from 542 feet to 950 feet, a range of 408 feet. The lowest point in the county is in the southeastern corner where Muddy Boggy Creek crosses the county line in sec. 33, T. 1 S., R. 11 E. The highest point is near the center of sec. 8, T. 1 S., R. 8 E., about one mile north of the town of Hunton.

GEOLOGY.

GENERAL STATEMENT.

Pennsylvanian, Devonian, and Silurian rocks are found at the surface in Coal County. The Silurian rocks are blue, thin-bedded limestones, blue friable shales, and white and yellow limestones. They are found in the southwestern part of the county. The Devonian rocks are black flint, chert, and shale. They are found in the southwestern part of the county. The Silurian and Devonian rocks are confined to the small area of 16 square miles in the southwestern part of the county. The remainder of the rocks, with the exception of some unconsolidated silt and sand, probably Neocene and the Pleistocene sand, silt, and gravel found along the present streams, are Pennsylvanian. The Pennsylvanian rocks are sandstones, shales, limestones, and coal.

The rocks exposed in the area consist entirely of sandstones and shales, with some beds of coal, of the lower part of the Pennsylvanian system. The stratigraphy of these rocks in the southern part was studied carefully by Taff,* and is given in the paper previously cited. The following descriptions of the formations exposed are summarized from his more

*Taff, Joseph A., and Adams, Geo. I., Geology of the Eastern Choctaw Coal Field, Indian Territory: Twenty-first Ann. Rept. U. S. Geol. Survey, Pt. II. pp. 271-279.

detailed descriptions. The formations exposed are as follows, named from the lowest upwards: Atoka formation, Hartshorne sandstone, McAlester shale, Savanna formation, and Boggy shale.

The following log will give an idea of some of the underground formations:

Log of well in NE. corner of SE. ¼ of SW. ¼ sec. 10, *T.* 1 *N., R.* 11 *E.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface	157	157	Shale, small stratum of coal	15	1,200
Fresh water sand	30	187	Lime	2	1,202
Blue to light shale	525	712	*Sand	27	1,229
Coal	5.5	7,13.5	Shale—variegated	624	1,853
Limestone	3.8	717	Lime shells with variegated sands	100	1,953
Sand, gas, and salt water	23	740	Shale	535	2,490
Shale	255	995	Lime	3	2,493
Sand—dry	190	1,185	**Sand	49	2,542

ATOKA FORMATION.

This formation outcrops in a belt varying from 1 to 18 miles wide along the southern border of the area, and also in a belt from 1 to 3 miles wide in the northeastern part of the area. The formation has a thickness of between 6,000 and 7,000 feet, but along most of the outcrop only the upper part of the formation is exposed, the lower portion being cut out by the Choctaw fault to the south. The formation consists principally of shale with four sandstone groups, each about 100 feet thick at intervals of about 1,000 feet apart. The sandstones are brown in color, and are usually thin-bedded and platy, with the beds separated by shale partings. The shales are rarely exposed, but where they are shown they are bluish clay shales with occasional sandstone concretions. The sandstone groups usually give rise to pronounced ranges of hills, while the shale outcrops form flat plains between them. The Atoka formation contains the gas-producing sands in the Mansfield (Ft. Smith) gas field in Arkansas.

HARTSHORNE SANDSTONE.

The Hartshorne sandstone is made up of sandstone, shaly sandstone, shale, and coal. The thickness is estimated at from 100 to 200 feet. The lower part of the formation is thin-bedded and shaly, and grades into the shales of the underlying Atoka formation. The beds in the upper part of the formation are usually more massive, but in some places the sand-

*The sand was black and loose, with a small amount of salt water. Gas began coming 36 hours after drilling in and increased in flow until it reached 2,500,000 cu. ft.

**This sand produced light gas. The hole was abandoned on account of caving.

stones of the whole formation are thin-bedded and shaly. In some localities there are three beds of sandstone separated by shales. The lower Hartshorne coal lies about 50 feet below the top of the formation, and the upper Hartshorne coal lies at the base of the McAlester shale immediately above the Hartshorne sandstone. The formation outcrops as a southward-facing ridge along the south side of the area. West of Heavener this ridge makes a pronounced loop to the east, around the end of Heavener anticline. The Hartshorne sandstone also outcrops around the Backbone and Milton anticlines farther north. The Hartshorne sandstone is important on account of its connection with two workable coal beds, as well as on account of it being the gas-producing stratum in the Poteau field.

McALESTER SHALE.

Lying above the Hartshorne sandstone is a formation estimated at 2,000 to 2,500 feet thick, consisting principally of shale, but with some lenticular sandstones, and coal beds, of which two are of workable thickness. The outcrop of some of the sandstones can be traced for several miles, and the beds are of considerable thickness, but none of them can be mapped over sufficient area to permit the formation to be subdivided. The great mass of the formation is of soft, clay shale which shows a blue-black color in fresh exposures. Such exposures, however, are rare, for the softness of the formation causes it to weather easily. The outcrop is a flat plain, usually prairie land between the hills of the Savanna sandstone, and the soil covering the shale is usually several feet in thickness. The flat lands of the McAlester shale area are poorly drained, and are characterized by peculiar, hummocky mounds which occur in great numbers. These are usually less than 100 feet in diameter, and do not stand more than 5 or 6 feet above the general level of the flats. The sandstones usually form low ridges. Two workable beds of coal, the McAlester beds, lie about 600 or 700 feet below the top of the formation. They are separated by about 70 feet of shale. The upper Hartshorne coal forms the lower limit of the formation.

SAVANNA FORMATION.

This formation consists of three sandstone groups separated by shales. The upper sandstone division is about 200 feet thick while the others are thinner. In all three divisions the beds are more massive toward the top. The shale between the lower and middle sandstone is 300 to 450 feet thick and that between the middle and upper is 450 to 530 feet. The shales are usually more sandy than those of the McAlester and Atoka formations. The Savanna outcrops on the slopes of the principal mountains of the area and, in fact, the mountains are due to the resistant character of this formation, combined with the structure. Large areas in the foothills and lower slopes of Poteau, Sugar Loaf, Cavanal, Potato Peaks, and Sansbois mountains are underlaid by the Savanna. The formation varies in thickness from 1,200 to 1,500 feet in the southern part of the area, the greater thickness being towards the east. To the north the Savanna thins very rapidly and in the Muskogee quadrangle, only 25 miles north of Sansbois mountain, it could not be differentiated. It is very probable that the heavy sandstones in Beaver and Brooken mountains, in the hills west of Porum, and along Canadian River south of its junction with the Arkansas, belong to the Savanna, but these ledges are not definitely known north of Arkansas River.

BOGGY SHALE.

Above the Savanna formation is a great thickness, about 3,000 feet, of shale with thin beds of sandstone irregularly distributed through it. The formation occurs well upon the slopes of Sugar Loaf, Poteau, Cavanal, and Sansbois mountains, and over large areas to the west and northwest. While the shale greatly exceeds the sandstone in the formation, the upper slopes of the mountains mentioned are covered by sandstone bowlders residual from the sandstones, which give the impression that sandstone is extremely abundant in the formation. The sandstones are usually thin-bedded, brown in color and fine-grained. Exposures of the shale are rare but it appears to be very similar to that of the McAlester.

THURMAN SANDSTONE.

Thurman sandstone represents the beginning of a marked change in the character of the sediments which were brought into the sea in this region in Carboniferous times. The fine shales and sandy sediments which characterize the Boggy shale are followed by coarse pebbles of white chert mixed with coarse quartz sand, which form a conglomerate. This formation has a maximum thickness of about 50 feet and is exposed along the north side of the county, occupying an area of about 35 square miles. Caney Boggy Creek marks the eastern limit of this formation in Coal County. To the east of this creek in Hughes County the surface area of the Thurman sandstone is much greater than in Coal County. West of the creek the width of the surface exposed is from two to three miles to within about four miles of the western border of the county, where it narrows to a strip less than a mile in width.

The sandstone beds in the upper part of the formation, while becoming finer and thinner in texture westward, include beds of shale, and near the western edge of the county there are some thick beds of impure, fossiliferous limestone. The regular dip of the formation is from 60 to 100 feet per mile in a northwesterly direction. In the eastern and central part of the area covered by this formation the surface is very rugged, and is covered with a dense growth of oak and pine, while farther westward the surface becomes less rugged and consists of diversified prairie and timber land.

THE STUART SHALE.

The Stuart shale is exposed along the immediate northern boundary of the county for a distance of 12 or 15 miles, west of Caney Boggy Creek, comprising in all about 8 or 10 square miles. This formation consists of beds of shale, sandstone, and interstratified beds of shale, which make up 3 members, an upper one and lower one of shale separated by a sandstone varying in thickness from 10 to 50 feet. The formation varies in thickness from about 100 feet in the western part of its exposure to about 275 feet at its maximum exposure in southeastern Hughes County.

STRUCTURE.

GENERAL STATEMENT.

There are anticlinal and synclinal folds in the southern and eastern parts of the county. The principal folds have been mapped by Snider in Bulletin 17 of the Oklahoma Geological Survey. The Lehigh syncline cuts across the southeastern corner of T. 1 N., R. 11 E., and runs southwest across T. 1 S., R. 11 E. The Coalgate anticline runs in a northeast-southwest direction across T. 1 N., R. 11 E., T. 1 N., R. 10 E., T. 1 S., R. 10 E., T. 1 S., R. 9 E., and part of T. 1 S., R. 8 E. The Kiowa syncline runs in a northeast-southwest direction across T. 2 N., R. 11 E., and T. 1 N., R. 10 E. The Savanna anticline runs in an almost east-west direction across T. 3 N., R. 11 E., and a part of T. 3 N., R. 10 E. These folds die out toward the western and northern parts of the county, where the strata lie in a monoclinal fold dipping to the northwest.

In the southwestern part of the county the Hunton anticline, together with faulting, has brought Devonian and Silurian rocks to the surface.

More detailed mapping may show several minor folds, especially in the northwestern part of the county.

In general, the relation of the structure to the topography is intimate. All of the large hills or mountains are synclinal and many of the smaller features are also related to the structure.

The deformation is greatest in the southeastern part of the county, which lies in the northwest continuation of the Ouachita uplift. However, this part of the uplift is not so overturned and broken as to the eastward. The following paragraph* describes the principal structural features outside the Ouachita uplift.

SAVANNA ANTICLINE.

The Savanna anticline is one of the last of this series and is the northernmost fold in the quadrangle. It crosses the east central part of the quadrangle and then bears northeastward across the McAlester quadrangle and joins the McAlester anticline in the vicinity of Alderson. In the Coalgate quadrangle it pitches east and west from a dome-like uplift near its western end, and the rocks on the northern side have much steeper dips than on the southern side. This arch flattens out in Caney

*Taff, Joseph A., Coalgate folio (No. 74), U. S. Geol. Survey, 1901, p. 5.

Boggy Valley and disappears near the middle of the quadrangle in the monoclinal dip to the northwest.

COALGATE ANTICLINE.

This anticline is a peculiar structural feature. From Coalgate southwestward this fold is broad and very obtuse. The strata below the Lehigh coal bear westward around the south end of the Lehigh basin and then northward toward Coalgate. Southwest of Coalgate these beds curve gradually westward and then southwestward into the boggy swamps of Clear Boggy Creek. The Lehigh coal bed in its outcrop emphasizes the character of this anticlinal structure more strongly. From Lehigh the strike of coal bears nearly due north, with low east dip to Coalgate, where it turns abruptly southwestward. One mile northeast of Coalgate this coal rises and is exposed for nearly 8 miles in an elongated dome bearing northeastward. The Lehigh coal and the sandstones and shales for several hundred feet above the coal dip 10° to 15° from the axis of this dome. From a point about 7 miles northeast of Coalgate the rocks upon the axis of the Coalgate anticline pitch rapidly northeastward. This pitch gradually grows less until the anticline is lost as a structural feature in the center of the Kiowa syncline near the west end of the Kiowa Hills, southwest of Kiowa.

Three to five miles northwest of the axis of the Coalgate anticline there is a parallel shallow syncline whose axis is nearly parallel to that of the Coalgate. The axis of this syncline rises toward the northeast and the syncline dies out or coalesces with the Kiowa syncline opposite the northeast end of the Coalgate anticline.

From a wide, indistinct fold at the southern border of the quadrangle the Coalgate anticline contracts and pitches toward Coalgate and then rises beyond in an elongated dome-like arch in Coal Creek Valley. Beyond Coal Creek it pitches rapidly northeastward for 2 miles and then the axial portion becomes nearly level and continues so to near the end of the fold, where it is lost in the south limb of the Kiowa syncline in the McAlester quadrangle. The rocks on the northern side of this arch also have steeper dip than on the southern side. This is especially the case west of Coal Creek.

KIOWA SYNCLINE.

The Kiowa syncline, which, within the Coalgate quadrangle, lies between the Savanna and Coalgate anticlines, bears eastward across the McAlester quadrangle for 30 miles. Beyond Kiowa the basin first grows deep and broad and then contracts and becomes flat, ending at the east in the form of a spoon in the Hartshorne basin. At the border of the Coalgate quadrangle the syncline is narrow and shallow. Westward it becomes broader and still shallower until it is lost in the undulating but gently northward-dipping rocks, north of Coalgate.

LEHIGH SYNCLINE.

The Lehigh basin or syncline lies between the Coalgate anticline and the Choctaw fault. Like the Coalgate fold, its eastern end begins in the southern limb of the Kiowa syncline, a few miles east of the quadrangle. It is unsymmetrical, the rocks on the southeastern side having been steeply upturned by the northwestward thrusts accompanying the adjoining fault. From the northeastern end to a point east of Coalgate it is narrow and shallow. Southward it becomes very much broader, changes its course from southwest to south, and pitches downward, making a deep oval basin which ends in the vicinity of Atoka, 8 miles south of the quadrangle.

The rocks of the coal-bearing McAlester shale on the eastern side of this basin dip at angles of 50° to 80°, while on the western side the dip does not exceed 5°. The beds at the top of this formation on the western side when followed downward are found to increase in dip to nearly 15° within 2 miles and then gradually to decrease, finally reaching a horizontal position at the center of the basin.

The additional paragraph from Taff's description of the McAlester-Lehigh coal field gives further details of this structure.

This basin is a southern prolongation, in part, of the Kiowa syncline. It is broad and deep in the central part, opposite Lehigh, and much contracted and elevated at the north end, where it joins the Kiowa syncline. The contraction at the north end is due to the eastward bearing and enlargement of the Coalgate anticline at its north end. The Lehigh basin in surface outline is elliptical. It is relatively deep and its axis lies near its eastern side. The Savanna sandstone series and other associated beds which outcrop on the east side of this basin are upturned until they are almost vertical. Along their outcrop they form a prominent ridge. As they extend around the south end of the basin, west of Atoka, these beds separate in outcrop as the dips become less, and the thick sandstone strata form low ridges which curve, one after the other, in gradually widening lines. From the vicinity of Lehigh on the west side for a distance of 6 miles inward toward the axis the beds dip about 4°. Beyond this the rocks increase in dip to nearly 10° toward the center of the basin. It will be seen by this description and by reference to the section and map that the Lehigh basin is structurally unsymmetrical. Extensive westward overthrusting and faulting of the beds lying beneath the coal-bearing strata, between Limestone Gap and Atoka, immediately east of the Lehigh basin. have pressed the coal-bearing rocks westward and upward, while the same beds on the west side of the basin have been but little disturbed. The basin is canoe-shaped, its axis rising at both the north and the south end.

DEVELOPMENT.

L. C. Snider* has discussed the development in Coal County up to the middle of 1913. The wells drilled up to that time were in T. 3 N., R. 11 E. Considerable gas was found. These wells were drilled on the Savanna anticline.

*Snider, L. C., Petroleum and Natural Gas in Oklahoma, p. 141.

The development in Coal County is in the extreme northeastern part near the Pittsburg County line. Well No. 1 is in sec. 24, T. 3 N., R. 11 E., in Coal County and is reported to have had 67 feet of oil sand at 1,527 feet and was a gasser, making 6,000,000 cubic feet per day initial flow. Well No. 2 is in NE. 1/4 of the same section and is reported dry at 1,200 feet. Well No. 3 is in sec. 17, T. 3 N., R. 12 E., across the line in Pittsburg County and had a capacity of 12,000,000 cubic feet of gas per day with 117 feet of sand. Well No. 4 is in sec. 20 or 21 of the same township and had a capacity of 8,000,000 cubic feet of gas per day. Well No. 5 in sec. 19 is reported to have had excellent sand and good oil showing, but no gas. Three or four other wells were completed during 1914.

Recently there has been considerable activity near Cairo, in secs. 9 and 10 N., R. 11 E., on the Coalgate anticline. Two holes have been put down in sec. 10. One in the NE. 1/4 of the section is reported a dry hole. The one in the SW. 1/4 sec. 10 is an abandoned hole, though it is reported as having 2,500,000 cubic feet of gas at a depth of about 1,200 feet. The hole was abandoned on account of caving. A hole is now (May, 1916) being drilled in the NE. 1/4 of sec. 9.

In sec. 5, T. 1 N., R. 10 E., Dr. Wolford drilled a well which showed neither oil nor gas. Excellent drinking water stands in this well in the casing to a little above the surface of the ground.

SUMMARY.

Exploration on the large anticlines in Coal County has in a way been disappointing. Considerable gas has been found, however. The folds are rather severe and of course narrow in width. In such severe folding there is danger of breaks or faults which might interfere with the accumulation of oil or gas by permitting it to escape to the atmosphere, or by interfering with the circulation of the ground water. More favorable structure may be found in the northwestern part of the county where the folding is more gentle.

COMANCHE COUNTY.

LOCATION.

Comanche County is located in the southwestern part of the State. It extends from T. 2 S., to T. 4 N., inclusive, and from R. 9 W. to R. 15 W., inclusive. It includes 27 entire townships and parts of 7 others. The entire area is 1,083 square miles.

TOPOGRAPHY.

The topography of Comanche County may be divided into two types; first, mountain, and second, plain. The Wichita Mountains enter the northwest corner of the county and extend in a southeastern direction to a point a few miles due north of Lawton. These mountains consist for the most part of low-lying granite ridges, knobs, and isolated peaks, rising a few hundred feet above the surrounding Redbeds Plains. Mounts Scott, Wall, Sheridan, Marcy, and Fauramet rise to altitudes of over 2,000 feet. In the nothern part of the county are found the limestone hills which rise several hundred feet above the surrounding plain. The remainder of the county is occupied by the Redbeds Plains.

GEOLOGY.

The rocks at the surface in Comanche County are Permian, Cambrian, and pre-Cambrian.

The pre-Cambrain rocks consist of granite, granite-porphyry, and gabbro. For a full discussion of these rocks the reader is referred to Bulletin No. 20, Oklahoma Geological Survey, "Granites of Oklahoma," by C. H. Taylor.

The Cambrian rocks consist of Arbuckle limestone and Reagan sandstone. The Reagan sandstone is made up of siliceous limestones, green clays, sandstones, and conglomerates. The Arbuckle limestone is made up of bluish and yellowish limestones and dolomites.

The Permian consists of alternating layers of shale and sandstone, and associated with the sandstone are thin layers of shale conglomerate. Near the base of the Permian as exposed along the Wichita Mountains there are several beds of limestone only a few inches thick. The most permanent bed in the entire area is east of Lawton, and in a sandstone ledge which can be traced 12 to 15 miles northwest of the Lawton pool.

STRATIGRAPHY.

The following discussion of the stratigraphy is by Wegemann.*

The Lawton field is only 8 miles from the Wichita Mountains, and a discussion of its stratigraphy involves a brief description of the geology of the mountain area. The Wichita Mountains consist of a core of igneous rock which is surrounded by steeply dipping strata of early Paleozoic age. At the east end of the uplift the only representative of these strata which reaches the surface is a limestone formation of Cambrian and Ordovician age, approximately 5,000 feet thick, known as the Arbuckle limestone. The granite and limestone of the mountains rise abruptly from the surrounding plain like islands in a sea. Against them and evidently covering part of their mass lie the almost horizontal strata of the Permian "Red Beds," which form the surface rocks in the Lawton field, as well as in all the area surrounding the mountains.

The "Red Beds" consist of alternating layers of shale and sandstone and, associated with the sandstone, thin layers of shale conglomerate whose pebbles consist of the same material as the shale forming the principal part of the series. Near the base of the Permian, as exposed along the Wichita Mountains, there are several thin beds of limestone only a few

*Wegemann, C. H., The Lawton oil and gas field, Okla.: U. S. Geol. Survey Bull.621-G., pp. 72-73, 1915.

inches in thickness. The shale of the Permian is predominantly red, but bluish-gray shale is present, especially near the base of the series. The sandstone is white and in some places red or pink. The Permian strata bear very few fossils, and none were collected in the Lawton area, although the remains of primitive amphibians and sharks as well as fossil plants have been found farther south.

The most prominent bed or group of beds in the Lawton field structurally and stratigraphically is the sandstone that forms the low rounded hills east and north of the gas wells. Its outcrop may be traced for 12 to 15 miles northwest of the Lawton pool and probably much farther along the north flank of the Wichita Mountains. The individual beds of sandstone are lenticular, being interbedded with shale, but the group as a whole appears to be continuous over a large area in this part of the State. It occupies about the same stratigraphic position as the sandstone that forms the high ridge 6 miles north of Loco, in which grahamite was at one time mined in sec. 6, T. 2 S., R. 4 W., and also the prominent wooded ridge extending across T. 1 S., R. 5 W., in the direction of the Duncan gas field. In the Lawton field the sandstone is barren of timber. This sandstone is about 200 feet thick. Some 400 or 500 feet above it lies the sandstone that forms the escarpment about the Duncan gas field, as well as the line of hills 6 miles northeast of the Lawton field. The rocks between these two sandstones are predominantly shale.

The character of the strata which underlie the surface in the Lawton field is indicated by the logs of the gas wells. Alternating beds of sandstone and shale, the shale for the most part red in color, extend to a depth of about 1,150 feet. At 1,165 feet in Marple well No. 4 of the Lawton Natural Gas Co. is recorded a bed of solid limestone, which was penetrated to a depth of 65 feet. As no limestone beds of such thickness are known in the Permian in this region, this bed presumably belongs to a formation older than the Permian and is doubtless separated from the red shale which lies above it by an unconformity as great as that which is to be observed along the mountains a few miles to the northwest, where the Permian is merely local in extent and is confined to the vicinity of the Arbuckle-Wichita Mountain uplift as indicated by the fact that in Clay County, Texas, where the base of the Permian is also exposed, the Cisco formation, the highest division of the Pennsylvanian, appears to be conformable with it. The unconformity at the base of the Permian in the region of the Lawton field is economically important, as it may have had much influence on the accumulation of the oil.

STRUCTURE.

In general, all the strata in Comanche County dip away from the Wichita Mountains, those older than Permian at rather steep angles, only locality where detailed work has been done. For a full description of this area the reader is referred to the discussion of the Lawton oil

*Wegemann, C. H., op. cit. pp. 73-84.

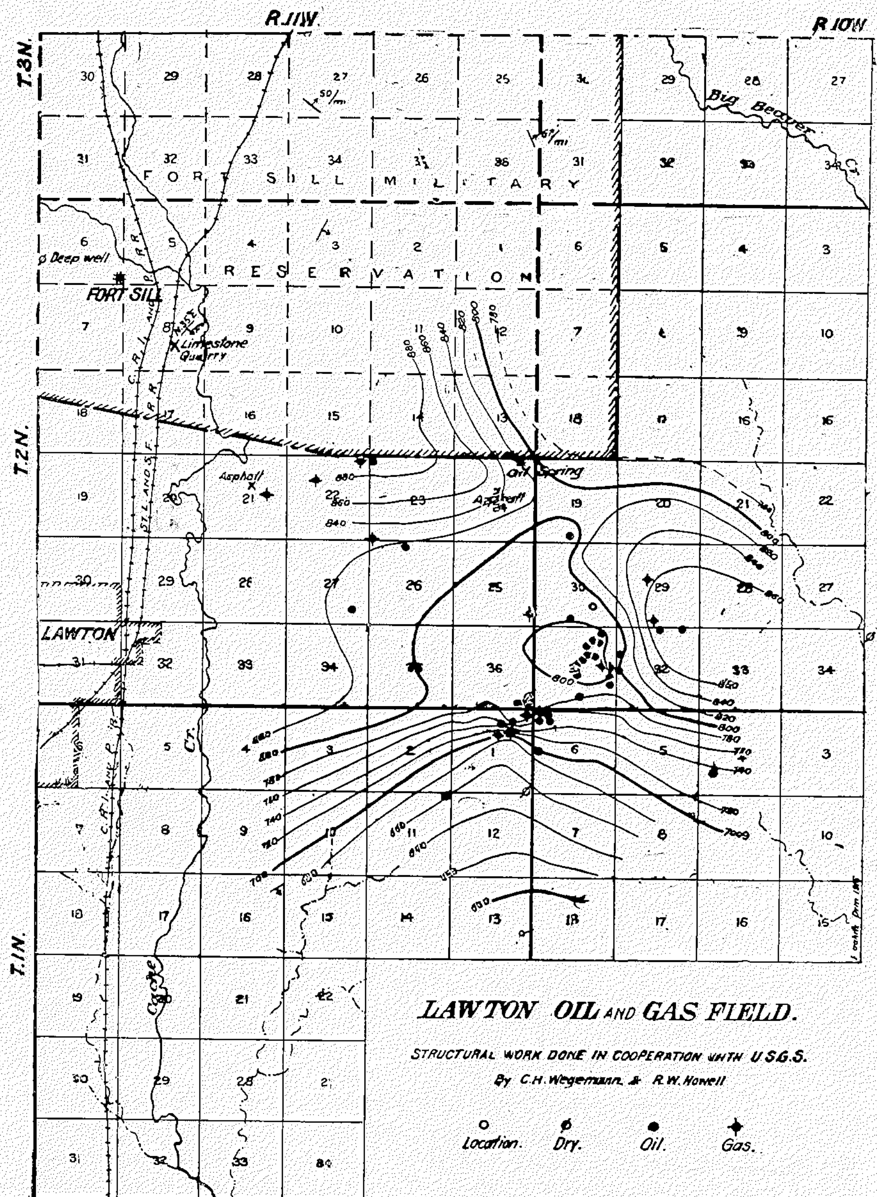

R11W.
R10W.
T.3N.
T.2N.
T.1N.
FORT SILL MILITARY RESERVATION
Deep well
FORT SILL
Limestone Quarry
Asphalt
Oil Spring
LAWTON
Big Beaver
Cr.
LAWTON OIL AND GAS FIELD.
STRUCTURAL WORK DONE IN COOPERATION WITH U.S.G.S.
By C.H. Wegemann & R.W. Howell
Location.
Dry.
Oil.
Gas.

Figure 4.

and the Permian at low angles. The Lawton oil and gas field is the and gas field,* which follows:

The Wichita and Arbuckle uplifts are of the nature of great arches or anticlines, the free Permian sedimentary rocks which now are exposed along their margins having at one time extended completely over their crests. The mountains appear to have been produced by at least two uplifts—the first at the close of the Mississippian time and the second at or near the end of Pennsylvanian time. Each uplift was followed by erosion and degradation of the mountain mass, and the Permian strata were formed of the materials removed from the mountains after the second uplift. Since the deposition of the Permian beds, perhaps in very recent geologic time, the Arbuckle-Wichita axis has been subjected to very slight uplift, which has bent the Permian strata covering the region between the two ranges into what appears to be a low anticlinal arch. Only the north limb of this arch can be recognized, because only north of the axis are the rock strata sufficiently well exposed to make geologic observations possible.

The Lawton oil and gas pool lies about 8 miles southeast of the southeast end of the Wichita Mountains, on the axis of the low arch just described. As will be apparent from an examination of the map, the folds on which oil and gas occur are by no means simple ones. The type of irregular folding is the same as that which has been found to exist in the Healdton and Loco oil and gas fields, as well as in areas examined in Tillman, Cotton, and Jefferson counties, Oklahoma.

The principal anticlinal axis in the Lawton field extends southeastward from the Wichita Mountains and is interrupted by a narrow syncline which crosses it almost at right angles, and which probably contains a small subsidiary dome in sec. 31, T. 2 N., R. 10 W. East of this dome lies the continuation of the principal axis of the fold. Southeast of the Lawton field, because of the absence of rock exposures, the exact position of the anticlinal axis connecting the two mountain uplifts can not be determined.

The marked escarpment formed by the group of sandstone beds in the vicinity of the Duncan gas field, 10 miles east of the town of Duncan, westward to a hill 1 mile north of the town, thence northwestward across the northeastern part of T. 1 N., R. 8 W., and the southwestern part of T. 2 N., R. 8 W., and thence in a due northwest direction past the northeast corner of the Fort Sill Indian Reservation to the region northeast of the Wichita Mountains. From these mountains it is about 6 miles distant. Along the escarpment the bed dips at angles of 1° or less toward the northeast, and the slope is in most places covered with post oak.

The lower group of sandstone beds which form the hills just east of the wells in the Lawton field are not in this area timber covered, so that the region between the escarpment of the upper group of sandstone beds and the oil well is almost treeless. Ten miles southeast of the wells, however, in sec. 24, T. 1 N., R. 9 W., a sandstone bed which appears to be of considerable thickness is exposed and the surface is covered with oak timber similar to that which covers the surface formed by the upper group of sandstone beds. It seems very probable that the sandstone exposed in sec. 24 represents this upper group and lies either on the crest of the arch between the Arbuckle and Wichita uplifts or south of it. From sec. 24 the edge of the timbered area may be traced southeastward, and in sec. 32, T. 1 N., R. 8 W., there appears to be a slight dip to the south or southwest. The axis of the Wichita-Arbuckle fold probably lies a mile or two northeast of this locality, and as its trend is southeasterly it probably passes about a mile southwest of the town of Duncan.

OIL AND GAS.

POSITION OF OIL SANDS.

Oil and gas are found in the wells of the Lawton field in three different sands, which are known in the field as the "200-foot," "400-foot," and "800-foot" sands. The "200-foot sand" is from 10 to 30 feet thick, and lies at depths of 150 to 250 feet, according to the location of the well with reference to the Lawton anticline. This sand has been found in the greater number of the wells and generally carries at least a show of oil. In some wells a production of several barrels of heavy oil is reported from this sand and in at least three of the wells gas is reported from it, though only in small quantity. In sec. 25, T. 2 N., R. 11 W., and sec. 30, T. 2 N., R. 10 W., there is a second sand from 60 to 75 feet below the first one which also has yielded a show of oil. This sand, however, is recorded in only three of the well logs.

The "400-foot sand," which appears to be recognized in all the wells that are deep enough to reach it, is found at 350 to 450 feet below the surface. Where it occurs as a single stratum it ranges in thickness from 6 to 30 feet. In certain wells two sands are found at about this horizon and are separated by shale from 5 to 60 feet thick. This sand is reported to yield from 10 to 15 barrels of oil in certain wells, and in Marple No. 2 of the Lawton Natural Gas Co. a flow was obtained from it, though lasting only a short time. The oil appears to be somewhat lighter in gravity than the oil found in the shallower sand. In some of the wells gas is reported in the "400-foot sand." Marple No. 1 of the Lawton Natural Gas Co. had an initial flow of 660,000 cubic feet. In other wells the production has been estimated as high as 1,000,000 cubic feet, but no accurate measurements appeared to have been made to support these estimates. From a comparison of well logs it is believed that the "400-foot sand" in the Lawton field is the approximate equivalent of the main gas sand in the Duncan field.

The "800-foot sand," which has been penetrated in only 13 wells, appears to be the most promising source of oil and gas in the field. It ranges in depth from 750 to 850 feet and is variously reported as one bed of sandstone about 90 feet thick or as several beds separated by shale. In the Havic & Hall well, on the Epstein farm, in the SW. 1/4 NW. 1/4 sec. 32, T. 2 N., R. 10 W., this sand was encountered at a depth of 756 feet. In the top 12 feet the sand carried oil; next came a soft shaly sandstone 14 feet thick, which was impregnated with asphalt; and the lowest 60 feet carried oil, but in small quantity. In the Reading well. in the SE. ¼ NW. ¼ sec. 29, T. 2 N., R. 10 W., on the Kadie farm, the sand was struck at a depth of 763 feet, is 22 feet thick, and carried gas with an estimated initial flow of 1,000,000 cubic feet. Below the sand is 38 feet of hard red rock, which is underlain by 10 feet of sand that did not yield gas. Below this sand is a gas sand, which was penetrated only 1 foot and which is said to have had a rock pressure of 400 to 500 pounds to the square inch, and an initial flow of gas of 4,000,000 cubic feet. In the well of the Lawton Imperial Oil & Gas Co., in the NE. ¼ NW. ¼ sec. 26, T. 2 N., R. 11 W., the sand was struck at a depth of 800 feet. The first 20 feet yielded a show of oil, but the next 33 feet carried water.

ORIGIN OF THE OIL AND GAS.

If, as is now generally believed, oil and gas are derived from organic remains, it is evident that rocks that were deposited in waters in which life abounded are to be considered a more probable source of oil than those that give little evidence of the existence of plant and animal life at the time of their formation. The Permian "Red Beds" carry very few fossil remains compared with the rocks of the preceding series, the Pennsylvanian. For this reason, if for no other, the Pennsylvanian rather than the Permian might be considered as the source of the oil and gas which are found in the Permian. Moreover, the Pennsylvanian is known to include in northern Oklahoma a great oil-bearing formation, and when this fact is taken into consideration, it seems more than probable that from the Pennsylvanian rocks were derived the oil and gas that are now found in the Permian strata in southern Oklahoma.

If the oil and gas of the Lawton field were derived from Pennsylvanian rocks, they probably rose along the steeply rising beds of the Pennsylvanian to the unconformity which exists between the Pennsylvanian and the overlying Permian. This unconformity marks an old erosion surface on which flat-lying sediments with probably a basal conglomerate were deposited, and these sediments doubtless are porous strata along which oil or gas might easily migrate. As the old erosion surface was somewhat irregular, sandstone beds in the lower part of the Permian probably terminate against its irregularities, making it easy for oil flowing along the unconformity to find its way into the sandstone beds of the overlying formation without being compelled to pass through strata of comparatively impervious shale. Were the sandstone beds of the Permian gently folded so that the influence of anticlinal structure would accelerate accumulation, the oil (or gas which later condensed into oil) might traverse these beds for several miles before at last finding lodgment near the crest of the anticline. Under such conditions the strata in which the oil was originally formed would not necessarily immediately underlie the place of accumulation.

The Lawton oil and gas pool lies 5 miles southeast of an outcrop of

Arbuckle limestone, of Cambrian and Ordovician age, the beds of which dip 4° SE. and strike N. 35° E. As the thickness of the beds between the top of the Arbuckle limestone and the base of the Pennsylvanian is approximately 5,000 feet, it is evident that if the dip of 4° holds for any considerable distance east of the outcrop of Arbuckle limestone mentioned above, the beds of the Pennsylvanian would lie at a distance of much more than 5 miles east of the Lawton field. Even were the dip of the rocks considerably steeper than 4°, the Pennsylvanian would hardly underlie the region of the oil and gas wells. It is, of course, possible that this area may contain faults, which may throw the Pennsylvanian very much nearer to the mountain uplift than it would be under conditions of regular folding. The occurrence, however, of asphalt in a zone encircling the Wichita Mountains and at about the same distance from them as the Lawton pool would suggest that the same general conditions prevail on all sides of the mountains and that the presence of faults is improbable.

There is a possibility that the oil and gas in the vicinity of the Wichita Mountains, as well as the asphalt, which is the residuum left by the evaporation and oxidation of petroleum, were derived from rocks older than the Pennsylvanian, perhaps from the Arbuckle limestone. In the deep well known as the Mineral Springs well, in the SE. ¼ NE. ¼ sec. 21, T. 2 N., R. 11 W., thick limestone beds, presumably those of the Arbuckle limestone, were encountered at 440 feet. "Showings" of oil are reported at 1,935 and 2,200 feet, and there seems little question that the beds in which it was found also belong to the Arbuckle limestone. On the south side of the SE. ¼ sec. 17, T. 2 N., R. 12 W., a bed of sandstone in which is presumably the Arbuckle limestone is impregnated with oil, but the oil in this locality may have come from overlying Permian beds that have since been removed by erosion.

The fact that the Arbuckle limestone is oil bearing of course does not preclude the Pennsylvanian from being also a source of oil and gas—probably the principal source in the region.

DEVELOPMENT.

The early history of the Lawton field from its discovery to the autumn of 1910 is given in the following paragraphs:*

The first well was located on the N. ½ NW. ¼ sec. 6, T. 1 N., R. 10 W., just five miles east of Lawton. It was completed in August of 1904 at a depth of 400 feet, and had an initial rock pressure of 125 pounds and a production of about half a million cubic feet of gas per day.

During the same year the company completed a well southeast of their number one. Gas was not found, as had been anticipated, but a light production of black oil was obtained. Nothing more was done in the pool until 1906 when a dry gas well was drilled in the E. ½ NE. ¼ sec. 1, T. 1 N., R. 11 W., being less than a half mile from the first one. It had

*Hutchinson, L. L., Preliminary report on the rock asphalt, asphaltite, and natural gas in Oklahoma: Okla. Geol. Survey Bull. 2, pp. 241-242, 1911.

an initial rock pressure of 100 pounds and produced a little less than a half million cubic feet of gas per day.

The third well drilled by the Lawton Company was on N. ½ NW. ¼ sec. 6, a location southeast of the first gas well. Oil was found at a depth of 320 feet. Packers were so set as to save the oil and the well was drilled on to the 400 foot sand where gas was found. The initial rock pressure was about 160 pounds, and the well is estimated to have produced 300,000 cubic feet per day, while the oil produced from the 320 foot sand originally amounted to about 15 barrels daily. A pump has been installed and the well is still producing a little oil.

The same company's well, number five, was drilled during 1906 in the north half of the northwest quarter of section 1, a few hundred feet northwest of number three. Oil was found at a depth of 400 feet. The capacity has never been tested, though oil is reported to be standing within thirty feet of the top.

The next well drilled was 200 feet to the southwest of number five and was brought in, during 1906, as a dry gasser at a depth of 400 feet. In 1907 the well tested nearly 450,000 cubic feet per day.

Well number seven was drilled, during December, 1906, a few hundred feet southwest of the one last mentioned. Oil of an estimated capacity of two or three barrels a day was found at a depth of 250 feet. Drilling continued to a depth of 390 feet where the gas was found and the well completed as a gasser. The last well reported by this company was completed during January of the present year (1910). Showings of oil were encountered at 225 and 250 feet, but the sand was dry at 380 feet. Owing to the general topography of the region the sand at 380 feet appears to be the regular 400 foot sand, so it is probable that this will ultimately prove to be a dry hole. Besides the wells already enumerated the Lawton Natural Gas Company drilled one in the E. ½ NW. ¼ sec. 6. It was completed during 1907 and produced oil in the 400 foot sand but has since been abandoned.

Wells drilled by companies other than the Lawton Natural Gas Company have uniformly been failures, as none of them have produced either oil or gas in merchantable quantities. Those to the southward from the Lawton Natural Gas Company's productions were drilled to various depths ranging from 500 to 700 feet, while one in sec. 21, T. 2 N., R .11 W. is reported to have been drilled to a depth of 2,250 feet. Neither oil nor gas was found, but an antesian well, flowing the full capacity of a four inch pipe, resulted. Another well drilled about a mile farther east is reported to have produced a little gas at 500 feet.

Development in Comanche County during 1916 may be summarized as follows:

The principal development was in the Lawton field, where there are over 50 producing oil and gas wells, many of which are shallow and produce from the 400-foot sand. The shallow wells produce on the average about 10 to 15 barrels of oil daily. The deeper wells encounter a sand at a depth of 800 to 1,000 feet, the daily production being about 40 barrels of oil. Over twenty-five companies are operating in the field. Most of the tests are shallow but a few deep tests are now drilling.

In sec. 23, T. 1 N., R. 10 W., several wells were completed. The Rosedale Oil & Gas Co. obtained an initial production of about 15 barrels from a shallow sand.

In T. 2 N., R. 10 W. 7 wells were completed and 11 were drilling near the close of the year. Berber-Redding, *et al* completed a well in sec. 20, the initial production of which was about 15 barrels. In sec. 31 Epstein *et al* have drilled several wells producing about 20 barrels each, at a depth of 400 feet. Epstein and Keady completed a 40 barrel well in sec. 29 at a depth of 850 feet. In sec. 25 the Rocky Mountain Oil Company completed a small well and are drilling others. The Night & Day Oil Company, Wood & Company, Tomelson & Company, Redding *et al,* Baker, Enid Oil Company, Lawton Natural Gas Company, Culbertson *et al,* and McBee Oil Company are drilling wells in the following sections: 31, 34, 29, 32, 26, 32, 32, 30, respectively.

In sec. 25. T. 2 N., R. 11 W. Bellamy Oil Company completed a well with an initial production of 10 barrels at a depth of 185 feet. In sec. 36 of the same township and range the R. & G. Oil Company completed two wells having a production of 8 and 10 barrels respectively, at a depth of 235 feet. In sec. 36 the Black Hawk Oil Company obtained a 15 barrel well at a depth of 237 feet. About 5 wells were drilling in this township at the close of the year.

Several wells are being drilled near Lawton. The Territorial Oil & Gas Company completed a dry hole in sec. 22, T. 1 N., R. 11 W. Culbertson *et al* completed a 20 barrel well in sec. 32, T. 3 N., R. 10 W. The Substantial Oil Company is drilling a well in sec. 18, T. 4 N., R. 9 W.

Notwithstanding the number of wells that have been drilled in this field, the pool has not yet been thoroughly prospected. The "800-foot sand," which appears to be the bed from which the greatest production is to be expected, has been reached in only 13 of the wells. Of these almost half have been drilled in localities that are geologically unfavorable. The highest part of the anticline in the field lies in the SW. ¼ sec. 28, the SE. ¼ sec. 29, the NE. ¼ sec. 32, and the NW. ¼ sec. 33, T. 2 N., R. 10 W. This anticline has been tested by three wells in sec. 29, T. 2 N., R. 10 W., all of which are among the best in the field, and there is no reason why the quarter sections named above should not produce equally good wells. A dry hole has been drilled in the NW. ¼ sec. 35, T. 2 N., R. 10 W., so that it is probable that the oil and gas pool does not extend far to the southeast. The area mentioned as most promising should be tested first, and if it is found productive the pool should be traced by carefully spaced wells in a direction a little south of east from the SE. ¼ corner of sec. 29, T. 2 N., R. 10 W.

The crest of the small dome lying in sec. 31 has not been tested by wells that reached the lowest sand, although wells that obtain showings of oil in this sand have been drilled east and northwest of it. Before the dome can be regarded as fully tested, one well deep enough to reach the "800-foot sand" should be drilled on the crest of this dome, as indicated on figure 4. A test might also be made in the NW. 1/4 sec. 24, T. 2 N., R. 11 W., northwest of the asphalt seep that occurs near the center of the section, although this territory is probably not so promising as that 2 miles southeast of it.

It is reasonable to believe that by careful testing of the areas outlined a profitable though small field may be developed in the Lawton anticline which will supply sufficient gas for the use of Lawton and give a moderate production of oil. Whether or not oil exists on the low arch of the Permian strata between the Wichita and Arbuckle uplifts it is impossible to say. The crest of this arch can not be very accurately defined but probably extends from the Lawton field east and south to the southeast corner of T. 2 N., R. 10 W., thence to about the middle of the east line of T. 1 N., R. 9 W., and from this point southeastward, passing south of the town of Duncan. Prospecting along this axis, while it may be productive of valuable results, will probably be very hazardous financially and should be undertaken only by companies that can well afford to risk considerable sums in such work.

ASPHALT SEEPS AND OCCURRENCES OF OIL AND GAS IN THE VICINITY OF THE WICHITA MOUNTAINS.*

No report on the Lawton field would be complete without mention of the numerous asphalt seeps and showings of oil and gas which occur in the region of the Wichita Mountains within and near the field.

Asphalt is formed by the evaporation and oxidation of petroleum, and its occurrence is in itself an indication of the presence of petroleum, now or in times past, in the vicinity, although not necessarily immediately below the seep. It is not to be regarded as proof of the presence of petroleum in commercial quantity. An asphalt seep may be derived from only a small accumulation of petroleum, or the reservoir which furnished the asphaltic material may have been drained of the greater part of its contents by the asphalt seep itself. The possibility of the migration of the oil for considerable distances along the sandstone beds of the Permian has been suggested * * * and it is evident that the oil from which the asphalt seeps were formed may have traveled for a considerable distance from its original source. The same is true of the "showings" of oil or gas which are observed in many wells sunk for water. Although such indications are found in most large oil fields, yet they may also be observed in many places in which oil and gas do not occur in commercial quantity.

A list of the occurrences of oil, gas, and asphalt in the vicinity of the Wichita Mountains, with a brief description of the localities, is given below.

T. 2 N., R. 11 W.

SW. 1/4 NE. 1/4 sec. 21 (elevation of asphalt, 1,089 feet), in the east bank of the creek a little north of the junction of the main stream with a small

*Wegemann, C. H., op. cit. pp. 80-84.

draw entering from the east. Here fine shaly sandstone is impregnated with and smells of petroleum for approximately 150 feet along its outcrop. The layers of shaly sandstone carrying the petroleum are not over 6 inches thick and are interbedded with shale that does not show oil. At one place asphalt oozes from the containing rock. There are small faults in the beds here, but no pronounced break. The oil probably migrates to the surface along joints or small fault planes. About 10 feet above the asphalt is dark-red shale. Underlying this and including the sandy layers bearing the asphalt is greenish-gray shale which weathers to gumbo.

SW. ¼ NE. ¼ sec. 24, asphalt impregnating a bed of sandstone which is also exposed on several rounded knolls a mile or so to the northwest. The outcrop occurs at the head of a small draw draining toward the northwest wnich has been dammed to form a "tank," or water reservoir. The rock is a medium-grained sandstone, of which 3 or 4 feet is exposed at the surface and a greater thickness is probably concealed. The impregnation with asphalt or oil is so thorough that specimens of the rock are plastic and sticky. This asphaltic rock has been quarried.

NE. ¼ NE. ¼ sec. 24. In the bottom of a small draw opening southward just south of the Fort Sill Military Reservation a small spring issues from sandstone, and the surface of the water is covered with a scum of heavy oil, which is seen also on the bed of the draw for a few feet downstream. Apparently the oil comes from some bed beneath the sandstone exposed at the surface, for this rock shows no impregnation of oil.

T. 3 N., R. 11 W.

SW. ¼ NE. ¼ and SW. ¼ NW. ¼ SE. ¼ sec. 9. In three small southward-opening draws that drain the S. ½ sec. 10 seepages of asphalt or asphaltic oil occur at about the same elevation, as if derived from one bed. The asphalt flows out of joints in red shale about 3 feet below a conglomerate of shale and sandstone. This conglomerate forms the base of a mass of sandstone which is probably the same as that capping the higher rounded knobs in sec. 14, T. 2 N., R. 11 W., and also that in which the asphalt occurs in sec. 24, T. 2 N., R. 11 W. The most westerly seep arises in an oil-soaked mud cone which holds about a pailful of thick black asphaltic oil. About 150 feet down this draw to the south sulphur water issues from a small spring.

T. 4 N., R. 11 W.

SE. ¼ SW. ¼ sec. 30. A dug well 72 feet in depth is reported to have struck a dark heavy oil amounting to 4 or 5 barrels.

SE. ¼ NE. ¼ sec. 32. About 10 feet of asphaltic sandstone, containing conglomerate in certain layers, is exposed in the bed of the creek. Asphalt impregnates several layers of the sandstone. The beds dip about 1° N. or NE. and are about 40 feet below the base of the sandstone which caps the highest rounded knoll in sec. 14, T. 2 N., R. 11 W.

NW. ¼ NW. ¼ sec. 34. It is reported that in a well drilled to a depth of 500 or 600 feet enough gas was encountered to burn for three weeks with a flame that could be seen for some distance. The report has not been verified.

NW. 1/4 SW. 1/4 sec. 26. About 8 feet of sandstone, some of which is impregnated with asphalt, is exposed east of the schoolhouse, on each side of a draw opening to the north. The rock has been quarried and is said to have been used in Lawton for paving. The sandstone probably represents one of the upper beds of the sandstone outcropping in the high knob of sec. 14, T. 2 N., R. 11 W.

T. 2 N., R. 12 W.

NW. 1/4 NE. 1/4 sec. 34. On the west side of a southward-flowing stream 8 to 12 feet of fine-grained and much cross-bedded sandstone is exposed. Asphalt impregnates the beds irregularly and appears to be more abundant in the thicker layers. Asphalt-bearing sandstone in considerable amount has been quarried at this locality for use in paving the streets of Lawton.

SW. 1/4 NW. 1/4 sec. 21. On both sides of a small draw which runs north about 10 feet of sandstone is exposed and is underlain by red shale. The sandstone is fine-grained, somewhat cross-bedded, and irregularly impregnated with asphalt. It has been prospected by small open pits about 4 feet in depth.

SE. 1/4 SE. 1/4 sec. 17. Asphalt impregnates sandy layers or lenses in a sandy limestone in the roadbed where the east-west section line crosses the limestone, which is exposed in a ridge to the southwest. The exposure occurs on the north side of the road where the road has been graded.

T. 3 N., R. 12 W.

Oil occurs along the bed of a draw opening east into Cache Creek in the Fort Sill Military Reservation, in what would be the NE. 1/4 sec. 29 were the land sectionized. The oil is contained in a cemented breccia or conglomerate of granitic rock that crops out along the creek bed and on its banks and may represent the basal conglomerate of the Permian. The outcrop lies close to the granite area. It is probable that the presence of the oil is due either to upward migration from some source farther to the east * * * or petroleum along the unconformity at the base of the Permian or to downward migration from "Red Beds" that formerly covered this area but have been removed by erosion. The rock, which is composed of fragments of altered rhyolite, yields on heating in a test tube a light-yellow oil.

T. 5 N., R. 12 W.

NE. 1/4 NE. 1/4 sec. 7. Oil is reported in a water well at 70 feet.

NE. 1/4 NW. 1/4 sec. 17. Oil is reported in a drilled well at 250 feet.

T. 2 N., R. 13 W.

SW. 1/2 SW. 1/4 SE. 1/4 sec. 15. On the west bank of a stream flowing southeast a large ledge of massive sandstone is impregnated in some layers with asphalt.

SW. ¼ SW. ¼ NE. ¼ sec. 22. Farther down the same stream what is probably the same massive sandstone bed outcrops in one small exposure on the northwest bank and bears asphalt.

T. 5 N., R. 13 W.

NE. ¼ NE. ¼ sec. 6. "Wildcat" well. No information is available.

T. 1 N., R. 14 W.

NW. ¼ NW. ¼ sec. 1. A dug well is said to have shown oil at a depth of 10 feet. When examined no trace of oil was seen.

SW. ¼ SW. ¼ SW. ¼ sec. 2. In grading the road across a sandstone outcrop a small spring was opened which when first discovered is said to have smelled of oil. No trace of oil was apparent at the time of examination.

T. 2 N., R. 14 W.

SE. ¼ sec. 36. On both sides of the creek flowing southeastward across the section are exposures of massive sandstone. Asphalt is reported from one place on the southwest bank of the creek, but no asphalt could be found on examination.

NE. ¼ NE. ¼ NW. ¼ sec. 24. North of the town of Cache a well drilled in 1904 is reported to have obtained a show of oil at a depth of 500 feet or more.

SE. ¼ SE. ¼ sec. 25. A well is reported to have shown oil. No indications were observed on examination.

T. 5 N., R. 14 W.

SE. ¼ SE. ¼ sec. 18. Oil occurs in a water well.

T. 6 N., R. 14 W.

SW. ¼ SW. ¼ sec. 32 (J. H. Madden farm.) Oil is reported in a water well.

T. 6 N., R. 15 W.

SE. ¼ SE. ¼ SW. ¼ sec. 23 (Fox farm.) Oil is reported to have been struck in a well at a depth of 75 feet, in 7-foot sand. Oil is said to have been bailed from this well.

NW. ¼ NW. ¼ sec. 23. "Showing" of oil is reported in a well 90 feet deep.

SW. ¼ SW. ¼ sec. 23. Oil is reported in a well at a depth of about 100 feet, in a sufficient quantity to be used in the vicinity.

NW. ¼ sec. 13. Gas is said to have been encountered in a water well

NW. ¼ sec. 11. Scum of oil occurs on water in a well on the Van Kirk farm. Southeast of this well is another which has a slight flow of water, and three "showings" of oil are reported from the well in 400 feet.

SW. ¼ sec. 12. A water well on the T. A. Cook farm is said to have showed traces of oil and gas. Oil was struck at a depth of 280 feet.

NW. ¼ sec. 2. Oil is reported in a well on the Givens farm.

SE. ¼ SE. ¼ sec. 19. A showing of oil was seen at the time of examination in a well 42 feet deep on the Reynolds farm. After the well is pumped nearly dry, globules of oil may be observed on the water.

SE. 1/4 sec. 29. Water in a well about 80 feet in depth is reported to show a "rainbow" of oil.

SW. 1/4 SW. 1/4 sec. 31. "Showing" of oil is reported in a water well. Sugar Creek flows across E. 1/2 secs. 32 and 29, and oil is reported to seep from its banks in warm weather. The report was not verified.

T. 7 N., R. 15 W.

NW. 1/4 sec. 13. A 40-foot well in this section is said to have struck a "pocket of oil" in drilling for water. The report was not verified.

NW. 1/4 sec. 24. A well 1,000 feet deep on the Franklin farm is said to have struck oil and gas at about 900 feet. The well is now flowing fresh water.

T. 1 S., R. 10 W.

NE. 1/4 sec. 27. In a draw which discharges northeastward across the NE. 1/4 sec. 27 several thin ledges of sandstone crop out. At one place a specimen was collected from which a light-yellow distillate of petroleum was obtained, on heating in a test tube.

Log of well in SE. 1/4 sec. 1, T. 4 N., R. 12 W. Apache Oil Company.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface soil and shale	25	25	Black slate	45	1,062
Blue shale	5	30	Slate and shell	4	1,066
Sandy blue shale	5	35	Soft slate	85	1,151
Blue shale	65	100	Lime	4	1,155
Dark blue shale	30	130	Very soft slate	75	1,230
Red shale	12	142	Hard white sand	6	1,236
Blue shale (red spots	10	152	Soft black slate	24	1,260
Blue shale	13	165	Dark soft shale	12	1,272
Red shale	25	190	Lime cavings	43	1,315
Light gray shale	25	215	White sand (water)	19	1,334
Gray sandy shale	5	220	Slate and shells	33	1,367
Light gray shale	5	225	Hard lime	18	1,385
Blue sandy shale	5	230	Soft dark lime	10	1,395
Light gray shale	10	240	Soft black shale	23	1,418
Red sand rock	23	263	Red rock	15	1,433
Light blue shale	12	275	White sand	17	1,450
Double sandy shale	10	285	Black slate	10	1,460
Red shale	20	305	Very hard sand	56	1,516
Blue shale	100	405	Soft shale	20	1,549
White lime shale	65	470	White sand (water)	28	1,577
Light blue lime	5	475	Blue shale	3	1,580
Red lime rock	29	504	Gritty lime	5	1,585
Chocolate limy shale	11	515	Black slate	53	1,638
Blue lime shale	20	535	Sandy lime	25	1,663
Sandstone	9	544	Soft black shale	22	1,685
Hard blue lime	11	555	Red shale	5	1,690
Red sandy mud	3	558	White sand	15	1,705
Sand (show of oil)	2	560	Black slate	3	1,708
Gray sandstone	5	565	White sand	28	1,736
Blue limestone	19	584	Black shale	20	1,756
Black sand	617	1,201	Lime shell	7	1,763
Hard gray sand	14	1,215	Soft black shale	36	1,799
Hard gray sandstone	85	1,300	White sand (water)	39	1,838

SUMMARY.

The part of the county included in the Wichita Mountains is to be eliminated from the probable oil and gas territory. This area includes about one-third of the county, embracing all of the northwestern part. In addition a considerable part of the immediately adjacent territory in which the mountain uplift is concealed by the younger rocks is not to be considered favorable for the finding of oil or gas in large quantities. It is true, however, that much of the oil and gas found in the county has been from drilling where the surface rocks were found and the oil and gas were encountered near the contact of the younger rocks with the mountain uplift. In fact, some oil has been encountered in the Arbuckle limestone of the Mountains, but it is very probable that the oil present in this formation has found its way from the overlying rocks and moving along the line of contact has followed the porous strata of the Arbuckle limestone. Practically every well drilled to the contact line or near this horizon gives at least a showing of oil or gas. However, very few wells have found either of these materials in large quantities.

At localities farther removed from the Mountains, and especially in the Lawton oil and gas field east of the city of Lawton, some fairly good shallow production has been found. The oil and gas occurs at various depths, ranging from 100 feet to 900 feet. The greatest yield of oil has been from what is termed the "800-foot" sand. Some wells have been reported to make 100 barrels daily, but from information gathered it seems that a better estimate is from 25 to 50 barrels daily from the best producers. Some miscellaneous drilling has been done in the county, but largely without regard to favorable structure. The eastern and southern parts of the county afford good prospective territory. The recent finding of favorable structure in adjacent areas may furnish additional data for the determination of the more favorable locations for the drilling of test wells.

COTTON COUNTY.

LOCATION.

Cotton County, of which Walter is the county seat, is located in the southwestern part of the State in the tier of counties just north of Red River and bordering Texas. It extends from T. 5 S. to T. 1 S. inclusive, and approximately from R. 9 W. to R. 14 W. inclusive. It includes 12 whole townships and parts of 13 others. The total area is approximately 640 square miles.

TOPOGRAPHY.

Cotton County lies in the area of the Redbeds Plains. In general the surface is a gently rolling plain. This plain has been the result of base leveling due to stream erosion in some former age, possibly in the Tertiary. The channel of Red River has cut down about 100 feet below the level of this plain. Variations from the normal topography are: (1) A few isolated hills capped by a sandstone more resistant than the associated formations, and (2) many large washes or "breaks" making a badlands type of topography. It is in these last mentioned places that the Permian rocks are exposed.

Red River, the largest stream in this part of the State, is the boundary line between Texas and Oklahoma. The average fall of this stream is about 3.5 feet to the mile in this area. The width of the valley is usually from 1 to 1½ miles. The principal tributary to Red River in Cotton County is Cache Creek. This stream and its tributaries, the most important of which is Deep Red Run, drain the whole county, with the exception of a small area in the northeastern part of the county which is drained by tributaries to Beaver Creek.

GEOLOGY.

The surface of Cotton County is made up of Permian Redbeds, Tertiary conglomerate and gravel, and Recent alluvium, and sand deposits. The Wichita formation, lower part of Permian, is the only formation of that age exposed in this area. It consists of beds of shale, sandstone, and thin beds of shale conglomerate. The Redbeds extend to at least a depth of 1,000 feet, as shown by well records.

A more detailed discussion of the topography and geology is given under the reconnaissance report of M. J. Munn on the Grandfield district and the report of C. H. Wegemann on anticlinal structure in parts of Cotton and Jefferson counties.

STRUCTURE.

The dip of the strata of the Permian Redbeds in this area is rather low, probably on the average of about 40 feet to the mile, and is not constant in direction. The prevailing dip appears to be to the south and southwest.

The southern part of the county has been examined from a geological standpoint for the discovery of structure favorable for the accumulation of oil and gas. During the last three years cooperative work between the Oklahoma Geological Survey and the United States Geological Survey has been carried on in this region. In Cotton, Tillman, Jefferson, Stephens, Comanche, and Carter counties some work has been done. Covering the southwestern portion of this area the United States Geological Survey has published Bulletin No. 547: A Reconnaissance of the Grandfield District, Oklahoma. This publication contains both structural and geologic maps of the region in addition to the general discussion. A report has also been made by C. H. Wegemann of the United States Geological Survey in connection with the Oklahoma Geological Survey. This covers the area to the east of Grandfield, extending as far west as Waurika. This publication is entitled: Anticlinal structure in parts of Cotton and Jefferson counties, Oklahoma.

The main portion of these reports mentioned above are included in this publication. The former is given under Cotton County and the latter under Jefferson County.

DETAILED SURVEY OF SPECIAL AREAS.

STRUCTURE NEAR APHEATONE.

Recent reconnaissance trips by members of the Survey have shown at least two anticlines of probable value lying in the vicinity of Apheatone and to the east. A well drilled about two years ago in sec. 26, T. 2 S., R. 13 W., about 2½ miles north of Apheatone, is located in the bottom of the syncline. A well record shows at least seven sands of importance in the 1,300 feet drilled. An abundant supply of fresh water in the upper sands and salt water in the lower sands was secured. A showing of oil was reported but has not been credited.

RECONNAISSANCE OF THE GRANDFIELD DISTRICT*.

LOCATION.

The Grandfield district as arbitrarily outlined in this report embraces about 360 square miles in southern Oklahoma, including the southeastern part of Tilllman County and the southwestern part of Cotton County. This district, which is bounded on the south by Red River, includes those parts of Tps. 3, 4, and 5, Rs. 12, 13, 14, and 15 W., that lie in Oklahoma; that part of T. 4 S., R. 11 W., that lies south of Deep Red Run; the west half of the area in T. 5 S., R. 11 W., that lies north of Red River; the southeast quarter of T. 3 S., the east half of T. 4 S., and the portion of T. 5 S., R. 16 W., that lies north of Red River. The district is named from Grandfield, the largest town within it, which stands near its center.

DRAINAGE AND TOPOGRAPHY.

The Grandfield district is drained by Red River and Deep Red Run, a tributary of Cache Creek, which empties into Red River from the north. Red River has an average fall across this district of 3½ to 4½ feet a mile. It flows in a relatively narrow flood plain, ranging in width from 1 to 1½ miles, bounded on both sides by bluffs covered by sand dunes and having a maximum elevation of about 175 feet above the river. The river bed is very broad in comparison with the width of its flood plain, being a most places from three-fourths of a mile to over a mile wide. At low water the river beds consist largely of shifting sand, across which narrow, shallow streams meander.

In contrast with Red River, Deep Red Run flows in a narrow channel 20 to 60 feet wide and 20 to 30 feet deep, across a flat alluvial flood plain ranging in width from 1 to 1½ miles. The average fall of this stream is about 4½ feet to the mile.

The interstream area is a smooth, slightly undulating, treeless prairie, into which the smaller streams have cut very slightly except near their mouths. The notable features of the topography are (1) the broad, smooth surfaces, (2) a few low, round isolated hills adjacent to the

*Munn, M. J., Reconnaissance of the Grandfield district: U. S. Geol. Survey Bull. No. 547, 1914.

divides, preserved by a capping of more resistant rocks, and (3) the many large "breaks" or washes similar in character to the well-known badlands of other portions of the West.

The "breaks" are of special importance to the geologist because they expose most of the beds of Permian rocks on which a map of the geologic structure of this area must be based. They consist of low bluffs, most of them roughly crescent shaped, from a few feet to half a mile in length, and having heights ranging from 5 to 20 feet, though at places adjacent to the larger streams they are somewhat higher. These "breaks" have been formed chiefly by the direct action of rain falling on the steep, bare, slopes of the very fine soft red clay of the "Red Beds." Most of them probably originated as small "potholes" dug out by running water of freshets pouring over small obstacles along the bottoms of "draws." "Breaks" thus started develop at all angles to the original drainage courses and some of them cut back across the crests of secondary ridges to points where water falling on the hillside, a few inches from the edge of the "break," flows directly away from it. Apparently one of the necessary conditions for the formation of a "break" is the presence of a more or less resistant layer above the soft red clay, so as to preserve a steel local slope. This resistant layer consists of a firm sod of grass at the surface, or, very often, of thin beds of soft sandstone, limestone, or conglomerate embedded in the fine red clay that makes up the greater portion of the section exposed in this district.

STRATIGRAPHY.

ROCKS NOT EXPOSED IN THE DISTRICT.

Permian Rocks.

The lowest outcropping rocks in the Grandfield district are "Red Beds" of Permian age. Very few geologic facts regarding the age and character of the rocks which underlie those that outcrop have been derived from this district. The relatively small amount of data at hand pertaining to the rocks not exposed in this district comes from the partial logs of three deep wells drilled for oil and gas in or near it, from logs of similar wells in the adjacent developed oil fields of northern Texas, and from outcrops of lower formations at more distant places in Oklahoma and Texas. The data indicate that the upper portion of unexposed beds is of Permian age and that this series is underlain by older Carboniferous beds of the Pennsylvanian series. The beds of the upper part of the Pennsylvanian are very similar to those of the lower part of the Permian in this district, so that the line of division between them can not be determined from the well records alone.

In Texas the contact between the Permian and the Pennsylvanian series comes to the surface south and southeast of the Grandfield district in a broad belt extending south-southwest from Clay and Montague counties, Tex., to the central part of the state. Along this belt the Wichita formation of the Permian appears to lie conformably upon the Cisco formation of the Pennsylvanian. This contact is also exposed at many places north and northeast of the Grandfield district in Oklahoma along the southern border of the Wichita and Arbuckle mountains, where the Permian "Red Beds," lying practically horizontal, rest unconformably on the sharply folded beds of the Pennsylvanian. The stratigraphic relation of these two great series of rocks in the large area that lies between the exposures of the Permian-Pennsylvania contact and that includes the Grandfield district is not known. A brief study of each of them at the places nearest to the Grandfield district where they are best exposed may be of some value in determining the general character of the rocks underlying the beds exposed in this district.

Pennsylvanian and Older Rocks.

In Clay, Montague, and Archer counties, Tex., where the rocks of the Pennsylvanian series are exposed, they are divided by Gordon[1] into the following formations, tabluated from top to bottom:

Section of Pennsylvanian formations in Wichita region, Tex.

	Feet
Cisco formation (clay, shale, conglomerate, and sandstone with some limestone and coal)	800
Canyon formation (alternating beds of limestone and clay, with some sandstone and conglomerate)	800
Strawn formation (alternating beds of sandstone and clay, with some conglomerate and shale; the lower 1,000 feet consists of blue and black clay locally containing beds of limestone, sandstone, or sandy shale, and a coal seam at the top	1,900
	3,500

Farther southwest in Texas in the upper division of the Strawn is said[2] to reach a maximum thickness of 3,000 feet, the whole formation being about 4,000 feet thick.

Under the Strawn formation in the Colorado coal field of Texas lies the Bend series of the Texas Geological Survey, consisting principally of limestone and shale, which is of Pennsylvanian age in its upper part and of Mississippian age in its lower part. Gordon[3] gives the combined thickness of the Pennsylvanian and Mississippian series at about 7,000 feet in this region.

Along the southern borders of the Wichita and Arbuckle mountains in Oklahoma north and northeast of the Grandfield district the Pennsylvanian and older rocks, originally deposited in a relatively horizontal position, have since been elevated and thrown into steep folds by the great crustal uplifts that formed the Wichita and Arbuckle mountains. The old granite floor of the ancient sea in which the oldest sedimentary

1. Gordon, C. H., Geology and underground waters of the Wichita region, north-central Texas: U. S. Geol. Survey, Water-Supply paper 317, p. 14, 1913.

2. Gordon, C. H., op. cit., p. 15.

3. Gordon, C. H., The Wichita formation in northern Texas: Jour. Geology, vol. 19, No. 2, p. 116, 1911.

beds of Cambrian age were laid down now constitutes the very resistant central cores of these mountains. Much of the strata which once arched over the old igneous rocks were removed by erosion before a later subsidence of the surface and encroachment of the sea allowed the deposition of the "Red Beds" in horizontal layers across the upturned edges of the older rocks. Since the "Red Beds" were deposited the region has been elevated to its present height, and streams have cut fairly deep valleys into them at many places adjacent to the mountains, where they were thin, exposing the older folded beds beneath. In the area indicated the Pennsylvanian rocks generally dip south or southwest beneath the less folded Permian beds. The southern extent of this unconformity between the Pennsylvanian and Permian is unknown, but, as noted above, the unconformity has not been observed in the next outcrops of these beds toward the south, in Texas.

The seemingly local character of the violent crustal movements which produced the Wichita and Arbuckle mountains suggest that the disturbance did not extend far south of a line joining these mountain areas and that the unconformity between the Pennsylvanian and Permian rocks dies out rapidly toward the south, terminating at a roughly east-west line in southern Oklahoma, beyond which there was seemingly continuous deposition throughout Pennsylvanian and Permian time.

No exposures of rocks older than Permian are known to occur for hundreds of miles west of the Grandfield district, and no data are available concerning the beds in that direction that will indicate the probable character of the rocks concealed in this district within reach of the drill. The presence, however, of Pennsylvanian rocks beneath the "Red Beds" on three sides of the Grandfield district suggests strongly that the ancient seas in which the beds were deposited covered territory extending westward over many thousands of square miles and that the beds beneath the "Red Beds" in the Grandfield district are probably similar to those which are exposed around it.

ROCKS EXPOSED IN THE DISTRICT.

Age and General Character.

In most of the Grandfield district the hard rocks are hidden beneath a superficial mantle of loose, unconsolidated material consisting of (1) dune sand, spread over a broad belt adjacent to Red River; (2) a dark or reddish sandy to clay soil, largely wind-blown, covering most of the smooth slopes of the interstream areas; and (3) a red clay-silt alluvium found in the broad, flat valleys of Deep Red Run and its tributaries. Beneath this thin veneer of Quaternary beds, exposed in many places in breaks and along the valley sides, lies a thin bed of coarse, hard quartz-lime conglomerate (here named the Grandfield conglomerate), very persistent and rarely exceeding 5 feet in thickness, which has been variously classified as of Quaternary or of late Tertiary age.[1] It is underlain unconformably by "Red Beds" of Permian age which are correlated with the Wichita formation of northern Texas.

1. Udden, J. A., and Phillips, D. McN., Geology of the oil and gas fields of Texas: Univ. Texas Bull. 246, p. 107, 1912.

Carboniferous System (Permian Series.)

Thickness and Subdivisions.

In the Grandfield district the lowest outcropping rocks are "Red Beds" of Permian age, but the total thickness of these beds can not be determined accurately from the data now available. In northern Texas, where more carefully studied by geologists, the "Red Beds" have been divided into three formations, the Wichita at the base and the Clear Fork and Double Mountain formations above. Gordon[1] estimates the thickness of the Wichita formation in Shackleford County, Tex., at 1,000 to 1,200 feet. Cummins[2] says: "These beds (the Wichita formation) are heaviest along the Big Wichita River, where they attain a thickness of 2,000 feet." He also assigns a thickness of 1,900 feet for the Clear Fork and 2,000 feet for the Double Mountain, thus giving the Permian series a maximum total thickness in northern Texas of about 5,900 feet.

It seems probable that the Clear Fork and Double Mountain formations are not present in the Grandfield district, the Permian series being represented by the lower portion of the Wichita formation. In the absence of an abundance of fossils there is no sure means of determining in well sections where the Permian leaves off and the Pennsylvanian begins. Udden[3] says:

> We know that the upper 300 feet or more at Electra belongs to the Wichita formation, and that the shales and sands penetrated from 1,400 to 2,000 feet under the surface belong to the Cisco, but how much of the intervening 1,200 feet should be allotted to each we can only guess from the lithologic appearance of the section as made known by the driller's records.

Wichita Formation.

Character and Occurrence.

In Shackleford County, Tex., the Wichita formation consists of blue clays, blue, gray, and black shales, and thick beds of blue, gray, and yellowish limestones. Northward from this county the thickness of the limestone decreases abruptly and the thickness of the sandstone and shale correspondingly increases. In Archer and Baylor counties the formation contains prominent beds of red, white, and yellowish sandstone. The limestone dimishes in amount northward and practically disappears from the formation south of Red River, and in the same direction there is a rapid increase in the amount of red material, consisting largely of red clay and soft sandstone. The upper portion of the Pennsylvanian series apparently shows the same change from blue to red sediments northward toward Red River from Young County, Tex., and where the contact between

1. Gordon, C. H., Geology and underground waters of the Wichita region, north-central Texas: U. S. Geol. Survey Water-Supply Paper 317, 1913.

2. Cummins, W. F., Texas Geol. Survey Second Ann. Rept., p. 401, 1890.

3. Udden, J. A., and Phillips, D. McN., Geology of the oil and gas fields of Texas: Univ. Texas Bull. 246, p. 86.

these two series is not exposed at the surface in Wichita and Clay counties it becomes more and more difficult to trace it northward by well records to the Grandfield district.

As already noted, the lowest rocks exposed in the Grandfield district belong to the Wichita formation. They outcrop along the bluffs of Red River in T. 5., Rs. 11 and 12 W., and consist of gray and red sandstone, red and gray shale, red, gray, purplish clay, and thin layers of reddish to gray clay-limestone conglomerate.

The above sections are typical of the larger exposures of the Wichita formation along Red River east of R. 13. West of that range the outcrops of Permian rocks along the north bank of Red River are very scarce and are uniformly of small vertical extent. The beds exposed are usually red clay and irregular beds of gray or reddish sandstone, which can not be correlated from one outcrop to another.

Auger Conglomerate Lentil.

An exception to the rule just stated—that correlations of the Permian from outcrop to optcrop is impossible west of R. 13—was noted along the river bluff in the northwestern part of T. 5 S., R. 15 W., and northward for several miles on the "breaks" on the east side of Auger Creek. At these places occur imperfect exposures of a thin series of gray to reddish sandstone beds separated by red clay and containing a peculiar conglomerate consisting principally of limestone with small included balls of red and gray clay. These beds are so characteristic that they may be recognized with certainty at many places over the area back from Red River. The clay-limestone conglomerate and its associated beds of sandstone are here named the Auger conglomerate lentil, from the exposures on Auger Creek and also at "Old Fort Auger," the site of which is in the N. ½ sec. 6, T. 5 S., R. 15 W.

These beds change greatly in thickness and appearance within the length of this outcrop and from one exposure to another. The conglomerate layers are everywhere very variable and are in places entirely absent. The sandstones are also very changeable in character and appearance, but the series taken as a whole, where well exposed, can be identified with reasonable certainty. Fortunately for the determination of the structure in this district the Auger conglomerate lentil outcrops at many places on streams tributary to Red River from the north, and on Deep Red Run and its tributaries from the south, from Rs. 11 to 16 W.***

No single exposure is typical of this conglomerate lentil, because each bed is variable from place to place. However, the lentil as a whole does not change so much from one outcrop to another that it may not be recognized wherever exposures are good. Toward the east, in Rs. 12 and 11, the clay-limestone conglomerate bed becomes more sandy and loses its characteristic lumpy conglomeratic appearance. If the writers correlations are correct the conglomerate bed becomes darker and harder toward the east, and in many places has the smooth-grained appearance of calcareous, somewhat ferruginous sandstone and weathers out of the inclosed sandstone in irregular, slab like lenses or more or less round to flattish concretionary masses, some of which are several feet in length.

The thin layers of sandstone in the red clay noted near the base of the above section appear to grow thicker toward the east, and in that direction other sandstones appear in the red clay at points in the stratigraphic section farther below the Auger lentil. The clay-limestone bed of the Auger lentil is generally present along the south side of Deep Red Run through R. 13, but in Rs. 12 and 11 the clay pebble content seems to be largely replaced by sand, making dark, hard, very limy sandstone concretions and slab like lenses in the gray "speckled" sandstone. The following section is generally typical of the Auger conglomerate in Rs. 11 and 12 W.

Section of Auger conglomerate lentil exposed in a small butte in SW. ¼ NE. ¼ sec. 13, T. 4 S., R. 12 W., about 4 miles northeast of Randlett.

		Feet.
1.	Sandstone, whitish to dark, with many large dark plate-like to roundish sand-limestone lenses from 1 to several feet in length. These lenses seem to be colored by a dark brittle substance, probably a manganese mineral	4
2.	Sandstone, soft, whitish, rather massive to thin bedded, carrying a "speckled" layer (gray sandstone with small black specks) toward the top and a dark mottled grayish to very dark sand-limestone bed at the base, which seems to contain considerable quantities of mineral resembling wad	4-6
3.	Sandstone, soft, white (in places bluish white), thin-bedded to massive; very irregular in distribution and thickness; seems to be cut out in places by underlying red clay; greatest thickness	3
4.	Clay, bright red, with very few grayish limestone concretions and some scattered gray spots a few inches in diameter	9
5.	Sandstone, massive, lumpy, reddish, very clayey; disappears to sandy red clayey shale within 100 feet	7
6.	Clay, red, tough; changes in places to clayey shale	10
7.	Sandstone, milk-white to bluish white (very conspicuous), massive, blocky, very irregular in distribution, changes to a few inches of ripple-marked reddish clayey thin-bedded sandstone within 50 feet; greatest thickness	4
8.	Clay, red, containing concretions of rough roundish limestone of peculiar burnt brick-red color. Other beds of this clay carry roundish concretions from 2 to 4 inches in diameter containing beautifully developed crystals of barite and also some peculiar brownish-yellow limestone concretions which fracture into halves. The thickness of these beds of clay could not be determined but is probably about	15
9.	Sandstone, reddish, massive to thin bedded, very irregular bedded and poorly exposed. This sandstone, with interbedded red clay, extends down to bed of Deep Red Run	20
		69-78

In this exposure sandstones 1 and 2 are very probably beds of the Auger lentil, which in the previous section includes the lower layer of the clay-limestone conglomerate but they may represent the upper layer of the Auger conglomerate, which in some places occurs a few feet above the speckled sandstone layer. Sandstone 3 is probably the irregular bluish-white layer that normally underlies the upper conglomerate layer of the Auger lentil.

The beds at the base of the above section are better exposed about 2 miles west of the section, where the rocks outcrop along the edges of a large "break" or "wash" covering several hundred acres.

Tertiary or Quaternary System.

Grandfield Conglomerate.

In this district there was observed at many places a thin bed of peculiar reddish conglomerate, consisting of a matrix of red clay and limestone inclosing many pebbles of quartz, quartzite, and a few of granite, together with fragments of chert and occasional pieces of limestone and silicified wood. The pebbles are waterworn and in general fairly well rounded, and the largest are 3 inches or more in diameter. This conglomerate is a compact, indurated bed, surprisingly uniform in character and probably averaging 3 or 4 feet in thickness. It is widely exposed, outcropping at many places on the broad divide between Red River and Deep Red Run and along both sides of the valley of the latter stream across the district. It is here named the Grandfield conglomerate, from the town of Grandfield, where it is well exposed on the south rim of the hill on which the town is built. It lies just below the surface at many places in this town. It also caps a dome-shaped hill, known locally as Curtis Hill, in the N. ½ sec. 13, T. 4 S., R. 15 W., and is found along the noses of the hills adjacent to most of the large tributaries to Deep Red Run from the north in this district.

The Grandfield conglomerate elsewhere lies unconformably upon the Wichita formation (Permian), and displays a structure that is surprisingly conformable to the present topography, being high on the divides and low near the valleys.****

The unconformity at the base of this conglomerate is clearly marked. It seems to be least at the south, where in places as much as 50 feet of red clay intervenes between the Grandfield conglomerate and the Auger conglomerate lentil below, and greatest toward the north, where in places the Grandfield conglomerate cuts out entirely the Auger lentil and rests on red clay several feet below its horizon.

Quaternary System.

Gravels.—Thin beds of loose gravel consisting largely of quartz, quartzite, and some chert were found at a number of places adjacent to the larger streams. As stated above, this gravel was probably derived from the disintegration of the Grandfield conglomerate and deposited at favorable places by the streams. Some of these beds of gravel seem to occupy poorly preserved terraces a few feet above the present valleys. A thin bed of fine quartz gravel, prevailingly amber colored, underlies the deep dune sand at the top of the bluffs at a few places on the north side of Red River in Rs. 11 to 15, inclusive, but a detailed study of this bed was not made.

At a number of places scattered quartz and quartzite, well-rounded to subangular pebbles, the largest 4 inches in diameter, were seen on the surface along the broad divide between Red River and Deep Red Run. The position of some of these pebbles seems to preclude the possibility that they were derived from the Grandfield conglomerate, and it seems probable that they are, in part at least, remnants of later deposits.

Alluvium.—Deep Red Run and all its larger tributaries flow in relatively broad, flat, alluvium-filled valleys. This alluvium is a fine to sandy red clay and silt, derived from the exposed rocks of the interstream areas. Red River, which, as already stated, has a very narrow flood plain and a broad bed, is closely bordered by dunes of wind-blown sand that rise as much as 100 feet above flood level. Throughout most of the year the bed of the river is dry, thin threads of water meandering from side to side across flat bars of sand and mud.*****

Dune sand and soil.—A belt of country, 1 to 2 miles wide, adjacent to Red River, extending across this district, is covered by hills of drifting sand, some of which reach a height of probably 75 feet above the general level. Permian beds lying inland from these sand dunes are covered by a thick bed of wind-blown sand, which forms a fairly even surface and through which the streams have trenched narrow ditch-like valleys. Farther back from Red River, toward the top of the divide between that stream and Deep Red Run, the mantle of wind-blown material grows thinner and finer until in places it has the general appearance of coarse loess, and in other places the soil is dark or black and seems to contain a relatively small amount of wind-blown material.

STRUCTURE.

The structure of the rocks in the Grandfield district has not been determined in detail, and in some parts of the district it is too obscure to be mapped with any degree of certainty. This structure is shown on Plate IV by numbers indicating the elevation above sea level of the Auger conglomerate lentil and also by structure contours connecting points of equal elevation on this bed. These contours are drawn on the horizon of the Auger conglomerate, but owing to the variability of the beds that make up this conglomerate no definite layer could be used as a key horizon throughout the area, so the elevations of this lentil may be locally as much as 10 feet in error.

DEVOL ANTICLINE.

The most important structural feature recognized in this brief reconnaissance of the district is an anticline that crosses it in a sinuous line trending generally east-southeast and west-northwest. Along the axis of this anticline lie a number of small elongated domes that are separated by low structural saddles. The rocks over the entire district generally dip eastward, and this dip is shown in the height of the Devol anticline. The axis of this fold in the Auger conglomerate dips from an elevation of about 1,160 feet at the western side of the district to about 1,040 feet at its eastern edge, a distance of about 24 miles. Within the district the highest portion of this anticline is in its western part, on one of two local domes, one near the center and the other in the extreme northwest corner of T. 4 S., R. 15 W., and the adjacent portions of T. 3 S., R. 15 W., and Tps. 3 and 4 S., R. 16 W. From near the center of T. 4 S., R. 15 W., the rocks dip in all directions but mostly to the north and south. There is evidence that a secondary fold trends almost south from the center of this dome through secs. 21 and 22 and possibly into or through secs. 27, 28, 33, 34, and 35, and in this general direction to Red River, but no direct evidence of this fold was obtained further south than secs. 27 and 28. From this dome another secondary fold appears to trend eastward to the vicinity of Curtis Hill in sec. 13, and from this point southeastward its axis passes through secs. 9, 28, 29, 30, 33, and possibly sec. 34, T. 4 S., R. 14 W. The axis of this fold is rather definitely located as far south as sec. 29, T. 4 S., R. 14 W., and there is some evidence of its presence still farther southeast, but its position could not be determined with certainty beyond the point indicated. From this dome eastward along the axis of the fold the rocks pitch slightly to the northeast corner of T. 4 S., R. 15 W. They rise again to the top of a small elongated dome in the vicinity of Grandfield.

A similar dome occurs in secs. 6, 7, 8, 9, and 16, T. 4 S., R. 13 W. This is separated from the dome at Grandfield, by a flat saddle in the northern portion of sec. 2 T. 4 S., R. 14 W.

There appears to be a somewhat smaller dome in secs. 25, 26, and 27, T. 4 S., R. 13 W., but owing to lack of outcrops south of this location the outline of this dome could not be determined. From the center of this dome eastward the rocks appear to pitch gradually along the axis of the fold to some point near the center of sec. 26, T. 4 S., R. 12 W., from which they rise slightly to a small dome in secs. 24 and 25, T. 4 S., R. 12 W., and possibly in sec. 30, T. 4 S., R. 11 W,. beyond which point the position of the axis of this fold could not be traced.

DEEP RED SYNCLINE.

Another important structural feature of this district is a broad, flat syncline or structural trough which lies north of and roughly parallel to the Devol anticline. The axis of this fold pitches slightly toward the east, but is somewhat modified by one or two shallow basins. The exact position of the axis of this syncline at many places could not be determined. The available data indicate that it passes a short distance south of Loveland in a northwest-southeast direction that is roughly coincident with the trend of the valley of Slough Fork of Deep Red Run. There appears to be a shallow basin in the bottom of this trough west and northwest of Loveland, in sec. 8, T. 3 S., R. 14 W. From this basin the axis of the trough seems to rise slightly to a point southwest of Loveland and thence to pitch eastward at a very low angle to some point near the northwest corner of sec. 21, T. 3 S., R. 14 W., which is the bottom of a small basin along this trough.

A similar larger and deeper basin along the axis of this trough is in sec. 13, T. 3 S., R. 14 W., and secs. 17 and 18, T. 3 S., R. 13 W. From the center of this basin there seems to be a slight rise in the trough to the southwest corner of sec. 16, T. 3 S., R. 13 W. From this point eastward the depth and position of this trough is uncertain, but the available evidence suggests that it becomes deeper and lower toward the east.

MINOR ANTICLINES.

There are indications of the presence of several minor folds in the Grandfield district, the most important of which is a clearly marked anticline that is partially revealed by outcrops in the bluffs of Red River in the southwestern portion of T. 5 S., R. 12 W. These outcrops, in secs. 30, 31, and 32, show a very marked dip to the northwest, amounting probably to as much as 100 feet within less than 1½ miles.

Udden[1] maps a very pronounced fold, with a northeast-southwest trend, in the Petrolia oil and gas field in the northern part of Clay County, Tex. His larger map[2], which shows the general dip of the rocks of the region, gives some evidence that this fold continues toward the northwest and that it may cross Red River somewhere in the southern part of T. 5 S., R. 12 W., in the Grandfield district; so it seems barely possible that the relatively steep dip shown by these exposures in the southwestern part of this township may be on the west limb of this fold. If this is true, the fold may have a north-northwest trend through this township, the axis crossing the northwestern part of T. 5 S., R. 13 W., and joining the Devol anticline at the small dome in the southeastern part of T. 4 S., R. 13 W., but there is no direct geologic evidence to substantiate this suggestion. On the other hand, it seems probable that the Burkburnett oil fields, which lie between 4 and 5 miles west-southwest of these outcrops, may be on an anticline, and that, if this anticline trends east-northeast south-southwest, it may be the same as that shown by the outcrops in the southwestern part of T. 5 S., R. 12 W. If this is true, the axis of the Burkburnett fold may continue northeastward and be shown by the exposures in secs. 9, 10, 15, and 16, and 1 and 2 of T. 5 S., R. 12 W. The evidence for each of these two structural conditions is about equal. It is impossible to determine the structural conditions in T. 5 S., R. 12 W., except that the southern portion of this township, especially secs. 28, 29, 32, and 33, are on or near the axis of a pronounced anticline, the trend of which is uncertain.

The rocks north of the Deep Red syncline appear to rise rather uniformly but the exposures are too poor and too scarce to permit a close delineation of the structure. Attention should be called, however, to the relatively rapid rise in the beds from this syncline northward in the northeastern part of T. 3 S., R. 14 W. The trend of the contours in this area also suggests that a local dome or anticline may be situated a short distance north of sec. 2, in T. 2 S., R. 14 W. There is also some evidence of a low fold in portions of sec. 9, T. 3 S., R. 13 W.

1. Udden, J. A., and Phillips, D. McN., Univ. Texas Bull. 246, Pl. II, 1912.
2. Indem, Pl. I.

LOCAL SYNCLINES.

South of the Devol anticline there appears to be a local syncline, the axis of which crosses T. 4 S., R. 14 W., in a northwest-southeast direction and seems to cross the valley of Big Blue Creek near its junction with Little Blue Creek and roughly to parallel the valley of the latter stream to the middle western part of sec. 7, T. 4 S., R. 14 W. The axis of this fold pitches to the southeast, but there is little or no evidence to show its trend southeast of the valley of Big Blue Creek.

A small secondary syncline appears to parallel the valley of Auger Creek in the southwestern portion of T. 4 S., R. 15 W., the pitch of the fold being somewhat steep toward the south. A similar fold is believed to lie somewhat west of the valley of Curtis Creek, in the southeastern portion of T. 4 S., R. 15 W., but owing to the poor exposures in both of these areas the exact position of these troughs can not be determined.

North of the Devol anticline small local synclines branch off from the Deep Red syncline and die out against the north limb of the Devol anticline, but none of these requires special description.

DEVELOPMENT.

The development of the greater portion of the county has been discussed in the reports made by Munn and Wegemann. Outside of that already mentioned the Rosedale Oil & Gas Company is reported to be drilling a test well in sec. 23, T. 1 S., R. 10 W., about 12 miles northeast of Walter. Nothing concerning the outcome or progress of this location is known by Survey members.

In the Grandfield district as covered by Munn, several wells have been drilled after the field work had been completed. The Green River Oil & Gas Company completed a dry hole in the NE. 1/4 of sec. 25, T. 4 S., R. 13 W. at a depth of 2,595 feet. The location is near the axis of the Devol anticline and about 1 1/4 miles east of a structural high or dome on this anticline. About 9 water sands were encountered. Some of the sands were dry, but in considering that feature it will be noted from a study of the log of this well that these sands are thin and are probably lenticular. It is not known whether they were hard and compact or porous. If the former is the case, then the dry feature can easily be accounted for. The log of this well is as follows:

A well is being drilled in the SW. cor. sec. 9, T. 4 S., R. 15 W., Tillman County. From last reports the drill had reached a depth of about 2,000 feet. From a structural standpoint the location of this well should be very favorable. The indications so far, however, are rather discouraging. A few small showings of oil have been encountered. Most of the sands have been dry.

Green River Oil and Gas Company's Well No. 1, NE. ¼ sec. 25, T. 4 S. R. 13 W.

Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*
Mud, variegated, red, brown, light colors	600	600
Brown sand with water	8	608
Mud of many colors	117	725
Sand, dry	7	732
Mud	60	792
Dry sand	8	800
Mud	258	1,058
Water sand	30	1,088
Slate, brown	32	1,088
Dry sand	10	1,130
Slate, red, bad cave	30	1,160
Slate, blue. (Water shut off at 1,168 ft.	20	1,180
Dry sand	5	1,185
Slate, blue	22	1,207
Water sand	58	1,265
Red	5	1,270
Slate, blue, (water shut off 1,275 feet	68	1,338
Water sand	17	1,355
Slate, blue	10	1,365
Red cave	5	1,370
Slate, light color (bad cave)	78	1,448
Red mud	11	1,459
Slate, blue	11	1,470
Sand and water	23	1,493
Slate, light color	22	1,515
Red mud	35	1,550
Slate, blue	15	1,565
Brown mud	7	1,572
Slate, blue, thin shell on top	50	1,622
Shale, white, bad cave	108	1,730
Shale, black	15	1,745
Slate, blue	25	1,770
Redbed	31	1,801
Shell, hard	5	1,806
Slate, red, caving a little	6	1,811
Sand, shell and hard boulder cave	20	1,831
Brown mud	9	1,840
Blue clay	44	1,884
Water sand	25	1,910
Red clay	15	1,925
Blue shale and thin shell	57	1,982
Lime	20	2,002
Blue shale	5	2,007
Brown shale, thin shells	18	2,025
Hard shell	2	2,027
Red cave	3	2,030
Slate and shells	12	2,042
Water sand	15	2,057
Shale and sand shells	143	2,300
Sand, white, full of water	18	2,318
Sand, dark	5	2,323
Shale, blue	37	2,360
Sandy shale, shell	165	2,525
White slate	47	2,572
Brown shale cave	15	2,587
Water sand (hole filled up)	7	2,595

SUMMARY.

Cotton County lies in probable oil and gas territory. The surface formation is Permian Redbeds, except probable Tertiary gravels and Recent sediments. The Pennsylvanian, which is the probable source of practically all oil in Oklahoma and the north Texas fields, underlies this area and is stratigraphically below the Redbeds. The thickness of the Redbeds is not so great as to make exploration impracticable on that account. Favorable structure has been worked out in this county by the Oklahoma Geological Survey and the United States Geological Survey. A few wells have been drilled in this county, but no encouraging results have been obtained. However, this should not condemn the area, because most of the wells were purely "wildcat" and were drilled irrespective of favorable structure. Some of the other wells were drilled to shallow depths and would not be considered tests.

A well, to be considered a test, should be favorably located with respect to structure and should not be abandoned at a depth less than 2,500 feet.

CRAIG COUNTY.

LOCATION.

Craig County is located in the northeastern part of the State. It extends from T. 24 N. to T. 29 N. inclusive, and from R. 18 E., to R. 21 E. inclusive. It includes 19 whole townships and parts of 4 others. The total area is approximately 770 square miles.

TOPOGRAPHY.

The greater part of Craig County lies in the Sandstone Hills region, while the southeastern corner is in the Ozark Mountain region. Most of the county is a rolling prairie except where it is cut into by streams. The most striking topographic feature is the deep valley cut by Cabin Creek. A few low hills not over 150 feet in height are scattered over the county. The range in elevation is about 350 feet, the highest point being 1,001 feet in the north central part and the lowest 650 feet on Cabin Creek along the south line of the county.

Craig County is drained for the most part by Cabin Creek and its tributaries. The Neosho River drains a small area in the northeastern corner of the county. Tributaries of Verdigris River drain the extreme western part.

GEOLOGY.

GENERAL STATEMENT.

The surface rocks exposed in this county consist of limestones, shales, and sandstones of Mississippian and Pennsylvanian age. The Mississippian rocks are the oldest exposed and are included under Boone formation and Chester group. The Pennsylvanian series from oldest to youngest consist of the Cherokee and Fort Scott formations, Labette shale, and Oologah formation.

MISSISSIPPIAN SYSTEM.

The Boone formation, the oldest formation exposed in this area, outcrops in the southeastern corner of the county. As a whole the formation consists of chert and limestone and has a thickness of about 350 feet in this area.

The Chester group outcrops around the margin of the Boone formation in the southeastern corner of Craig County. The Chester has been subdivided* into the Mayes, and Fayetteville formations, and Pitkin lime-

*Snider, L. C., Geology of Northeastern Oklahoma, Okla. Geol. Survey, Bull. No. 24, p. 27.

stone. The Mayes formation, the basal part of the Chester, is unconformable on the Boone formation. It consists principally of shales and limestones, the latter predominating, and has a maximum thickness of about 50 feet in this county. The Fayetteville formation lies immediately above the Mayes and consists typically of black shale and locally with a limestone member near the top. The thickness of the formation is about 35 feet. The Pitkin limestone, the uppermost division of the Chester, is conformable on the Fayetteville formation and unconformable beneath the Pennsylvanian beds, but is not exposed in this area.

For a more detailed discussion of the Mississippian rocks the reader is referred to part I of Bulletin No. 19, pages 127 to 130.

PENNSYLVANIAN SYSTEM.

The Cherokee shales, the basal part of the Pennsylvanian series, consist of a succession of shales with interstratified sandstones, thin beds of coal and lenticular limestones. It has been correlated in general with the Vinita formation*. The western limit of the outcrop extends in a general northeast-southwest direction, diagonally across the county. The average thickness is approximately 700 feet. The Bartlesville sand, which is the chief oil and gas horizon in the northeastern Oklahoma oil and gas fields, is thought to outcrop or be the equivalent of a sandstone outcropping near Blue Jacket and Welch.

The Fort Scott formation lying above and outcropping to the west of the Cherokee formation is equivalent to the Claremore formation**. The Fort Scott consists of a lower limestone, a shale parting, and an upper limestone and has an average total thickness of approximately 50 feet in Craig County. The Labette shale, which outcrops to the west of the Fort Scott formation, consists of thick shales with occasional beds of sandstone. The thickness increases to the southward and does not attain a maximum thickness over 150 feet in Craig County.

The Oologah formation, which includes the Pawnee limestone, Bandera shale, and Altamont limestone, is exposed in the northeastern corner of the county. The Pawnee, the lowest member, consists of a hard, massive bluish limestone; the Bandera of black carbonaceous shale; and the Altomont of a highly siliceous limestone. The average thickness of the Oologah is about 100 feet.

STRUCTURE.

GENERAL STATEMENT.

In general the region is a westward-dipping monocline. No pronounced structure has been worked out in the Pennsylvanian rocks of this area. In the Mississippian area, the Horse Creek anticline has been described by Siebenthal.*

*Siebenthal, C. E., Bull. U. S. Geol. Survey No. 340, 1908.

**Ohern, D. W., Research Bull. Univ. of Oklahoma No. 4, 1910, p. 12.

HORSE CREEK ANTICLINE.

The Horse Creek anticline, a symmetrical fold which starts at a point in Cabin Creek, 5 miles southeast of Big Cabin station, extends across the southeast corner of the county in a east-northeast direction to Cleora and still farther northeast. The average dip of the northern limit is about 2°, while for the southern limit it ranges from 5° to 18°.

The Pennsylvanian rocks, the source of oil and principal source of gas, have been eroded from the region involved in this folding. It appears, then, that as far as the oil and gas is concerned that the area covered by the anticline is in improbable territory, at least for oil.

DEVELOPMENT.

GENERAL STATEMENT.

The Weimer pool is the only area of development lying wholly within the county.

WEIMER POOL.

The Weimer pool occupies a portion of T. 28 N., R. 18 E. in the northwestern part of the county. Development has been slight, having been limited to a very small productive area. The sand, which is chiefly oil producing, is supposed to be the Burgess and occurs at a depth of 680 feet.

MISCELLANEOUS.

In the southwestern portion of the county there has been some development as extensions from the Chelsea Pool. Here the sand is found at a depth about 200 feet shallower than in the Weimer Pool to the north.

SUMMARY.

Only the northwestern townships of this county can be regarded as favorable for prospecting for oil and gas. The Mississippian area and some of the Pennsylvanian area in the southwest part of the county, on account of the shallow depth of the Boone chert, are regarded as very improbable territory. The production in the northwest part of the county lies at a depth of about 680 feet. Any test well in this area should not be drilled to a depth of more than 750 feet, unless it is intended to penetrate rocks older than Pennsylvanian.

CREEK COUNTY.

LOCATION.

Creek County is located a little north and east of the center of the State. It extends from T. 14 N. to T. 19 N. inclusive, and from R. 7 E. to R. 12 E. inclusive. It includes 25 whole townships and parts of 4 others. The area is approximately 963 square miles.

TOPOGRAPHY.

Creek County lies within the Sandstone Hills region. The county is drained by Cimarron River and streams tributary to it, by Deep Fork and Little Deep Fork, tributaries of the North Fork of Canadian River, and by Polecat Creek, a tributary of Arkansas River.

The valleys of the streams are almost V-shaped with very narrow flood plains, with the exception of Canadian River valley which has a broad flood plain. The outcrops of the Pawhuska limestone in the north and central parts form prominent escarpments. In the south and eastern parts of the county the hills are capped by sandstones. Sandstone boulders occupy the surface over considerable of the county, concealing the underlying strata and giving the appearance of massive sandstone formations.

In the eastern part of the county the fairly rugged sandstone hills lie in roughly parallel zones trending northeast-southwest. Between these zones are belts of smoother low lands developed in the softer strata. In this part of the country the surface elevations vary from 600 to 950 feet, a range of 350 feet.

GEOLOGY.

The surface rocks are all sedimentary and, with the exception of terrace sands and alluvial deposits, are Pennsylvanian in age. The outcrops in the western part of the county are near the top of the Pennsylvanian series. J. W. Beede* has drawn the line between the Permian and the Pennsylvanian at the base of the Elmdale formation which includes about 130 feet of sediments beneath the Neva limestone of the Kansas section. This formation outcrops about 12 miles west of the western county line. It is estimated that the rocks outcropping along the western county line are about 400 feet down in the Pennsylvanian series.

The structure of the Cushing oil pool was worked out by members of the Survey by taking elevations on the Pawhuska limestone. This limestone has an average thickness of 5 feet. Frank Buttram** has correlated this limestone with the Pawhuska of the Cleveland field. The strata above the Pawhuska in Creek County consist of alternating shales, limestones, and sandstones.

The upper shales are for the most part red. The limestones vary in color from gray to reddish. The sandstones are fine-grained to coarse, and are, for the most part, brown in color.

Buttram's*** section from the Pawhuska limestone to the Elgin sandstone shows alternating sandstones and shales with one thin, siliceous

*Beede, J. W., The bearing of the stratigraphic history and invertebrate fossils on the age of the anthracolithic rocks of Kansas and Oklahoma, Journal of Geology, vol. XVII, No. 8, Nov. Dec., 1909, pp. 710-729.

**Buttram, Frank, Bull. Okla. Geol. Survey No. 18, 1914, p. 8.

***Op. cit., p. 10.

limestone. Sandstones predominate in this section, though there is considerable shale.

Carl D. Smith* has made a section of the rocks in the Glenn pool district. It is estimated that the Dawson coal is the lowest stratum in the Pennsylvanian series in Creek County. This section is made up of shales, sandstones, and limestones. No detailed section has been made of the rocks between Buttram's Cushing section and Smith's Glenn pool section.

STRUCTURE.

The general attitude of the rocks in Creek County is a westward-dipping monocline. In some places there are many variations from the normal dip, and also reversal dips to the east. The kinds of foldings discovered are anticlines, synclines, domes, and structural terraces. A few faults have been found in the Cushing field. The structure of the various fields is discussed in detail under their respective headings under the main heading of "Development" of Creek County.

DEVELOPMENT.

GENERAL STATEMENT.

There was no active development in Creek County until 1906, when the Glenn pool was opened. The first well was completed in this area in December, 1905. The total number of wells drilled during 1906 was about 110. In 1907 Glenn pool yielded a remarkable production, amounting to 385,939 barrels per month. In October of that year it reached a maximum production of 2,441,662 barrels. After that the pool began to decline and at present is almost exhausted. The Cushing field was opened in 1912. Rapid development followed with the result that during the next two years a prolific production was obtained. At present this field is producing a large quantity of oil, but it is gradually declining.

The greater portion of Creek County has been developed. Minor areas which have received some attention are in the vicinity of Bristow, Depew, Kelleyville, Mannford, and Mounds.

The respective areas in which development has been carried on are discussed under their headings.

CUSHING FIELD.

LOCATION AND EXTENT.

The Cushing field as now developed may be divided into several parts, namely: North extension, middle or old pool, and south extension. The whole area lies in the extreme western part of Creek County, 12 miles east of the town of Cushing in Payne County. The area covered by this field embraces all or a part of Tps. 16, 17, 18, and the southern part of T. 19 N., R. 7 E., a more or less productive area

*Smith, Carl D., Bull. U. S. Geol. Survey, No. 541-B, 1913, p. 16.

of about 50 square miles. The north end or north extension embraces approximately that part of the field between Oilton on the north and Drumright on the south; the old Drumright pool is that area around, east of, and about 4 miles south of Drumright; the south extension, which includes the Fox or Shamrock pool, lies in parts of secs. 33 and 34, T. 17 N., R. 7 E., and secs. 4, 9, and 16, T. 16 N., R. 7 E.

GEOLOGY.

GENERAL STATEMENT.

The geology of this area as described by Frank Buttram* is as follows:

The rocks of the area are exclusively sedimentary. With the exception of terrace sands and alluvial deposits, the formations are of Pennsylvanian age. The Pennsylvanian formations exposed at the surface lie near the top of the series. Between the western limit of the field and the upper or western limit of the Pennsylvanian series approximately 400 feet of strata outcrop, J. W. Beede,** drawing the line between the Permian and Pennsylvanian series at the base of the Elmdale formation which embraces 130 feet of sediments beneath the Neva limestone of the Kansas section. This limestone forms the prominent east-facing escarpment just west of the town of Cushing, Okla., and 12 miles west of the old field.

The Pennsylvanian rocks in this area are composed very largely of shales with an abundance of sandstones, and with limestones much less prominent. The composition and thickness of the beds sometimes vary considerably from point to point because of local conditions of deposition. Not infrequently, likewise, similar changes occur in the vertical succession of strata. The rocks exposed at the surface within the confines of the field approximate 225 feet in thickness.

At present all production of oil and gas is from strata of Pennsylvanian age, and so far as the writer knows, no well, with possibly one or two exceptions, has been sunk to the base of the Pennsylvanian series.

SURFACE FORMATIONS.

The most prominent stratum outcropping within the Cushing oil field is a bed of limestone, and because of the prominence given hereto in this report special mention is here made. This limestone is prominently exposed in the north and east parts of the field, where it can be seen outcropping near the summit of bluffs and at or near the summit of several hills. In the southwestern part of the field it can be traced from Drumright south to the limits of the area, but in this direction it rapidly thins out and is hence not so prominent as elsewhere. This limestone is used as a key formation for the region, the structural contours of the large map accompanying this report being drawn thereon.

Preliminary field work extending from the northern limit of the Cushing field northeastward toward the Cleveland oil field leads the writer to

*Buttram, Frank, Bull. Okla. Geol. Survey No. 18, 1914, pp. 7-16.

**Beede, J. W., op. cit.

believe that this limestone is, in part at least, the equivalent of the Pawhuska limestone of Smith.* Hereafter it will be referred to as the Pawhuska limestone, but it is understood that careful and accurate correlation is yet to be made.

Formations Above Pawhuska Limestone.

It has already been observed that the Cushing oil field is located near the western border of the Pennsylvanian series. The following section was made from the Neva limestone (near the base of the Permian series) on the escarpment just west of the town of Cushing, east to the top of the Pawhuska limestone in Drumright.

	Feet	In.
Neva limestone massive white	4	....
Red shale	30	....
White sandstone	3	....
Red shale	16	....
Reddish sandstone	8	....
Red shale	8	....
Massive, blue limestone	2	....
Red shale	13	....
Massive, brown, siliceous limestone	1	....
Red shale	3	....
Massive, white, friable sandstone	8	....
Red shale	16	....
Massive, white, friable sandstone	22	....
Red shale	5	....
Siliceous limestone	1	....
Red shale	27	....
Massive, white, friable sandstone	5	....
Reddish shale	23	....
Sandstone	6	....
Red nodular limestone	5	....
Shale	17	....
Soft, massive, sandstone	5	....
Shale	20	....
Limestone, upper part pure limestone grading into coarse conglomeratic limestone at base	5	....
Blotchy, white sandstone	3	....
Shale	7	....
Soft massive sandstone	57	....
White limestone	2	....
Shale with two intervening thin layers of limestone	14	....
Reddish nodular limestone		6
Reddish shale	5	....
Nodular limestone		6

*Smith, James Perrin, The Arkansas Coal Measures in their relation to the Pacific Carboniferous province: Jour. Geol., vol. II, 1894, p. 199.

Reddish shale	4	....
Brownish, calcareous sandstone	1	....
Reddish shale	15	....
Very hard fine-grained white sandstone	6	....
Reddish sandy shale	10	....
Soft sandstone	5	....
Shale	14	....
Hard sandstone	4	....
Shale	6	....
Limestone	1	....
Shale at top grading downward into sandstone	35	....
Shale mostly red	25	....
Fine-grained sandstone	7	....
Shale mostly red	25	....
Gray limestone	1	....
Brownish ferruginous limestone	1	....
Shale	6	6
Massive, brownish sandstone	19	....
Shale	18	....
Massive, ferruginous limestone	2	....
Shale	3	....
Massive sandstone	18	....
Pawhuska limestone	top	....

According to the above section it is 556.5 feet stratigraphically from the Pawhuska limestone to the top of the Neva limestone.

Terrace and Alluvial Deposits.

On both sides of Cimarron River and some of its chief tributaries, the Pennsylvanian formations are more or less completely concealed by terrace sands deposited by the stream when it flowed at a higher level. These sands are thicker and more widely spread on the inside of the curves and loops of the main stream.

The present flood plains of the streams likewise conceal effectually the underlying Pennsylvanian deposits. In a few places where the Cimarron meanders against its banks the stream deposits have been removed, exposing the underlying Pennsylvanian rocks.

Formations Below Pawhuska Limestone.

The Pawhuska limestone has been removed by erosion over large areas of the Cushing field. The following section made along the stream in the southwest corner of sec. 10, T. 17 N., R. 7 E., gives the formations underneath the Pawhuska limestone that outcrop in different parts of the Cushing field.

	Feet.
Pawhuska limestone	5
Green shale	13
Brown, siliceous lime	1
Sand	4

Green shale	10
Hard, brown sand	5
Shale	5
Sand	6
Shale	12
Massive sand	17
Shale	7
Massive, brownish friable sandstone	44
Shale	10
Elgin sandstone	top

It will be noted that at the base of the above section lies what is termed the Elgin sandstone. This term is used as a matter of convenience rather than as one of strict accuracy in correlation. The basis of the correlation of what is termed the Pawhuska limestone serves also to correlate this sandstone with the Elgin sandstone of the Kansas section. Further detailed work between the present field and the territory to the northeast is necessary before final correlation can be made.

SUBSURFACE FORMATIONS.

For a depth of 1,000 feet or more beneath the Elgin sandstone little is known of the strata, except as their thickness and composition are revealed in the logs of wells. In the Hominy quadrangle which lies to the northeast of the Cushing oil field, and in which these strata outcrop, Robert H. Wood, of the United States Geological Survey, has made careful detailed study of these formations. This work has been done under cooperative agreement with this Survey, but Wood's results are not yet ready for the public.

Formations Outcropping in the Hominy Quadrangle and to the North.

A general idea of the nature of the formations in the Hominy quadrangle and to the northward is given in Bulletin 16 of this Survey as follows:*

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

*Ohern, D. W., Ponca City oil and gas field, Bull. Okla. Geol. Survey, No. 16, 1912, pp. 12-14.

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

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

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

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

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

Formations Outcropping East of Osage County.

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

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

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

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

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

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

Formations Outcropping in the Vicinity of Glenn Pool.

The formations lying at greater depths and outcropping in the vicinity of Glenn Pool and eastward have been described by Carl D. Smith. He gives the following section* as extending from the Lost City limestone, which outcrops on the south side of Arkansas River, about 6 miles west of Tulsa, down to the Boone limestone of the Mississippian series.*

Section showing relation, character, and thickness of formations exposed in and to the east of the Glenn Pool area, Oklahoma.

	Feet.
Pennsylvanian series:	
Limestone, bluish gray; locally known as the "Lost City limestone"	1-40
Shale and sandstone	350
Limestone, bluish, hard; checkerboard lime of the drillers	2½
Shale, with variable beds of sandstone	215
Coal, Dawson	1 2-3-2½
Shale with irregular beds of sandstone	210-350
Limestone, massive gray; big lime of drillers	0-40
Shale, with irregular beds of sandstone	200
Limestone, Fort Scott; Oswego lime of drillers; bluish gray limestone with 3 to 5 feet of shale near middle	10-30
Shale, sandstone, limestone, and coal; Cherokee formation	1,000
Unconformity.	
Blue to white limestone with some shale and thin sandstone; Morrow formation	100-120

*Smith, Carl D., Bull. U. S. Geol. Survey, No. 541-B, 1913, p. 16.

Section showing relation, character, and thickness of formations exposed in and to the east of the Glenn Pool area, Oklahoma.—Continued.

Unconformity.
Mississippian series:
Limestone, blue and brown, locally sandy and shady; Pitkin 60
Black shale with thin beds of limestone and sandstone; Fayetteville formation 20-60
Unconformity.
Limestone, Boone; flinty limestone and flint........ 200

Formations Shown By Well Records.

In order that the reader may have a further general conception of the strata as encountered by the drill, the following logs are given as typical:

Magnolia Mikey No. 1, *NW.* ¼ *sec.* 33, *T.* 18 *N.*, *R.* 7 *E.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	4	4	White slate	30	735
Sandstone	9	13	Sand and water	5	740
Shale	52	65	Lime	5	745
Sandstone	5	70	Sand and water	40	785
White slate	28	98	Black shell	30	915
Lime	12	110	Lime shell	5	920
White slate	35	145	Black slate	80	1,000
Red rock	5	150	Sand	20	1,020
White slate	30	180	Black slate	20	1,040
White sand	3	183	Lime	5	1,045
White slate	35	218	White slate	45	1,090
Red rock	17	235	Black slate	230	1,320
White slate	35	270	Lime	8	1,328
Sand	8	278	Layton sand	18	1,346
Red rock	9	287	Slate	5	1,551
White slate	10	297	Sand and gas "Big"	54	1,411
Red rock	13	310	Slate	10	1,421
White slate	40	350	Sand (show of oil)	49	1,470
Red rock	10	360	Slate	80	1,550
White slate	35	395	Lime	3	1,553
White sand	15	410	Slate	79	1,632
White slate	20	430	Jones sand	18	1,650
Red rock	14	444	Blue slate	25	1,675
White sand	26	470	Lime	3	1,678
Blue mud	39	509	Blue slate	60	1,738
Lime	21	530	Sand and gas	22	1,760
Sand	15	545	Slate	30	1,790
Blue slate	30	575	Sand and gas	10	1,800
Sand	15	590	Slate	255	2,055
Blue slate	14	604	Lime	5	2,060
Slate	31	635	Slate	20	2,080
Red rock	15	650	Sand	12	2,092
Sand	30	680	Largest gas		2,092
Sand and water	25	705			

Laura Hutton No. 12, *N.* ½ *SW.* ¼ *sec.* 8, *T.* 17 *N., R.* 7 *E.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
No record	75	75	Blue shale	10	900
Sand (water)	10	85	Shale and shells	110	1,010
Light shale	45	130	Sand	10	1,020
Sand	20	150	Shale	10	1,030
Light shale	50	200	Sand	10	1,040
Sand	10	210	Blue shale	30	1,070
Red rock	30	240	Lime	10	1,080
Sand	15	255	Sand	20	1,100
Red rock	30	285	Shale	349	1,449
Light shale	30	315	Sand (water, little oil Layton)	60	1,509
Sand	40	355	Shale	91	1,600
Red rock and light shale	45	400	Dark shale	100	1,700
Sand	15	415	Light shale	20	1,720
Blue shale	5	420	Jones sand	40	1,760
Sand	10	430	Light shale	40	1,800
Light shale	10	440	Lime	25	1,825
Sand	10	450	Light shale	215	2,040
Red rock	50	500	Little gas sand	10	2,050
Sand	20	520	Light shale	146	2,196
Red rock	80	600	Top of Wheeler sand (little gas)	21	2,217
Sand	45	645	First gas (5 3-16" casing)	8	2,225
Light shale	25	670	Strong gas	5	2,230
Sand	10	680	Through gas	5	2,235
Blue shale	30	710	Wheeler sand	35	2,270
Red rock and sand	110	820			
Sand	70	890			

Jemima Richards No. 3, *SW. of the N.* ½ *of sec.* 3, *T.* 17 *N., R.* 7 *E.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Sand	54	54	Lime	9	729
Slate	46	100	Lime	3	732
Lime	5	105	Sand	17	749
Slate	15	120	Lime	4	753
Red rock	48	168	Sand	7	760
Slate	12	180	Slate	16	776
Sand	25	205	Sand	24	800
Slate	29	234	Slate	3	803
Sand	23	257	Sand	7	810
Lime	5	262	Lime	2	812
Sand	22	284	Sand	6	818
Lime	10	294	Slate	62	880
Sand	6	300	Lime	5	885
Slate	5	305	Sand (water)	13	898
Red rock	9	314	Slate	14	912
Slate	21	335	Sand	41	953
Lime	4	339	Slate	16	969
Slate	29	368	Lime	4	973
Red rock	22	390	Sand	39	1,012
Sand	20	410	Slate	13	1,125
Slate	5	415	Slate	201	1,326
Sand	20	435	Lime	6	1,332

Jemima Richards No. 3, SW. of the N. ½ of sec. 3, T. 17 N., R. 7 E.
—Continued.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Slate	26	461	Slate	15	1,347
Sand	13	474	Sand (Layton)	40	1,387
Slate	15	489	Shale	5	1,392
Lime	21	510	Slate	169	1,561
Sand	20	530	Lime	4	1,565
Slate	4	534	Sand (Cleveland)	12	1,577
Sand	12	546	Slate	444	2,021
Slate	22	568	Wheeler sand	14	2,035
Lime	8	576	Break	12	2,047
Slate	14	590	Lime (2nd gas)	43	2,090
Lime	30	620	Slate	106	2,196
Sand	7	627	Lime	3	2,199
Slate	8	635	Slate	101	2,300
Lime	12	647	Sand (water)	1	2,301
Slate	10	657	Slate	95	2,396
Sand	33	690	Sand (gas)	15	2,411
Slate	20	710	Slate	20	2,431
Lime	10	720	Bartlesville sand*	54	2,485

*Entire production 110 bbls. per hour.

The Lost City limestone at the top of Smith's section seems to correspond to the limestone at 1,040 to 1,045 feet and 1,070 to 1,080 feet respectively in the logs above cited. The average distance from the Pawhuska limestone in the Cushing field down to the Fort Scott or Oswego limestone (Wheeler sand of the drillers) is 2,340 feet. Deducting the average thickness as given by Smith from the Lost City limestone down to the top of the Fort Scott, the distance from the Pawhuska to the Lost City is about 1,250 feet, which agrees very closely with the two logs above given, considering that the mouth of the first of these wells is 203 feet and that of the second 192 feet below the top of the Pawhuska. This gives, then, the interval from the top of the Pawhuska limestone to the Lost City limestone as 1,243 feet and 1,262 feet respectively in these wells as compared with 1,250 feet as obtained by deducting Smith's section.

Further discussion of the formations encountered by the drill will be made in a succeeding section on productive horizons, but it should be specifically mentioned here that the so-called Wheeler sand of the driller is believed to be the Fort Scott (Oswego) limestone.

STRUCTURE.

The general attitude of the rocks in Creek County is that of a westward-dipping monocline. The general westward dip is interrupted in places by up-folds, the largest of which is found in the Cushing field. This fold is an anticline which extends from Cimarron River in the west-central part of sec. 34, T. 19 N., R. 7 E. southward to the south-central corner of sec. 33, T. 17 N., R. 7 E. This anticline is crowded into four more or less sharply demarked elongated folds which have been named the Dropright dome, the Drumright dome, the Shamrock dome, and the Mount Pleasant dome.

The axis of the Dropright dome, named for the oil town of that name, extends from the center of sec. 4, T. 18 N., R. 7 E. southwest to the E. ½ of sec. 17, T. 18 N., R. 7 E., thence almost south to the center of the NW. ¼ of sec. 20, T. 18 N., R. 7 E., a distance of 3 miles. The highest point on this dome is a short distance west of the E. ¼ cor. of sec. 17, T. 18 N., R. 7 E.

The axis of the Drumright dome extends from the SE. cor. of sec. 20, T. 18 N., R. 7 E., southwest to a point about one-fourth of a mile west of the E. ¼ cor. of sec. 33, thence almost due south to the E. ¼ cor. of sec. 4, T. 17 N., R. 7 E., a distance of about 2½ miles. The highest point in this dome is located about one-fourth mile west of the E. ¼ cor. of sec. 33, T. 18 N., R. 7 E. The Drumright dome is not so clearly defined as is the Dropright dome.

The Shamrock dome extends from the center of the NW. ¼ of sec. 15, T. 17 N., R. 7 E., almost due south to the center of the NW. ¼ sec. 34, T. 17 N., R. 7 E. The highest point on this dome is in the center of sec. 22, T. 17 N., R. 7 E.

The axis of the Mount Pleasant dome runs in an east-west direction and at right angles to the axes of the other domes. It extends from the center of sec. 10, T. 17 N., R. 7 E. east to a point one-fourth of a mile north of the E. ¼ cor. of sec. 11, T. 17 N., R. 7 E., a distance of 1¼ miles. The highest point on this dome is located near the center of sec. 11, T. 17 N., R. 7 E.

Just east of the Dropright dome is a well developed syncline—the Dropright syncline—whose axis extends from the center of the NE. ¼ of sec. 3, T. 18 N., R. 7 E., in a southwest direction to the center of the SE. ¼ of sec. 21, T. 18 N., R. 7 E., a distance of 3¼ miles. The lowest point on this syncline is located at a point about one-fourth of a mile south of the N. ¼ cor. of sec. 10, T. 18 N., R. 7 E. The difference in elevation between the highest point (1,050 feet) of the Dropright dome and the elevation of the lowest point (890 feet) of the Dropright syncline is 160 feet.

Just to the east of the Drumright dome lies the Drumright syncline. This syncline is rather poorly developed, but in general its axis extends from a point one-fourth of a mile south of the NE. cor. of sec. 27, T. 18 N., R. 7 E., southeast to the center of the SW. ¼ of sec. 35, T. 18 N., R. 7 E., a distance of 1¼ miles. The lowest point on this syncline is near the E. ¼ cor. of sec. 27, T. 18 N., R. 7 E. The difference in elevation between the highest point (1,050 feet) of the Drumright dome and the lowest point (1,000 feet) of the Drumright syncline is 50 feet.

Just to the east of the Shamrock dome is the Shamrock syncline. Its axis extends from a point about 1,500 feet west of the SE. cor. of sec. 34, T. 17 N., R. 7 E., northeast to a point about 1,500 feet west of the NE. cor. of sec. 23, T. 17 N., R. 7 E., where it branches. One of these branches extends in a northwest direction to a point about one-fourth of a mile west of the NE. cor. of sec. 15, T. 17 N., R. 7 E. This branch of the syncline separates the Mount Pleasant dome from the Shamrock dome. The other branch extends in a northeast direction to the NW. cor. of sec. 7, T. 17 N., R. 8 E. The lowest point on the Shamrock syncline is located on its northeastern branch near the W. ¼ of sec. 13, T. 17 N., R. 7 E. The difference in elevation between the highest point (1,120 feet) of the Shamrock dome and the lowest point (1,010 feet) of the Shamrock syncline is 110 feet. The difference in elevation between the highest point (1,100 feet) of the Mount Pleasant dome and the lowest point of the Shamrock syncline is 90 feet.

The Oklahoma Geological Survey's structural map of the Cushing field shows three faults. The one which lies farthest north extends in a southeast direction from the W. ¼ cor. of sec. 36, T. 19 N., R. 7 E., to the center of the SE. ¼ of sec. 7, T. 18 N., R. 8 E., a distance of 3 miles. The maximum throw of this fault is a distance of 130 feet.

There is a short fault extending in a southeast direction from the center of the SE. ¼ of sec. 2, T. 18 N., R. 7 E. to near the E. ¼ cor. of sec. 12, T. 18 N., R. 7 E., a distance of 1½ miles. The maximum displacement of this fault is 80 feet.

Another fault extends from the center of the SW. ¼ of sec. 14, T. 18 N., R. 7 E. in a southeast direction to the center of sec. 25, T. 18 N., R. 7 E., a distance of 2 miles. The maximum displacement of this fault is 123 feet.

The following facts concerning these faults are worthy of study:

(1) All three of these faults strike in parallel directions ; (2) the upthrow side in each case is on the northeast side of the fault line; (3) in a general way the strike of these three faults parallels the strike of the axes of the synclines and anticlines of the Cushing field. A study of the above facts leads to the following conclusions: (1) The forces that caused the faults were the same as those that caused the anticlines and synclines; (2) the forces were acting toward each other; (3) the major force was applied from the northeast.

These faults are, therefore, thrust faults, and with depth merge into anticlines. Whether there be production near these faults will depend on (1) whether the fault zone extends to the productive sands, and (2) in case it does, whether the fault zone is impervious at its contact with the productive sand. If the fault zone does not reach the productive sand, then the conditions are similar to those of an anticline and wells started on both sides of the fault line would be expected to get production. If the fault zone penetrates the productive sand, whether there be production associated with the fault will depend on whether that part of the fault zone in contact with the broken end of the productive sand is impervious to the ground water. In case it is pervious to the ground water the chances are that the oil and gas would be lost by seepage to the surface or by being distributed in any number of porous strata. If the general movement of the ground water in the Prairie Plains monocline is eastward, and if these fault zones penetrate the productive sands and are impervious to ground water, wells started on the southwest side of the fault line would be expected to get the major production.

SANDS.

GENERAL STATEMENT.

Commercial quantities of oil and gas have been found in four different major horizons, namely: The Layton, the Wheeler (Oswego or Fort Scott limestone), Bartlesville, and Tucker sands. Other sands also productive of oil and gas, but of minor importance, are the Musselman, Jones, Cleveland, Squirrel, and Skinner. The correlation of the different sands and their respective stratigraphic positions are shown in the table on "Correlation of Oil Sands of Oklahoma," accompanying this publication. A brief discussion of the major sands is given.

LAYTON SAND.*

The Layton sand received its name from the Layton farm in the Cleveland field and the name was applied to the sand in the Cushing field which was supposed to be at the same horizon. In general this sand is a fairly soft, porous, coarse-grained sandstone. It has an average thickness of about 50 feet, but in a few wells scattered over the field the sand is reported to be considerably less and even altogether lacking, while in other portions of the field as much as 100 feet or more has been reported as encountered by the drill. Although the thickness, porosity, and other physical properties of this formation vary somewhat in different localities, yet in a general way they are much the same over the entire field. There is no disposition on the part of the writer to question the fact that the Layton sand is irregular but on the other hand it is very probable that in the wells where extreme irregularity is reported there are several cases where the drillers failed to note closely the changes in the rock formations as the drill passed through them. A study of the well logs, from the different wells in this field, shows that in a number of wells a thin shale or "break" occurs in the Layton sand, while in other wells within close proximity to these the break is not recorded and therefore the sand is reported as being much thicker than ordinary. It is also very likely that at least some of the Layton wells in which the sand is reported to be thin, the drill stopped in the upper sand and did not pass through the shale break into the lower sand.

Notwithstanding the probability that the formations in the Cushing field are more nearly constant than the well logs indicate, yet there are certain variations that appear evident. * * * The top of the Layton is found at an average depth of 1,530 feet below the top of the upper Pawhuska limestone and 810 feet above the top of the Wheeler lime. The wells from which the records were taken to determine these intervals occur in secs. 30 and 31, T. 18 N., R. 7 E. and secs. 6, 7, and 17, T. 17 N., R. 7 E. When the field work for this report was done the principal development was in this general area. Since then, however, development has extended to

*Buttram, Frank., Bull. Oklahoma Geol. Survey, No. 18, 1914, pp. 37-41.

the northward and eastward and covers much larger territory. The records of the wells to the eastward show that the formations between the Layton and Wheeler sands are thinning in that direction, because the interval between the Layton and Wheeler formations is only about 700 feet in the area around sec. 10, T. 17 N., R. 7 E. This thickening of formations from east to west apparently continues westward to the Fortuna Oil Company's well in sec. 24, T. 18 N., R. 5 E., where the Wheeler lime lies at a depth of 300 feet in excess of the westward dip of the formations. There is no evidence of faulting and since the two localities have about the same elevation above sea level, the increase in depth must be due to a thickening of the formations to the west. Most of the records taken from the wells along the west side of the field show a limestone just above the Layton sand, but only shale is reported in the formation immediately above the sand in the central and eastern areas of the field.

The areal extent of the Layton sand is unknown, but it probably underlies a large area outside of the Cushing field. Robt. H. Wood in Bulletin 531-B of the United States Geological Survey, in speaking of the producing sands in the Cushing field correlates this sand with an upper sand of the Cleveland field which occurs at a depth of about 1,300 feet. * * *

Oil and gas pools occur in structure, with the gas usually at the top of the fold, the oil area down the slope a short distance, and the salt water still farther down the slope and in the syncline. The data for these general conclusions were based on the production from the different producing horizons taken collectively, and therefore, it will be of interest at this point to study more in detail the production in the Layton sand itself to see if these general conditions obtain.

A detailed study of the well records * * * shows that the principal gas production in the Layton occurs on or near the axes of the different anticlines in this field and that the major production of oil occurs a greater or less distance down the slopes below the gas. * * *

In this connection it should be specially noted that there is one structural feature in the Cushing field that stands out very prominently. * * * A terrace structure occurs in the general area of Drumright along the west side of the Drumright anticline. On the north end, however, as the terrace structure disappears into the west-dipping monocline the formations rise, while on the south end they dip to the southward as the terrace structure disappears. * * * The effects of this variation in structure on accumulation is very interesting. The gradual rise in the formations to the north from the terrace structure allows the Layton production in this area to connect up with the Layton pool in secs. 5, 6, 7, and 8, T. 18 N., R. 7 E. On the other hand, the small southward dip in the formations on the southern end of the terrace structure shuts off the production and the Layton sand in this area contains salt water.

In addition to the terrace structure which appears to be the important factor in the accumulation of oil and gas in the vicinity of Drumright, there are other structural features of lesser importance that should also be mentioned. The comparatively uniform but very pronounced surface anticlinal structure is graphically portrayed by longitudinal and transverse profiles drawn on the horizon of upper Pawhuska limestone. A study of these profiles shows that the structure is somewhat undulating, but when the magnitude of the folding is taken into consideration it is rather surprising that the undulation is not more pronounced. A profile running north and south along the axis of the major fold shows an extreme vertical variation of 250 feet between the north end in sec. 27, T. 19 N., R. 7 E., and the crest of the Shamrock anticline in sec. 22, T. 17 N., R. 7 E. The alternating swells and troughs in this profile from north to south represent the crests of the three domes and the small transverse synclines which were described under the discussion of the chief structural features and therefore will not be discussed further at this point. Suffice it to say that the location of the oil and gas production * * * shows that, in general, the oil and gas occur as would be expected according to the structural theory.

Since the nature and character of the Layton production, in a general way, conform closely to the surface structure, the natural conclusion is that the underground structure of this formation is similar to the surface structure. * * * A section obtained in the Layton sand in a series of wells beginning at the north in sec. 20, T. 18 N., R. 7 E., with well No. 5 on the Johnson Wacoche lease and continuing southward through secs. 29 and 32, T. 18 N., R. 7 E., and secs. 5 and 8, T. 17 N., R. 7 E., to well No, 10 on the Lucinda Tiger lease in sec. 17, T. 17 N., R. 7 E. shows that the small minor undulations do not conform altogether with the surface structure but the major underground undulations in sec. 32, T. 18 N., R. 7 E., and secs. 5 and 8, T. 17 N., R. 7 E., are similar to those of the surface structure. * * * Later development shows that the undulations in the Layton sand extending north from this section up to the big pool in sec. 8, T. 18 N., R. 7 E. also conform closely in their general features to those of the surface formations.

The problems confronting the writer in obtaining data for the transverse sections were more difficult. In the first place, the Layton production extended only a short distance down the slope, and in the second place, the principal development extended only over to the gas area as there were very few wells along the east slope of the anticlines and even along the axes in the gas area. This latter fact prevented the acquiring of a sufficient amount of data to extend the sections eastward across this area. * * * The development along the east slope of the Shamrock anticline shows that it dips to the east. The Layton sand in the vicinity of the Hill Oil Company's well in sec. 23, T. 17 N., R. 7 E., is considerably lower than it is at the crest of the anticline in sec. 22 to the west. * * *

WHEELER SAND.

The second important producing horizon in the Cushing field is known as the Wheeler sand. This formation received its name from the Wheeler farm on which the first producing well in this horizon was obtained. In reality, it is not a sandstone but a formation composed of two members of coarse-grained light-brown limestone with a thin shale interval between, the three being regarded as the equivalent of the Fort Scott or Oswego limestone. * * *

The average thickness of the Wheeler sand in this area is about 75 feet. The shale break usually runs from 5 to 20 feet in thickness and ordinarily occurs just above the center of the formation. In a number of wells the break is not recorded but the writer believes that the drillers simply failed to detect the shale.

The physical characteristics of the Wheeler sand are very constant and since there are no other formations in this area that resemble it, the ordinary driller readily recognizes this formation as soon as the drill penetrates its different members. For this reason there is little danger of confusing the members of the Wheeler horizon with overlying and underlying strata as in the case with the Layton sand. Ordinarily both lime members of the Wheeler formation produce oil or gas or both. The upper member is usually a little thinner and also contains smaller quantities of oil and gas but this is not always true. In the productive areas those members are quite porous, but the dry holes usually find them tight and hard.

The interval between the Wheeler and Layton sands * * * ranges from 810 feet along the west side of the field to about 700 feet around sec. 10, T. 17 N., R. 7 E., in the new Bartlesville area. The same records that give these data also show that the interval between the top of the Wheeler and the top of the Bartlesville is variable in different portions of the field, and ranges from 390 to 460 feet with an average interval of about 421 feet.

The Wheeler sand in the Cushing field is probably the equivalent of the Fort Scott or Oswego which is one of the most constant formations underlying practically the entire oil and gas area in northeastern Oklahoma and also a large part of southeastern Kansas.

In a general way the production of the Wheeler sand as related to structure coincides very closely with the production in the Layton sand which has already been discussed, that is, the gas usually occurs on or near the axes of the anticlines and the oil a short distance down the slope. The oil in the Wheeler sand, however, extends somewhat farther down the slope than production in the Layton sand.

The terrace structure in the general region around Drumright which was briefly referred to above, under the discussion on the Layton sand, also plays an important role in the general accumulation of oil and gas in the Wheeler sand. The surface formations in this area which have a comparatively strong uniform west dip on the west side of the axis flatten out to the eastward in secs. 4, 9, 16, and 17, T. 17 N., R. 7 E., forming a bench or terrace. The surface formations have comparatively uniform dips, and are only slightly undulating, * * * but the underground structure * * * is much more irregular and complex. This folding was sufficient to prevent any large quantities of oil from migrating farther up the slope; but it permitted the gas to pass and disseminate itself over the area between the crest of the terrace on the west and a point a short distance beyond the axis of the anticline to the east. As a result of this arrangement the gas territory extends much farther down the west slope of the Drumright and Shamrock anticlines than it usually does along the west slope of the Dropright anticline in the north end of the field.

The behavior of the structure of the Wheeler sand in the Drumright region is very similar to that of the Layton. To the north of Drumright in sec. 20, T. 18 N., R. 7 E., the formations begin to rise and the terrace structure gradually merges into a strong monoclinal dip to the west. Since the formations rise as the terrace structure disappears, there is no prominent barrier and therefore the production is more or less continuous to the north end of the field. On the south end, however, as the terrace structure merges into the monoclinal dip on the west slope of Shamrock anticline, the formations dip slightly to the southward and this south dip shuts off production in the southern part of secs. 19 and 20, T. 17 N., R. 7 E.

It was shown above under the discussion of the Layton sand that in a general way the underground structure of this formation is very similar to the surface structure. * * * A study of the Wheeler sections * * * shows that the main north and south undulations occur in the localities where the surface undulations are more pronounced. The underground structure of the Wheeler sand * * * also conforms closely with the surface structure in that area. These studies, however, cover only the west side of the field and therefore show only the general west dip, but later development in the Bartlesville sand region shows that the Wheeler formation rises toward the axes of the different anticlines, where it is found at a shallower depth than at points down the slope.

BARTLESVILLE SAND.

The most important producing horizon in the Cushing field occurs in a sand known as the Bartlesville sand, so called because it is thought to be a continuation of the principal oil-bearing horizon near the town of Bartlesville from which this sand takes its name. The average thickness of the Bartlesville horizon in the Cushing field is not known because in practically all of the wells the drill was stopped in the sand itself, but the main sand is probably about 100 feet thick. The C. B. Shaffer well in the SE. corner of the NE. ¼ of sec. 18, T. 18 N., R. 7 E., is reported to have gone 135 feet in the horizon without passing through the sand. It is doubtful, however, if the Bartlesville sand is this thick, and the driller probably included in this 135 feet an upper sand and shale such as shown in the well logs below. (See pp. 191-192.)

The Bartlesville horizon is composed principally of a soft brown, porous, coarse-grained sandstone. The upper portion, however, is usually somewhat broken, ordinarily beginning with a thin sandstone followed by a comparatively thin shale interval, below which the top of the Bartlesville sand proper is found. Quite frequently the top of the main sand is hard and coarse-grained and only gas occurs in this. In a few wells a thin interval of shale or broken sand occurs in the main producing sand. In most cases these minor changes are not noted by the driller and the strata immediately above the production are recorded as one formation. * * *

The Bartlesville sand is the most interesting and most important formation in the Pennsylvanian series. This is due to the fact that it is more constant in its physical characteristics and has a larger areal extent and also produces much more oil than any other oil-bearing horizon in the Mid-Continent field. In the different oil fields of northeast Oklahoma, this sand has probably produced as much oil as all of the other oil bearing horizons in the Mid-Continent field. * * *

The stratigraphic position of the Bartlesville sand with respect to the overlying strata is well known in this field, but its relation to the formations occurring underneath is largely a matter of conjecture since there are no wells in the Cushing field that have been drilled down to the Mississippi lime. Carl D. Smith estimates that in the famous Glenn pool area the Mississippi lime occurs at a depth of about 1,300 feet below the Wheeler sand or Oswego lime. The names and approximate thicknesses of the formations which make up this interval beginning at the top and going down according to Smith are as follows:

	Feet.
Cherokee formation	1,000
Shale, sandstone, limestone, and coal.	
Morrow formation	100-120
Blue to white limestone, with some shale and thin sandstone.	
Pitkin formation	50
Limestone, blue and brown, locally sandy and shaly.	
Fayetteville formation	275
Black shale with thin beds of limestone and sandstone.	

In general the formations in the Pennsylvanian series in northeastern Oklahoma thicken to the south and to the west and therefore the interval between the Wheeler sand and the Mississippi lime in the Cushing field is probably somewhat in excess of 1,300 feet. Since the well records in the Cushing field show that the top of the Bartlesville occurs at an average depth of 421 feet below the top of the Wheeler, it is evident that the Mississippi lime lies at a depth of at least 880 feet below the top of the Bartlesville sand.

The areal extent of the Bartlesville sand is probably as great if not greater than that of the other producing horizons in the Pennsylvanian series. Correlations show this sand in every producing field in northeast Oklahoma, and that it also underlies a large part of southeast Kansas.

The first discovery well in the Bartlesville sand was not finished until December, 1913. Since the completion of this well in sec. 3, T. 17 N., R. 7 E. by the Prairie Oil and Gas Company, a large number of wells * * * have been drilled into this formation with the result that the greatest oil pool in the Mid-Continent field and in fact, one of the greatest in the history of the oil industry has been opened up. The limits of this pool which lie principally to the west of the Mount Pleasant anticline and along the Drumright anticline have been pretty well defined, but only a few wells have been drilled on the Shamrock and Dropright anticlines where the writer believes that other important pools will be opened up. * * *

A study of the Bartlesville production in the Cushing field shows that it is limited to a comparatively narrow strip extending in a general north and south direction along the axis of the major fold. The Bartlesville production east of Drumright is very unlike the Layton and Wheeler in two respects. In the first place the west dip in the Bartlesville is much more rapid than it is above in the Layton and Wheeler horizons, and therefore, the production does not extend as far to the west. In the second place, there is no distinct area as in the Layton and Wheeler sands. There is more gas along the crests of the folds, but this is accompanied with oil. A brief discussion of the relation of accumulation in the Bartlesville to structure will be made at this time.

The terrace structure which plays an important role in the accumulation of oil and gas in the Layton and Wheeler sands is not a very important factor in the accumulation in the Bartlesville sand. In fact, a study of the well records in the Bartlesville sand shows that there is no terrace structure in the Bartlesville, but rather the terrace structure above has given place to a small anticline below. This anticline apparently forms in the east-central part of the SE. ¼ of sec. 5, T. 17 N., R. 7 E., and extends southward along the east line of sec. 8, T. 17 N., R. 7 E., almost to the SE. corner of this same section and then swings rather abruptly to the east and continues to the central part of the NE. ¼ of sec. 16, T. 17 N., R. 7 E. It is very probable that the anticline continues to the southeast and connects up with the main fold of the Shamrock anticline. The production in sec. 8 is apparently due to this fold, because to the north and west down in the synclines there is no production. The area along this fold extending to the southeast and joining up with the Shamrock fold in sec. 15, T. 17 N., R. 7 E. and thence southward through secs. 22 and 27, T. 17 N., R. 7 E., should be very favorable territory. A few wells have been drilled in this general area and they are yielding a good production. The territory lying east of this fold in the southern part of sec. 10 and connecting up with the syncline extending to the southeast and passing between the Shamrock anticline and the Mount Pleasant anticline is not favorable territory.

The principal Bartlesville production at the present time occurs along the prominent anticlinal structure extending from the south side of sec. 33, T. 17 N., R. 7 E. southeast through sec. 3, T. 17 N., R. 7 E. This fold undoubtedly continues to the southeast connecting up with the Mount Pleasant anticline in sec. 11, T. 17 N., R. 7 E., but there has not been enough drilling to prove this. On the northwest, near the center of sec. 33, T. 17 N., R. 7 E., the Bartlesville sand dips off very rapidly to the north and west which is also true to a less extent of the surface structure, and therefore the territory between this area and the southern end of the Dropright anticline should be unproductive territory. The dry hole in the

NE. corner of the SE. 1/4 of sec. 29; also the one in the NE. corner of the NW. 1/4 of sec. 28; and still another in SE. corner of the SW. 1/4 of sec. 20, T. 18 N., R. 7 E., all in the Bartlesville sand seems to prove this. A short distance to the north, however, where the formations begin to rise toward the Dropright anticline Bartlesville production is obtained and all of the territory near the crest of this anticline should be favorable. The underground structure of the Bartlesville sand in the Dropright area is not known, since there is very little development in this horizon along the Dropright anticline. There is very little doubt, however, that the main folding will conform in a general way to the north and south fold in the surface structure, yet there may also be some minor folding that does not show up on the surface structure. In fact the underground structure in the different producing horizons over the developed areas, as has already been shown, although conforming very closely in the main features is much more irregular and pronounced than it is on the surface. This is especially true of the Bartlesville sand. * * * There is some evidence that the production in the northwest part of the Dropright area occurs along an anticlinal fold which probably branches off from the main Dropright anticline near the southeast corner of sec. 8, T. 18 N., R. 7 E. and extends northwest through sec. 5 into sec. 6. The surface structure in this area along Cimarron River and some distance to the west is covered up with river sand and alluvial deposits and therefore is probably not mapped very accurately since the contour lines connecting known structural points on the north and south were only drawn in roughly.

TUCKER SAND.

The Tucker sand, like the Bartlesville, has been of late development. Lying below the Bartlesville sand, it is the deepest producing sand of the Cushing field. The interval between them is approximatelly 100 feet and the two are frequently confused for this reason. Some oil men are of the opinion that the Tucker is a part or extension of the Bartlesville sand. However, from a study of available data the Tucker sand seems to be distinct and separate from the Bartlesville. In the north extension the Tucker is encountered at a depth of approximately 2,600 feet, and in the old pool near Drumright, about 2,950 feet.

The development in this sand at present is insignificant in comparison with that of the Bartlesville. It has not been regarded as a sustaining producer. The production is very erratic, decreasing rapidly. In some cases it has fallen off more than 1,000 barrels during 12 hours. One of the disadvantages in drilling into this sand is the necessary precaution required so as not to run into salt water. The largest producing oil well in Oklahoma was obtained from the Tucker sand by the Gypsy-Gillespie interests on the Jackson Barnett lease in sec. 5, T. 17 N., R. 7 E., 4 miles north of Shamrock. It was reported that the daily production reached a maximum of 18,000 barrels per day soon after the well had been completed. The success of the large well stimulated a very active campaign in deepening the shallow wells.

CHARACTER OF OILS IN CUSHING FIELD.

In spite of the fact that Oklahoma is one of the principal oil producing areas in the world, very little work has been done in the way of investigating the character of its oils. David T. Day, working under the auspices of the United States Geological Survey, is the only one, until recently, who has done any extensive work. His samples were collected in the spring of 1908, and therefore do not include the Cushing oils. Several years ago, however, the Corporation Commission of this State decided that, in view of the rapid reduction of the market value of crude oil by the Prairie Oil & Gas Company and other corporations, it should, among other things attempt to regulate the price of this commodity. In order to carry out its plans intelligently, the Commission asked I. C. Allen, an expert oil chemist for the United States Bureau of Mines, to analyze samples of oils from the different fields in the State and to make a report on same.

In order that the reader may know the character of the oils in the Cushing field, and also that of the oils in the other fields in the State, the anaylses by Allen are here given.

Average analyses of Oklahoma oils, by fractional distillation.

Location.	Specific gravity. (at 15° C.)	Degrees Baume (60° F.)	Calories per gram.	B. t. u. per pound.	Viscosity at 20° C. (Engler scale.)	Sulphur. (per cent.)	Water. (per cent.)
Composite of 6 samples from Cushing field. Taken by O. U. Bradley, May 28, 1914	.8190	40.94	10,975	19,755	1.3	*	0.22
Composite of 5 samples from Boston pool. Taken by O. U. Bradley, May 30, 1914	.8330	38.07	10,924	19,661	1.5	0.1	0.15

*Trace.

DEVELOPMENT.

The discovery well in the Cushing field was completed in March, 1912. During the first twelve months of the history of this field the principal development was within the vicinity of Drumright in the Layton sand and Wheeler limestone. After this period, however, development spread rapidly in the Layton and Wheeler horizons and soon test wells were drilled in almost every part of the present productive area. At the time the pools appeared to be isolated but later development shows that they are all more

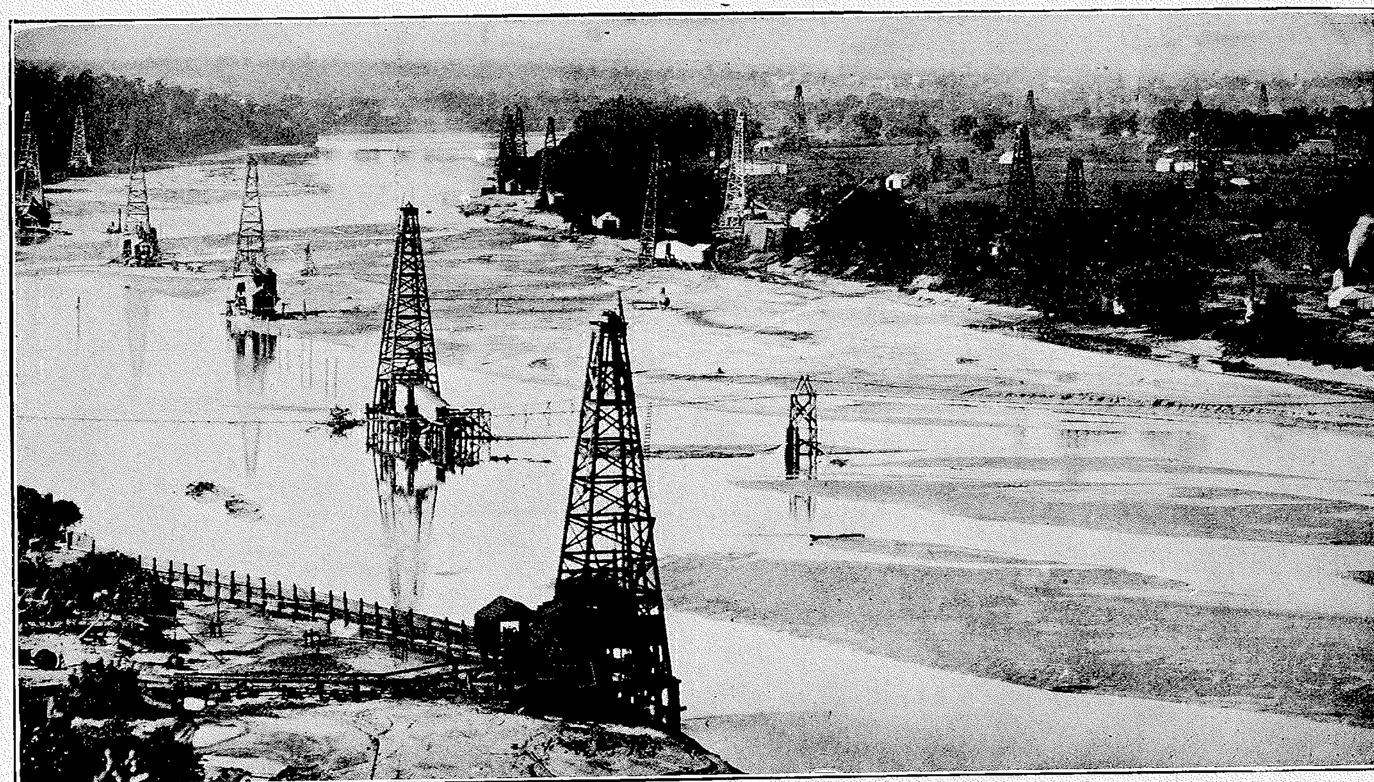


PLATE XV. OIL AND GAS DEVELOPMENT IN BED OF CIMARRON RIVER NORTH END OF CUSHING FIELD.

or less connected with the possible exception of the area in sections 14, 15, 22, and 23, T. 18 N., R. 7 E. The north end of the field along Cimarron River, which caused considerable excitement at the time, was not discovered until the summer of 1913. Rapid development continued, but there was no new pool opened up until in December of that year, on the completion of the Prairie Oil & Gas Company's well on the Tucker farm in sec. 2, T. 17 N., R. 7 E., which started off at 500 barrels a day in the Bartlesville sand.

Data gathered from drilling records in the Bartlesville, Layton, and Wheeler sands seem to warrant the following general conclusions. The Bartlesville, which is essentially an oil sand, contains little gas. As a result of the absence of gas and the extreme porosity of the rock, the oil extends up the slopes and over the crests of the anticlines. The oil of the Wheeler sand is found farther down the slope than that of the Layton or Bartlesville. The porosity of the Wheeler seems to be less than in either of the other sands. The fineness of the sand combined with the pressure exerted by the gas, serve to keep the oil of the Wheeler at a lower level on the structure. Of the wells drilled to the three sands, those to the Bartlesville are highest structurally, while those to the Wheeler are lowest. The Layton wells hold the intermediate position.

The bringing in of several other good wells in this area was followed by very great development. Most of the wells were drilled to the Bartlesville sand. In 1914 development increased. At first there was considerable development east of Drumright, but later the north end of the field was the most active. This drilling campaign opened up one of the greatest fields in the history of the petroleum industry and placed the production of this field above that of any other in the United States, and as a high grade oil field, above that of any in the world. Most of the development during the year was centered in the Bartlesville sand, the upper sands being cased off. In 1914 more than 750 wells were completed, which was about 9% of the total number in the State. The Bartlesville sand area occupies a belt 3 to 5 miles in width, extending from secs. 21 and 22, T. 17 N., R. 7 E. northwestward to the southern tier of sections in the W. ½ of T. 19 N., R. 7 E., a distance of 9 miles or more.

During 1915 the field was still being extended in the north and south ends. The production began to decline, regardless of the completion of many good wells. A new feature of development was the south extension of the field in secs. 4, 9, and 16, T. 16 N., R. 7 E. north of Depew in what is known as the Fox pool. The Layton sand was found to be very productive in the initial wells. The Gypsy Oil Co., No. 1, on the Bennie Trent farm in sec. 9, T. 16 N., R. 7 E., is reported to have had an initial daily production of 1,000 barrels in the Layton sand at a depth of 1,505 feet. Much activity followed in this area. In the latter part of the year the price of petroleum began to rise and as a result renewed activity followed.

During the first half of 1916 the most interesting feature, outside of the continued development, was the deepening of the Layton, Wheeler and Bartlesville wells, in the old pool to the Tucker sand. A prolific production was obtained from some of these wells. At present, August, 1916, the production is gradually declining and the same is also true of the price of petroleum.

The following tables give a summary of the development in the field up to April, 1916.

Date.	Wells completed.	Dry.	Gas.	Oil producing	Oil production.	Initial production.
1912						
November	29	0	1	28		4,250
December	33	0	2	31		6,015
1913						
January	50	1	3	46		4,575
February	46	1	2	43		7,500
March	45	0	2	43		7,600
April	61	2	3	56		5,875
May	47	1	5	41		7,615
June	71	1	4	76		9,587
July	68	3	3	62		11,070
August	69	0	1	68		12,661
September	51	3	3	45		8,657
October	52	1	2	49		9,718
November	27	0	1	26		8,493
December	88	4	11	73		8,630
1914						
January	53	7	7	39		13,631
February	42	1	9	32		13,688
March	50	2	5	43		24,364
April	38	2	2	34		24,218
May	66	8	3	55		60,135
June	83	1	2	80		82,459
July	67	1	0	66		60,480
August	77	3	2	72	4,690,000	63,960
September	79	10	2	67	5,037,000	76,480
October	59	2	1	56	5,164,000	72,975
November	50	1	2	47	4,732,000	72,975
December	94	14	1	79	6,867,500	121,345

Date.	Wells completed.	Dry.	Gas.	Oil pro-ducing	Oil production.	Initial production.
1915						
January	60	1	3	56	7,393,934	116,490
Febuary	63	1	0	62	5,712,000	106,110
March	83	4	3	76	6,916,720	77,135
April	102	1	1	100	8,658,000	136,850
May	117	0	1	116	7,471,000	120,575
June	118	0	1	117	8,002,500	104,770
July	116	12	1	103	6,324,000	67,470
August	98	7	7	90	5,618,750	40,765
September	57	3	0	54	4,260,000	15,295
October	67	6	2	59	3,820,750	19,205
November	57	6	1	50	3,390,000	14,570
December	79	11	5	63	3,137,200	8,440
1916						
January	47	0	0	47	2,837,000	51,590
February	61	0	0	61	2,768,000	24,784
March	42	7	2	33	3,702,000	11,935
April	51	5	1	45	3,253,000	7,610
May	70	2	3	65		24,775
June	81	2	2	77	3,596,000	52,875
July	82	7	3	72	4,347,750	25,055
August	68	0	7	61	3,972,650	19,130
September	48	4	2	42	3,435,000	7,845
October	116	3	13	100	3,180,600	14,080
November	40	1	2	37	2,944,710	8,135
December	62	3	3	56	2,659,800	8,670

MARKETS.

PIPE LINES.

There are three main pipe line companies, the Prairie Oil & Gas Company, the Texas Company, and the Gulf Pipe Line Company, operating in the Cushing field. All three companies entered the field soon after production was found there and have since carried most of the crude to refineries in different parts of the country. The crude carried by the Prairie lines is taken to the Standard plants at Neodesha, Kan.; Sugar Creek, Mo.; Wood River, Ill.; and Whiting, Indiana. The Texas Company transfers the crude to its own refineries at Dallas, Port Arthur, and Port Neches, Texas. The Gulf lines carry the crude to the refineries of that company at Fort Worth and Port Arthur, Texas.

In addition to the three main pipe lines mentioned above, all the refineries located in Cushing have their own pipe line connections for transporting the crude oil from the field to their respective refineries. The J. S. Cosden Company's plant at West Tulsa, the plant of the Milliken Refining Company at Vinita, and the Pierce Oil Corporation's plant at Sand Springs are also connected with the field by their own lines. * * *

Some of the production is transported from the field to the railroad in small lines and loaded into tank cars by means of loading racks, and shipped to market. The amount of crude oil transported in this manner is very small compared to the amount piped away.

At the present time the transporting facilities in the Cushing field are not adequate to carry away the total production. The lighter compounds in the Cushing crude volatilize rapidly when allowed to stand in the open and therefore the oil depreciates in value. In order to care properly for the over-production practically all of the producing companies owning Bartlesville productions have acquired one or more farms on which they are constructing storage tanks. A large number of these tanks have already been completed. * * *

REFINERIES.

The Cushing field furnishes a large percentage of the refineries in Oklahoma, and some in Kansas and Texas, with all or a part of their supply of crude oil. On account of the transportation facilities and location to production many refineries have been established at or near the town of Cushing. Soon after the field was opened several refineries were located there. At present there are about 10 refineries in Cushing. They are as follows: Chanute Refining Company, capacity 2,750 barrels; Brown's Refining Company, capacity 500 barrels; Chelsea Refining Company, capacity 2,000 barrels; Consumers' Refining Company, capacity 4,500 barrels; Cosden Refining Company, capacity 1,000 barrels; Colonial Refining Company, capacity 1,500 barrels; Cushing Refining Company, capacity 2,600 barrels; Jane Oil Refining Company, capacity 2,000 barrels; New State Refining Company, capacity 1,000 barrels; International Refining Company, capacity 3,000 barrels.

The most important refineries outside of the Cushing field that use Cushing crude are as follows: Those to which the Prairie Oil

& Gas Company, the Gulp Pipe Line Company, the Oklahoma Pipe Line Company, and the Texas Company lines transport crude, as mentioned above in dealing with those lines; J. S. Cosden Company's plant at West Tulsa; the plant of the Milliken Refining Company at Vinita; and the Pierce Oil Corporation's plant at Sand Springs. All of these plants are connected with the field by their lines. The Milliken plant is at present using Cushing crude entirely, and the plants of J. S. Cosden & Company, and Pierce Oil Corporation get most of their crude from this field.

The chief refined products secured from Cushing crude are: Gasoline, naptha, kerosene, machine oils, and fuel oil. They are marketed throughout the middle states and large quantities are exported.

GENERAL CONCLUSIONS.

The discussions above based on actual development and structural maps reveal the fact that there is a general stratigraphical arrangement of gas, oil, and salt water in the Cushing field, and that the accumulation of these is dependent largely on the folding in this area. This relation of accumulation to structure is evident because the general gas pools occur along the crests of the different anticlines just above the general oil territory, and the wells drilled into the producing horizons down the slopes below the area of oil production almost invariably get large quantities of salt water.

Although folding has been the principal factor in the accumulation of the oil and gas pools in the Cushing field, yet the variations in the physical characteristics of the receiving sand have also played an important part. The irregularity in thickness, porosity, and other physical characteristics of the individual producing horizons are the principal factors which prevent the oil, gas, and salt water from arranging themselves in the respective horizons in such a way as to have a constant ratio of production in areas occurring on similar structure. At the time of deposition the physical properties of the Layton, Wheeler, and Bartlesville sands were probably much more uniform than they are at present, because the individual deposits along the shores of the ocean in horizons similar to these are usually comparatively regular in thickness, porosity, and other physical characteristics. After these formations were laid down, however, they were covered up with succeeding formations and subjected to erosion by circulating underground waters. This erosion undoubtedly formed porous channels through which these percolating waters could pass. The ordinary processes of erosion, solution, and redeposition, have altered considerably the original character of the sands, with the result that in some places the sands are very soft and porous; while in other places, sometimes within close proximity, redeposition has rendered the formation so hard and close grained that oil and gas could hardly penetrate these locally hardened areas. The occurrence of small producing wells and even a few dry holes in different producing sands over the Cushing field in areas of good production is due, in the opinion of the writer, to these irregularities in the individual sands. The variation in the initial production, closed rock pressure, proportion of oil to gas or salt water or both, and also the variation of the life of individual wells on the same structural horizons in the same community is also due to this irregularity in the physical properties of the sands.

In addition to this folding and variation in the physical properties of the producing sands which are the principal factors in the accumulation of the oil and gas pools in the Cushing field, there are other factors which play a minor part in this general process. The large quantities of oil and gas in this field have very likely been under process of accumulation since the first folding took place. Within this long period of time many changes have probably occurred, such as the changes in the places at which the oil and gas were forced into this folded area and also the variation in the force or power of the transporting agents.

GAS PRODUCTION.

DEVELOPMENT.

The Cushing field is one of the greatest gas producing fields of the world. In 1912, when the field was opened, only a few gas wells were completed with an initial volume of about 10,000,000 cubic, with rock pressure varying from 250 to 850 pounds. In 1913, 40 gas wells were completed and the production of gas became troublesome in drilling. In 1914, 36 gas wells with the enormous initial volume of 608,000,000 cubic feet per day, and rock pressure as high as 800 pounds were completed. In 1915 the field only yielded 189,000,000 cubic feet, on initial flow, but in 1916 about 1,000,000,000 cubic feet, the largest amount in the history of the field was uncovered.

Table showing number of gas wells and initial guage of volume and pressure in the Cushing field, 1912-1916, *by years.*

Year	No. of gas wells.	Initial volume cubic feet	Pressure pounds
1912	9		
1913	43		20-900
1914	36	608,000,000	40-800
1915	19	199,000,000	20-900
1916	43	608,000,000	40-800

SANDS.

Almost all the sands in the Cushing field contain gas in some parts of the field. The first gas sand is encountered at from 650 to 950 feet. The production is small in comparison with the deeper sands. The Layton sand, besides producing oil, is a heavy gas producing horizon in some parts of the field. The Jones and Cleveland sands yield some gas. The Wheeler sand is an oil and gas sand, and yields a considerable volume of the gas. The Bartlesville, besides being the heaviest producer of oil, also yields some very large gas wells.

The McMann Oil Company's No. 2 on the Nora Williams allotment, 2 miles south of Shamrock, was a gas well with an estimated initial volume of 100,000,000 cubic feet. This well is reported to be the largest producing gas well in the State. Gas was found in the Bruner, Jones, Layton, Skinner, and Bartlesville sands, the latter having the greatest volume. The force of the gas coming from the well was tremendous. After reaching the Bartlesville sand there was sufficient force to throw the drilling tools out of the hole from a depth of 2,800 feet. Several other large gas wells have been completed near this well.

WASTE OF NATURAL GAS.

In 1913 and 1914, when development became very active in this field, the question of handling the gas became very serious. Especially was this true of the wells drilled in the north extension where a heavy gas production was encountered in the shallower sands. At that time there were no pipe line facilities for taking care of the gas and besides the operators were not seeking gas production, but were after the heavy oil production in the Bartlesville sand. Consequently the gas was allowed to escape, and drilling was continued to the Bartlesville. Enormous quantities of gas were wasted in this manner. It has been estimated that at times during 1913 and 1914 the daily waste of gas in the field was at least 500,000,000 cubic feet, which was enough to supply all the principal cities of the State.

Conservation laws were passed by the State and steps were taken to enforce them, so that the greater portion of the gas which had been going to waste would be conserved for future use. During 1913 the United States Bureau of Mines sent two experts to Oklahoma to prevent a large part of this waste. They started their experiments in the Cushing field and in most cases received the hearty cooperation of the oil men. The system used consisted in pumping a mud-laden fluid into the porus space of the gas sands, thus sealing them, so that the gas could not penetrate the well. This method has been used very successfully, so that the waste of gas decreased considerably.

It has been estimated by the Bureau of Mines that in the Cushing field alone a total of over 250,000,000,000 cubic feet of gas have been wasted, enough to supply the domestic needs of a million people for eight years, and if calculated in terms of coal would be equal to 10,000,000 tons.

During 1915, however, an enormous quantity was wasted, which if calculated in terms of coal would be equal to 2 1-2 times the value of coal produced in Oklahoma during that year. The operation of the gas conservation law by the Corporation Commission has had the effect of saving the State millions of dollars worth of gas.

MARKETS.

Only a small amount of the gas which is encountered in the Cushing field is being consumed. In 1913 considerable gas was piped from the field and marketed by the Creek County Gas Company. Other gas lines are now operating in this field. The Creek County Gas Company supplies Cushing, Sapulpa, Drumright, and other towns, and also furnishes some gas to the Wichita Gas Company.

In 1914 the Wichita Gas Company completed a 50-mile pipe line from this field to its compressor station near Bigheart and supplied gas to the Quapaw Gas Co., and also to its own customers in northern Oklahoma, southeast Kansas, and southwest Missouri.

The Oklahoma Natural Gas Company also operates in this field. One of its main compressing stations is located at Shamrock, which is in the midst of enormous gas production. This company supplies many towns in Oklahoma and has one line now in use and another under construction to Oklahoma City.

The casing-head gasoline industry is another market for the natural gas production in the Cushing field. The gas from this field is rich in gasoline, so that this industry is becoming a very important factor in the utilization of the gas.

The following table shows the name, location, and capacity of the casing-head gasoline plants in the Cushing field.

Name	Location	Capacity
Mid-Continent Gasoline Co.	Drumright	11,000
Mid-Continent Gasoline Co.	Cushing	11,000
Victor Gasoline Company	Drumright	10,200
Hillman Gasoline Company	Drumright	550
C. B. Shaffer		500
Osage and Oklahoma		1,100
Hill Oil & Gas Company	Drumright	10,000
Creek County Gas Company	Shamrock	

FUTURE SUPPLY OF GAS.

Notwithstanding the fact that enormous quantities of gas have been utilized and wasted, a considerable amount has been so conserved that it can be used in the future. In all of the areas where the conservation methods were used, this supply can be recovered and would amount to a very large quantity. Besides this there are known areas where a large supply can be procured. Up to the present time the oil companies have been seeking oil production so that in an area where gas was the only production encountered only a few wells were drilled. When needed, large quantities could be supplied by developing these areas. As stated in the discussion on oil sands, large volumes of gas are encountered near the top of the anticlinal structure. This reservoir of gas has not been developed.

This field offers wonderful possibilities for the manufacturing of casing-head gasoline. This industry is only in its infancy, and in the future as the field becomes exhausted, it will probably become the greatest field for that product that the State has ever produced.

Taking into consideration the tremendous amount of gas which is still uncovered and also that which has been conserved, it can be safely estimated that this field, if economically and conservatively utilized, will furnish a very large supply for many years to come.

GLENN OIL AND GAS POOL.

LOCATION AND EXTENT.

The Glenn pool includes the W. ½ of Tps. 17 and 18 N., and all of T. 19 N., R. 12 E., and NE. ¼ T. 18 N., R. 11 E., in Creek and Tulsa counties, near Sapulpa and Tulsa. Included in Glenn pool are several minor pools known as Taneha, Red Fork, and Perryman. The main pool is in the W. ½ of T. 17 N., R. 12 E., near Kiefer.

GEOLOGY.

GENERAL RELATION OF THE FORMATIONS.*

In order to understand conditions that probably prevail beneath the surface in the Glenn pool, it is necessary to consider the character and attitude of formations 35 to 40 miles to the east, where the deeply buried strata of the Glenn pool area come to the surface and can be studied in outcrops. The section of rocks exposed in the area represented by the map is about 850 feet in thickness and comprises alternating beds of shale, sandstone, limestone, and coal, named in the order of their relative thicknesses. These formations are Carboniferous in age and constitute a part of the Pennsylvanian or middle series of the Carboniferous, which outcrops in northeastern Oklahoma, on the west flank of the Ozark uplift, extends as a broad northeast-to-southwest trending belt from Kansas into Oklahoma, and dips gently beneath the Permian series (Redbeds).

The contact of the Pennsylvanian series with the Mississippian series below, which lies near and roughly parallels Grand River, is unconformable, but the angle of unconformity between the two series is so light that the discordance in strike and dip of the strata is scarcely perceptible. It is probable that the Pennsylvanian sediments were deposited upon a slightly eroded and gradually sinking land surface composed of the Mississippian series, and were derived, in part at least, from the Mississippian and older rocks which form the core of the Ozark dome. No unconformities of more than local development have been noted in the Pennsylvanian series above the base of the Cherokee formation, which is described below.

Section showing relations, character, and thickness of formations exposed in and to the east of the Glenn pool area, Okla.

Carboniferous system:

Pennsylvanian series:

	Feet.
Limestone, bluish gray; locally known as the "Lost City limestone"	1-40
Shale and sandstone	350
Limestone, bluish, hard; checkerboard lime of the drillers	2½
Shale, with variable beds of sandstone	25
Coal, Dawson	1 2/3- ½
Shale, with irregular beds of sandstone	210-350

*Smith, Carl D., Bulletin U. S. Geol. Survey, No. 541, 1912, pp. 35-36.

Section showing relations, character, and thickness of formations exposed in and to the east of the Glenn pool area, Okla.—Continued.

Limestone, massive gray; big lime of drillers	0-40
Shale, with irregular beds of sandstone	200
Limestone, Fort Scott, Oswego lime of drillers; bluish-gray limestone with 3 to 5 feet of shale near middle	10-30
Shale, sandstone, limestone, and coal; Cherokee formation	1,000
Unconformity.	
Blue to white limestone, with some shale and thin sandstone; Morrow formation	100-120
Unconformity.	
Mississippian series:	
Limestone, blue and brown, locally sandy and shaly; Pitkin	60
Black shale with thin beds of limestone and sandstone; Fayetteville formation	20-60
Unconformity.	
Limestone, Boone; flinty limestone and flint	200

On account of their greater hardness the sandstone and limestone beds are much more conspicuous in their outcrops than the shale, but probably the shale constitutes four-fifths to nine-tenths of the geologic column. The shale is generally soft and friable and disintegrates rapidly on exposure, thus giving rise to valleys or lowlands where unprotected by caps of harder material. The sandstone varies greatly in hardness. Many beds are so loosely cemented that they weather as easily as shale, thus giving the impression that they are extremely variable or lenslike in development, whereas others are of sufficient hardness to form bold escarpments many miles in length.

*Pre-Pennsylvanian Series.**—The Boone formation or main "Mississippi lime" is not thought to have been encountered in drilling wells in this area. A black limestone encountered at a depth of 950 to 1,200 feet has been called the "Mississippi lime" by drillers, but it is thought that the Boone probably lies deeper, about 1,300 feet below the Fort Scott (Oswego) limestone. From a study by Smith of the logs of the wells in the Glenn pool area the thickness of the section between the base of the Cherokee and the top of the Boone is about 550 feet. It is generally considered that no oil or gas occurs in paying quantities below the top of the Boone, but a further correlation is necessary to prove this conclusion in all cases.

From a study of well records the Fayetteville formation of Mississippian age appears to be about 275 feet thick. The Pitkin limestone,

*For a discussion of the individual formations reference is made to other counties in which they outcrop and are discussed in that connection.

or upper "Mississippi Lime", mistaken in many cases by drillers for the Boone (main Mississippi lime) lies at the top of the Mississippian.

Pennsylvanian series.—The Morrow formation, the basal part of this series, if extending as far west as this area, is indistinguishable from the Pitkin. The Cherokee formation, also basal Pennsylvanian, lies at a depth of about 850 feet in this area and contains the most productive oil sands. The Fort Scott or Oswego lime is encountered at an average depth of 1,040 feet, and the Big lime at about 800 feet, the latter lying about 200 to 240 feet above the top of the former.

FORMATIONS EXPOSED IN THE GLENN POOL AREA.*

From 210 to 350 feet above the Big lime is a coal bed 20 to 30 inches thick, whose outcrop passes through Dawson, thence southeast of Tulsa, 3 miles northwest of Jenks, just west of the town of Glenpool, thence southwestward to a point a mile or so east of Mounds. For convenience of discussion it is called in this paper the Dawson coal. This coal is an excellent datum surface for working out details of structure but is noted in only a few well logs. In the neighborhood of Tulsa the coal bed lies about 465 feet above the Fort Scott limestone. Near Mounds it should be found about 550 to 570 feet above the Fort Scott limestone.

About 215 feet above the Dawson coal and 680 to 780 feet above the top of the Fort Scott is a thin hard limestone of remarkable persistence and uniformity, which outcrops in a number of places in the Glenn pool area. This bed is exposed in Tulsa at the junction of the St. Louis & San Francisco and Missouri, Kansas & Texas and Midland Valley railroads, near the north end of the St. Louis & San Francisco Railroad bridge over Arkansas River, at a number of places between Red Fork and Jenks, at many places in Glenn pool proper, and a short distance northeast of Mounds. It varies little from 2 feet 6 inches in thickness and is an excellent datum surface for working out details of structure. It is known to drillers as the Checkerboard lime.

Another recognizable bed in the Glenn pool area is a limestone which outcrops at Lost City and is locally known as the "Lost City limestone." It lies stratigraphically about 350 feet above the Checkerboard lime and 1,030 to 1,130 feet above the top of the Fort Scott limestone. Its maximum measured thickness is about 40 feet, where it is exposed at the site of a proposed cement plant near the northeast corner of sec. 18, T. 19 N., R. 12 E. From this point, both northeast and southwest, the thickness of the limestone diminishes in short distances to a foot or so. It is quarried northeast of Sand Springs and at Lost City, in the south bluff of Arkansas River southeast of Sand Springs. From this latter point the outcrop of the limestone trends south and southwest, passing west of Sapulpa. Above this limestone, in the area shown on the map, is an unmeasured thickness of shale and sandstone that has not been examined in detail and will receive no further consideration in this report.

*Smith, Carl D., op. cit., pp. 40-41.

SANDS.

A study of the formations in a large number of wells shows that there are several producing sands in various parts of the field. Three are the most productive.

The 760 to 800-foot sand is encountered in the northern portion of the field and is a small producer. This sand has a thickness of 50 feet. Some geologists consider this horizon the same as the "Big lime," or Oologah formation.

A little more than 100 feet below is another light producing sand. This occurs at about 975 to 1,000 feet and holds about the same stratigraphic position as does the Cleveland sand. Three other sands 30, 20, and 25 feet thick, respectively are found at 1,035, 1,075, and 1,150 feet. The last mentioned sand is probably the equivalent of the Skinner and is the best producer of the three.

The Red Fork sand is an important producer. It is recorded at depths varying from 1,275 to 1,500 feet. As a producer it is second in importance, being exceeded only by the Glenn sand. The thickness varies from 10 to 30 feet.

In some wells a 25-foot oil producing sand is recorded at from 1,600 to 1,650 feet. Production from this horizon is light.

The Glenn sand is given by Carl D. Smith* as being 90 feet thick, and 1,700 to 1,790 feet beneath the surface. L. C. Snider, in his book on Petroleum and Natural Gas in Oklahoma, finds the Glenn reported at shallower depths than those given above. Logs show, however, that the thickness varies from 10 to 125 feet in different points. It is probably true, though, that 80 feet is a fairly accurate estimate, since so many of the wells are drilled only a short distance into the sand. By many drillers and some geologists of repute, this sand is correlated with the Bartlesville, which occurs farther north.

At about 1,900 feet the Squaw, or Taneha, sand is found. In thickness it varies from 10 to 50 feet with an average of about 30 feet. Rough correlations seem to show that the Burgess and Tucker sands to the north and west hold the same stratigraphic position as does the Squaw, or Taneha. It is impossible with the data at hand to absolutely prove or disprove this conclusion.

The Rhodes, or Dutcher, sand occurs about 50 feet above the Morrow limestone at 2,000 to 2,025 feet below the surface. The Morrow and Pitkin limestones mark the top of the Mississippian rocks and were formerly considered as the "Mississippi lime," and the lowest point at which production in this part of the State could be secured.

Two sands have been found below these limestones, one at a depth of 2,390 feet, termed by some geologists the "Mounds sands"; while the other sand is found at a depth of 2,530 feet, and lies upon the Boone

*Smith, Carl D., The Glenn oil and gas pool and vicinity, Oklahoma: Bull. U. S. Geol. Survey No. 541, 1912, Pl. III.

chert or Mississippi lime, and must be in the Fayetteville shale. Little is known as to the character of these sands.

STRUCTURE.

The Glenn pool lies in the region of the Prairie Plains monocline, which extends from Iowa through western Missouri, eastern Kansas, and central Oklahoma. In the Glenn pool region the rocks dip westward about 50 feet to the mile. There is however a great variation in the dip. The general structure is complicated, being a series of minor folds whose axes extend north of west. These flexures are not well defined and merge into the west dip, both to the east and to the west. According to the structural map of Carl D. Smith, in Bulletin 541-B of the United States Geological Survey, two anticlinal folds occur in the field. The axis of the larger fold, which is about 1¼ miles north of Kiefer, extends in a slightly north of west direction for several miles, and the other is shown 7½ miles due north of Kiefer and 1½ miles south of the Tulsa-Creek county line. It seems, however, that the absence of the larger folds in this region does not prevent the occurrence of oil in the minor crumplings. The fact that the maximum production has resulted in the vicinity of the larger fold does tend to show, however, that the size of the structure does directly influence the production.

DEVELOPMENT.

After the discovery in 1906 development was rapid, and in a short time the pool became world famous as a phenomenal producer. At the present time about 20 square miles of territory are thoroughly developed. From March, 1907 to June, 1911, with two exceptions, December, 1910 and February, 1911, the monthly production was above a million barrels. In fact, the maximum output, 2,584,464 barrels, came in March, 1911, after over 78,000,000 barrels had been produced. For 1913 the total production was 9,469,870 barrels, an average monthly production of about 790,000 barrels, while for 1914 it has been estimated that the total production was 8,677,589 barrels, an average monthly production of approximately 723,000 barrels.

Gas wells in this field make up about 4 per cent of the total number drilled. Many wells produced from both above and in the oil sand. Wells with capacities varying from 10,000,000 to 30,000,000 cubic feet were often allowed to run open for weeks and the amount of gas utilized was negligible as compared with that wasted. Gas wells flowing 30,000,000 to 70,000,000 cubic feet have been exhausted entirely within three or four months. At the present time most of the gas which is being produced from the 1,400-foot sand along the eastern side of the oil area is being utilized, mainly in the manufacture of natural gas gasoline.

The table of production given below shows in a concrete form the rapid rise and gradual decline of the output from January, 1907, to December, 1915.

Table showing the production of the Glenn pool, 1907-1914, by months, in barrels.

Month	1907	1908	1909	1910	1911	1912	1913	1914
January	385,939	1,796,461	1,362,602	1,745,206	1,099,192	882,385	792,336	829,483
February	572,414	1,897,054	1,410,878	1,543,660	967,924	867,566	718,580	769,809
March	1,084,636	2,098,411	1,543,463	1,974,514	2,584,464	924,144	807,022	871,334
April	1,716,079	1,968,761	1,467,179	1,674,709	1,570,947	898,527	823,645	849,316
May	1,923,262	1,630,111	1,590,730	1,676,366	1,069,863	927,182	850,607	897,397
June	1,971,387	1,051,045	1,809,898	1,573,578	958,519	816,028	816,789	852,901
July	1,922,387	1,914,134	1,856,524	1,557,869	965,122	880,906	787,274	828,350
August	2,003,607	1,770,819	1,699,486	1,609,702	891,946	927,675	734,476	535,027
September	2,309,205	1,639,252	1,570,167	1,593,986	937,886	794,958	773,847	431,051
October	2,441,662	1,832,033	1,602,988	1,521,794	969,247	921,736	817,628	584,178
November	1,971,595	1,404,234	1,039,342	1,400,118	864,519	768,254	753,115	504,397
December	1,625,127	1,491,998	1,393,392	1,365,412	910,489	886,157	794,551	514,346
Total	19,927,300	20,494,313	18,946,740	19,236,914	13,880,118	10,495,518	9,469,870	8,677,589

The following table of development covers the Glenn, Sapulpa, Tulsa, and Taneha pools for the years 1909 to 1915, inclusive.

Drilling record and initial production in barrels of wells in the Sapulpa, Tulsa, Glenn, and Taneha pools.

	Wells completed.				Initial production (bbls.)	
Year.	Total.	Oil.	Dry.	Gas.	Total.	Average per well.
1906	4,853	4,301	296	222	138,816	31.8
1909	462	422	28	12	49,665	117.7
1910	409	366	28	14	35,160	96.0
1911	355	282	65	8	27,270	96.7
1912	698	457	147	94	35,279	77.2
1913	989	740	186	63	31,595	42.7
1914*	1,195	874	252	51	56,920	65.3
1915*	1,744	915	477	152	83,541	91.3
Total	5,852	4,054	1,183	395	319,430	78.8

*Includes also Inola and Wicey.

CHARACTER OF OIL.

Samples of oil collected and analyzed by D. T. Day of the United States Geological Survey from wells in the Glenn pool ranged in gravity from 32.2° to 38° Baume, the average being about 35°. The samples were collected from 10 different wells which vary in depth from 1,500 to 2,340 feet. The oil was, with one exception, black. The sample collected from the 2,340-foot sand was bright green in color, had a specific gravity of 32.2° Baume, contained 8.44 per cent paraffin and .62 per cent asphalt. Other samples contained from 11.46 to 3.12 per cent paraffin. The asphalt content is always low, being less than .50 per cent in most cases.

MISCELLANEOUS DEVELOPMENT.

There has been some activity in drilling near Bristow. Sheets Brothers were reported to have completed a small producer in sec. 36, T. 15 N., R. 8 E., in a sand found at 3,160 feet, and later, on deepening, had an initial production of 100 barrels per day. Joe Abraham has completed several small gas wells in sec. 18, T. 15 N., R., 9 E. A number of dry holes have been drilled and so far, no production of any importance has been encountered. However, this fact does not necessarily condemn all of the territory in the vicinity of Bristow. The United States Geological Survey expects in the near future to publish a report on the oil and gas conditions in the Bristow quadrangle. The same can be obtained, when ready for distribution, by writing to the Director of that Survey at Washington, D. C.

South and southeast of Mannford several wells have been completed and some are drilling. E. N. Gillespie is reported to have drilled a well in sec. 22, T. 19 N., R. 9 E. to a depth of 2,247 feet, which produced about 6,000,000 cubic feet of gas daily. In addition, a number of dry holes, a few gas wells, and some small producers have been completed.

Around Kelleyville two small pools have been opened up. The Scott pool is located in sec. 2, T. 16 N., R. 10 E. More than a dozen wells have been completed and range in production from nothing up to as high as 300 barrels daily. A few dry holes and gas wells make the remainder of completed drillings.

The New York pool, the greater portion of which is located in sec. 5, T. 16 N., R. 11 E., is reported to have been discovered by the New York Oil Company in the early part of 1915. More than 14 wells have been drilled, the largest producer averaging about 100 barrels per day.

Many "wildcat" wells have been drilled at various other places throughout the county, a few of which have been partially successful.

SUMMARY.

The greater portion of the territory in Creek County has been developed, but it is possible that other fields will be discovered besides those already mentioned. The whole county is considered in general as favorable territory. Any structure found ought to be productive of oil and gas. As soon as the Cushing field and other productive areas have declined to a large extent more drilling will probably be done throughout the county in territory outside the main fields.

The following* is a general summary of development in Creek County for 1915:

Outside the developments in the Cushing field, near the western boundary, operations in Creek County in 1915 were negligible. In the Cushing field the year's developments added little to the areal extent of the productive territory as roughly outlined at the close of 1914. Line drilling and, on many leases, "inside" development furnished the greater portion of the production. As defined at the close of 1915, the Cushing field has an extent from north to south of approximately 10 miles, a width ranging between 3 and 5 miles, and a proved acreage, of, roughly, 10,000 acres. Although the southern portion of the field in the vicinity of Drumright and Tiger, where the prolific Bartlesville sand was first tapped in 1913, has an enviable record for wells of large capacity, it is not to be compared with the territory to the north, in T. 18 N., R. 7 E., where the largest wells in the history of the State were found, one of which, No. 10 on the Benoche Fixico lease, in sec. 17, completed in July by the Mid-Co. Petroleum Co., gaged 10,752 barrels for the first day's run and 10,848 barrels for the second, settling, however, to a 4,000-barrel rate within a week after completion. The discovery early in 1915 by deepened drilling of a prolific "pay" in the lower part of the Bartlesville sand in this part of the field resulted in the deepening of a great many of the wells and the development of the gusher production that raised the output of the field

*Northrop, John D., Mineral resources of the United States, 1915-Part II, pp. 661-662.

to approximately 300,000 barrels a day for a brief period in April. With the decline of production from the Bartlesville sand in the last half of 1915, increased attention was given to the development of production in the shallower Layton sand that had been cased off in the earlier rush for the gusher sand.

Marketing facilities in the Cushing field were notably increased in 1915. A railroad connecting with the Frisco at Jennings was built and put in operation as far south as Drumright. The Oklahoma Pipe Line Co. extended its 8-inch trunk line for the Glenn pool to the field. The McMan Oil Co. constructed and put into operation an 8-inch line from its properties in the field at Addington, a distance of 138 miles, where connection was made with the trunk line of the Magnolia Petroleum Co. A 6-inch line was built by the Hill Oil & Gas Co. from its producing properties to a tank farm at Depew, 7 miles distant. The Milliken Refining Co. laid a 6-inch line from this field to Alluwe. The Twin State Refining Co. (Sun Co.) laid a 4-inch line from the field to its refinery at Yale. Three-inch pipe lines were laid by the Indiahoma Refining Co. and the Slick Oil Co. from the Cushing field to Bristow, a distance of 15 miles. Eighty miles of 4-inch line was laid by the Ponca Refining Co. from Yale to the company's refinery at Ponca City. Both the Prairie and the Gulf Pipe Line companies increased the capacity of their trunk lines from Oklahoma as a consequence of the enormous production developed in the Cushing field.

At the close of the year interest in western Creek County was centered in the development of a new pool of oil and gas 4 miles south of the southern limits of the Cushing field, following the completion in August of an oil well by the Gypsy Oil Co. on the Trent lease, in the NW. ¼ sec. 9, T. 16 N., R. 7 E. The oil was found in the Layton sand at a reported depth of 1,530 feet and the initial flow was 500 barrels. This well is in a locality where previous tests had resulted in gas wells, with the exception of one drilled in February, which reported a 500-barrel showing of oil at 1,680 feet. The showing was not developed, however, the well being drilled deeper into the Bartlesville sand and eventually ruined by salt water. The relatively shallow depth of the productive sand favored the rapid development of the pool, and before the end of 1915 the productive area had been extended to the north into sec. 4, and to the south into sec. 16, T. 16 N., R. 7 E.

Following is a summary of production in Creek County for 1916. The best pool opened in Oklahoma during the year 1916 was the Shamrock pool, which is a south extension of the old Cushing pool. According to figures compiled by the Oil and Gas Journal 768 wells were completed in the Cushing-Shamrock pool. Of these 40 were dry, 41 produced gas, and 687 produced oil. The total production was 40,656,260 barrels of oil, the approximate value of which was $25,000,000.

In Creek County outside of the Cushing-Shamrock pool 3,082 wells were completed. Of this number 698 were dry, 165 produced gas, and

2,219 produced oil. The total production was 19,447,400 barrels of oil, the approximate value of which was $52,000,000.

To sum up—Creek County during the year 1916 produced 60,103,660 barrels of oil, valued approximately at $77,000,000.

The following logs in T. 17 N., R. 7 E., show the character of the formations encountered in drilling to the Bartlesville sand.

Susanna Dacon, sec. 16, *T.* 17 *N., R.* 7 *E. Completed Sept.* 9, 1914.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Mud	39	40	Sand	60	810
Slate	60	100	Slate	50	860
Sand	20	120	Sand	40	900
Slate	20	140	Shale	30	930
Sand	45	185	Lime	15	945
Slate	55	240	Slate	50	995
Slate	60	300	Sand	55	1,050
Lime	20	320	Shale	50	1,100
Slate	20	340	Lime	20	1,120
Lime	10	350	Shale	325	1,445
Sand	40	390	Layton shell	15	1,460
Slate	10	400	Gas	30	1,490
Sand	15	415	First oil (200 bbls.)	25	1,515
Slate	10	425	Lime	5	1,520
Sand	15	440	Shale	55	1,575
Slate	20	460	Jones sand (big gas)	35	1,760
Lime	10	470	Shale	460	2,220
Red rock	20	490	Shale	37	2,257
Lime	10	500	Sand, Wheeler (big gas)	28	2,285
Red rock	10	510			
Slate	10	520	Shale	40	2,325
Sand	20	540	Penn. sand (big gas)	95	2,420
Slate	10	550	Slate	190	2,610
Lime	25	575	Sand	20	2,630
Slate	5	580	Slate	23	2,653
Sand	35	615	Bartlesville sand	12	2,665
Slate	50	665	Sho oil at		2,665
Red rock	10	675	*Sand	18	2683
Slate	15	690	Hard mud	11	2,694
Lime	10	700	**Good oil sand	41	2,735
Shale	50	750			

*Produced 120 bbls. over night in this sand.

**Entire production 250 bbls.

Sandy Fox No. 4, NE. cor. NW. ¼ sec. 10, T. 17 N., R. 7 E. Completed Sept. 3, 1914. Elevation 945-5.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Sand	20	20	Blue shale	7	945
Limy shells	10	30	Shell	315	1,260
Blue shale	40	70	Shelly (gas)	20	1,280
Soft sand	50	120	Lime	10	1,290
Shale	40	160	Blue shale	29	1,319
Shell	4	164	Lime shell	102	1,321
Shale	36	200	Blue shale	18	1,339
Sand (water)	32	232	Lime shell	2	1,341
Blue shale	48	280	Layton gas sand	9	1,350
Lime shell	4	284	Slate	10	1,360
Sand	6	290	Sand	15	1,375
Yellow mud vein	12	302	Slate	125	1,500
Light blue shale	40	342	Black shale	50	1,550
Red mud	13	355	White slate	33	1,583
Blue mud	6	361	Jones sand (gas)	50	1,633
Red mud	4	365	Slate	37	1,670
Shell and sand	6	371	Lime (gas)	5	1,675
Red mud	29	400	Blue shale	205	1,880
Blue shale	70	470	Sand (second gas)	25	1,905
Sand and gravel	10	480	Blue shale	118	2,023
Light blue shale (blue mud vein)	12	492	Lime shell	13	2,036
Sandy shale	10	502	Lime shell (top of Wheeler)	58	2,094
Blue mud	18	520	Slate	41	2,135
Sand and shell—hard	12	532	Sand (gas)	35	2,170
Blue shale	28	560	Shale	25	2,195
Water, sand and shell	20	580	Lime	5	2,200
Blue shale	15	595	Blue shale	45	2,245
Shell and sand	12	607	Sand (second gas)	20	2,265
Blue mud vein (cave)	12	619	Slate	80	2,345
Sandy shale	4	623	Lime	5	2,350
Sand	29	652	Slate	10	2,360
Blue mud	20	672	Lime	5	2,365
Lime	8	680	Slate	40	2,405
Blue mud or shale	175	855	Shell	5	2,410
Shell	5	860	Shale (black)	52	2,462
Slate	5	865	White hard, gas sand. top of Bartlesville	5	2,467
Shell	5	870	Gray sand	16	2,483
Slate	5	875	Gray sand, fine	5	2,489
Shell	5	880	More gas, first flow	13	2,502
Slate	20	900	Broken sand	10	2,512
Sand	5	905	*Big pay	6	2,518
Black shale	30	936			
Water gravel	3	938			

*First 24 hrs. 964 bbls. Tools in hole. Entire production 1,000 bbls.

CUSTER COUNTY.

LOCATION.

Custer County is located in central-western Oklahoma. It is rectangular in shape and includes all of 28 townships. It embraces Tps. 12 to 15 N. inclusive, and Rs. 14 to 20 W. inclusive. The total area is 1,008 square miles.

TOPOGRAPHY.

The surface of the county is rolling to hilly. The streams have cut deep valleys in the uplands. The drainage of the county enters Washita River except that of the northeast corner, which is crossed by the South Canadian. Deer Creek, a tributary, drains the eastern part of the county. Beaver, Barnitz, Turkey, Quartermaster, and other creeks are tributary to the Washita.

GEOLOGY.

Custer County is entirely within the Redbeds area and these rocks attain a thickness of hundreds of feet. The outcropping rocks of the eastern part of the county belong to the Woodward formation, those of the central part to the Greer, and those of the western third to the Quartermaster. Small areas of Comanche Cretaceous rocks are found throughout the western half of the county. Some sand areas and sand hills occur along the Washita and South Canadian rivers, but are limited in their extent.

The reader is referred to the discussion of geology under "Blaine County" for general information concerning the geology.

The deep well drilled at Clinton indicates that the Redbeds are at least 2,500 feet thick in that vicinity. This deep well began on the top of the Greer formation and was apparently discontinued before the bottom of the Enid was reached. The following log shows the character of the formations encountered:

Log of Deep Well Drilled at Clinton, Custer County, Oklahoma.

Character of rock.	Thick-ness.	Depth.	Character of rock.	Thick-ness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	5	5	Blue clay	45	945
Clay	10	15	Red rock	455	1,400
White sand	20	35	Sand, dry	12	1,412
Quicksand and water	67	102	Red rock	98	1,510
Gyp rock	12	114	Blue clay	90	1,600
Sand	151	265	Red rock	190	1,790
Quick sand	137	402	Blue clay	10	1,800
Gyp rock	10	412	Red rock	200	2,000
Sand and water	38	450	White sand, dry	15	2,015
Red clay	30	480	Red rock	25	2,040
Quick sand	17	497	Blue clay	40	2,080
Red clay	53	550	Red rock	60	2,140
Blue clay	50	600	Blue shale	10	2,150
Red clay	100	700	Red rock	82	2,233
Blue clay	15	715	Shell	5	2,238
Red clay	30	745	Sand, dry	12	2,250
Blue clay	100	845	Red rock & thin shell	257	2,507
Gyp rock	20	865	White sand, dry	15	2,015
Red rock	35	900			

DEVELOPMENT.

The Banner Elk Oil & Gas Company of Thomas are planning to drill a well about 5 miles northeast of Putnam in Dewey County. If drilled it is expected that a 4,000 foot test will be made if necessary. The Johnson Drilling Company which is drilling in the SW. ¼ sec. 10, T. 12 N., R. 13 W., near Hydro, reported some gas at a depth of 900 feet. Another well is being drilled by the Monroe Prospecting Company in sec. 5, T. 12 N., R. 11 W., near Bridgeport. It is reported that this well has reached a depth of about 800 feet. A well has been drilling for some time near Canute, just south of the county line, but nothing of importance has been encountered. Several large blocks of acreage are being secured in Custer County and other locations are being made for the drilling of test wells.

It is very probable from the interest taken, that several deep tests will be drilled in this county and territory immediately adjacent during the next few months.

SUMMARY.

The Redbeds series consisting of red shales, sandstones, and gypsum beds have great thickness over the county. Structural conditions have not been found which are favorable for the accumulation of oil or gas. Even if anticlinal structure were apparent on the surface it would, no doubt, be necessary to drill through the Redbeds into the Pennsylvanian rocks before any production of value would be encountered. However, much of the surface is of such character that no geological determinations can be made for the location of test wells. Therefore any drilling done in such region must be strictly as a wild-cat proposition.

Large blocks of land have been leased and arrangements are being made for the drilling of wells within the county. Probably one of the first places to be tested will be in the vicinity of Butler. The well which is being drilled near Foss in Washita County is being watched with much interest by companies considering drilling within the bounds of Custer County.

DELAWARE COUNTY.

LOCATION.

Delaware County, located in the northeastern part of the State, is bounded on the north by Ottawa County, on the east by the States of Missouri and Arkansas, on the south by Cherokee and Adair counties, and on the west by Mayes and Craig counties. It comprises an area of about 794 square miles, extending from T. 20 N. to T. 25 N. inclusive, and from R. 22 E. to approximately the middle of R. 25 E. inclusive.

TOPOGRAPHY.

Delaware County lies wholly within the physiographic division known as the Ozark Plateau, which is the westward extension of the uplifted area covering the southeastern half of the State of Missouri and a large portion of northern Arkansas. It is a great dome with mountainous dimensions, having an igneous core but made up in large part of Cambro-Ordovician limestones surrounded by an area of Mississippian limestone. It is this circular area of Mississippian rocks that sweeps around into Oklahoma from Missouri and forms the Ozark Plateau and the surface outcrops in Delaware County.

The general slope of the country is westward. The elevation of the area varies from 1,200 feet, the height attained by some of the high divides in the southern part of the county, to about 700 feet, the elevation of the flood plains along Grand River to the northwest. The general relief, however, is much less than 500 feet, and the average elevation is between 1,000 feet and 1,100 feet. Broad U-shaped valleys and low divides have been developed in general throughout the area and the country everywhere is well drained and much dissected by the numerous creeks and streams which flow westward to the Grand. Many of the smaller creeks, however, have not reached beyond a youthful stage in their development and have, locally, V-shaped valleys or even canyons and flow only intermittently. In the southern part of the county, extending in a general east-west direction for 20 miles or more, is a stretch of prairie country locally called Ulm Prairie, Blackjack Prairie and Long Prairie, and in the extreme northeastern corner of the county is Cowskin Prairie, all of which regions form broad, rolling divides between the main drainage systems. In general terms, therefore, both topography and river systems may be said to be in a stage of late maturity in their process of development. Only the Grand River has developed a meandering course and flood-plains and is the only river which may be said to be approaching old age in this county.

GEOLOGY.

The surface rocks belong chiefly to the Mississippian system. The only exposures of pre-Mississippian strata occur as inliers in the creek bottoms where they have been brought to the surface by the removal, through erosion, of the overlying rocks. The largest of these in the county is a strip about 15 miles long and a mile wide along the lower stretches of Spavinaw Creek. A similar exposure found about the town of Flint in the valley of Flint Creek extending from its junction with Illinois River upstream about 5 miles, and two small areas covering less than a square mile each located in the north-central part of the county are the only other exposures of pre-Mississippian rocks known to occur in Delaware County.

Of the Mississippian series of rocks the Boone chert is the principal formation, and consists of interstratified chert and cherty limestone. At some localities near the base of the formation there are some thin limestones free from chert, while in other regions the cherty beds rest directly upon the Chattanooga shale of Silurian-Devonian age. The thickness varies from 100 to 300 feet and is the formation known as the "Mississippi lime" of the drillers. It is the Boone limestone which forms the surface outcrops practically all over Delaware County. Three small areas of limestones and calcareous shales outcrop in the northern part of Delaware County on either side of Grand River, known as the Chester group which overlies the Boone, but their areal extent is less than 25 square miles.

SUMMARY.

While the limestones are gently folded into northeast-southwest anticlines and synclines there appears to be no oil or gas in any of the favorable structures. Drilling operations carried out in the areas of outcropping Mississippian limestones have everywhere resulted in finding nothing but salt water. It is the Pennsylvanian shales and sandstones which lie above the Mississippian series that carry the oil sands. In Delaware County they have long since been eroded away by the rivers. It is not deemed advisable to prospect for oil anywhere in this county.

DEWEY COUNTY.

LOCATION.

Dewey County is located in the western part of the State. It is regular in shape, being that of a rectangle 24 miles wide and 42 miles long. It extends from T. 16 N. to T. 19 N. inclusive, and from R. 14 W. to R. 20 W. inclusive. It includes 28 entire townships. The total area is 1,008 square miles.

TOPOGRAPHY.

The topography of Dewey County is that of a high prairie plain into which the Canadian River has cut a wide and rather deep channel. Short streams flowing into Canadian River have diminished the bluffs of the river, giving a very rough topography. In the southeastern part of the county north of Canadian River there is a considerable area of sand plains which are covered with blackjack oaks.

The northern part of the county is drained by the North Fork of Canadian River and streams tributary to it. Nearly all the southern part of the county is drained by Canadian River and its tributaries. The extreme southern part is drained into Washita River.

GEOLOGY.

The rocks at the surface in Dewey County are Permian and Quaternary. The following Permian formations are found: Woodward, Greer, and Quartermaster. The Woodward formation occupies the surface in the eastern part of the county. It is at or near the surface over an area of approximately 400 square miles. In the central part of this area dune sand and alluvium cover the Woodward formation over an area of about 150 square miles. The Woodward formation consists of shales, sandstones, and dolomites.

The Greer formation is at or near the surface over an area of approximately 400 square miles. It lies immediately west of the Woodward formation. The northwestern part of this area is covered with dune sand. The Greer formation consists of red clays, shales, and sandstones interbedded with gypsum and dolomite ledges.

The Quartermaster formation is found in the southwestern part of the county and occupies an area of approximately 70 square miles. This formation consists of soft red sandstones and arenaceous clays and shales.

The Quaternary consists of alluvium and dune sand. The dune sand areas have been mentioned above. The alluvium occupies a narrow belt along Canadian River.

STRUCTURE.

The strata in Dewey County have a general southwest dip. There may be local variations in this general dip. The dolomites of the Woodward formation in the eastern part of the county seem to be the most reliable ledges from which to determine underground structure. There are no surface indications of the underground structure in the dune sand and alluvium areas. The strata of the Greer formation were either laid down in a very erractic manner or else there has been considerable slumping. In a distance of a few hundred feet gypsum ledges and sandstone ledges can be found dipping in all directions. It is quite certain that most of these erratic dips are due to slumping. An examination of one hillside found evidence of an area 600 feet wide and 800 feet long moving down the hillside. In the area of the Greer formation no reliable surface indications can be found.

The Quartermaster formation in Dewey County also shows slumping and very few reliable dips can be found.

SUMMARY.

It is probable that the productive Pennsylvanian sands underlie Dewey County, though at great depths. The eastern part of the county, in the Woodward formation area, is the most suitable for working out the underground structure from surface indications.

ELLIS COUNTY.

LOCATION.

Ellis County is located in the northwestern part of the State. Its western boundary is a part of the Oklahoma-Texas boundary. It extends from T. 16 N. to T. 24 N., inclusive, and from R. 21 W. to R. 26 W. inclusive. It consists of 25 entire townships and parts of 16 others. The total area is approximately 1,188 square miles.

TOPOGRAPHY.

The topography is that of a high upland prairie plain into which the streams have cut only shallow valleys. The northern part of the drainage of the county is by Beaver Creek and streams tributary to it; the central part by Wolf Creek, which is a tributary to North Fork of Canadian River; and the southern part by Canadian River and short tributary streams.

GEOLOGY.

The rocks at the surface in Ellis County are: Permian, Tertiary, and Quaternary.

The Permian is represented at the surface in the eastern and southern parts of the county by the Woodward and Greer formations. The Woodward formation consists chiefly of shales, sandstones, and dolomites. The Greer formation consists of red clays, shales, and sandstones with beds of gypsum and dolomite. Gypsum is the characteristic deposit of this formation. The stratification of the Greer formation is quite variable.

The Tertiary is exposed in the central and western parts of the county. The exact age of these deposits has not been determined. They overlie unconformably the Cretaceous and Permian rocks. The Tertiary consists for the most part of clay, sand, and gravel.

The Quartermaster in Ellis County consists of two kinds of deposits —alluvium and dune sand. The alluvium consists of sand and clay and is found along the large streams. The dune sand consists of that deposited by the wind, the source of which has been Tertiary sands and sand in the stream valleys. The large deposits of dune sand are found on the north side of rivers, indicating a certain relation between the prevailing south wind and the location of the dune sand with reference to the river valleys. As winds from the north in this part of the State are accompanied by precipitation they are robbed of their sand carrying power. This is, no doubt, the reason why so little sand is found on the south side of the river valleys.

SUMMARY.

So much of Ellis County is covered either with Tertiary or Quaternary sand that it is hard to find outcropping ledges on which structure can be determined. The Greer formation is so erratic in the stratification of its deposits that readings on its strata cannot be trusted. The Woodward formation contains some dolomites on which structure could be determined. The area of Woodward outcrop compared to the entire area of Ellis County is very small.

If, as is generally supposed, we must look to the Pennsylvanian rocks for the origin of oil and gas in Oklahoma, it is safe to figure on drilling to that depth. In order to reach the Pennsylvanian a drill started in most locations in Ellis County would have to penetrate Tertiary, and possibly Cretaceous and Permian rocks,—a probable maximum distance of 6,000 feet, and to reach the productive levels in eastern Oklahoma, much farther than that.

A well recently drilled near Arnett reached a depth of 1,743 feet and Redbeds formations were encountered the entire depth. The formations consisted of brown to red sandy clay shales, sand, sandstones, gypsum, salt, and conglomerates. Occasional layers of blue shale and light-colored sandstone were encountered. The well is located in sec. 1, T. 19 N., R. 25 W.

It appears from all available data that any test begun in this region should be started with the purpose of drilling to a depth of at least 3,500 to 4,500 feet, or even deeper, to reach certain strata as indicated above.

GARFIELD COUNTY.

LOCATION.

Garfield County is located in the northwestern part of the State. It extends from T. 20 N. to T. 24 N., inclusive, and from R. 8 W. to R. 3 E.

inclusive. Thirty entire townships are included within Garfield County. The total area is 1,080 square miles. It is regular in shape, being a rectangle 36 miles long and 30 miles wide.

TOPOGRAPHY.

Garfield County lies within the Redbeds Plains. The topography is that of a level to gently undulating plain. On some of the high divides the streams have dissected the surface, giving locally a bad-land type of topography.

The northern part of Garfield County is drained by tributaries to Arkansas River, the largest of which is Red Rock Creek. The southern part of the county is drained by tributaries to Cimarron River, the largest of which is Turkey Creek.

GEOLOGY.

The surface rocks belong to the Enid formation of the Permian series. It consists chiefly of brick-red clay shales with some interbedded sandstones. In the eastern part of the county there are some well-bedded calcareous sandstone ledges. The Pennsylvanian underlies the county at a depth of about 1,000 feet. The following log will give an idea of the underground formations:

Enid Well, NW. cor. sec. 30, T. 23 N., R. 6 W.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface	48	48	Red rock	10	2,618
Red sand and shale	782	830	Lime	25	2,640
Lime shell	2	832	Red rock	20	2,660
Red and sandy shale	168	1,000	Slate (white)	20	2,680
Shale	430	1,430	Lime	5	2,685
Lime	10	1,440	Slate (white)	5	2,690
Shale	160	1,600	Lime	60	2,750
Lime shell	5	1,605	Slate, (white)	20	2,770
Slate and rotten shale	195	1,800	Slate cave (bk)	15	2,785
Lime	20	1,820	Slate (white)	15	2,800
Slate	70	1,890	Lime	5	2,805
Lime	40	1,930	Slate (white	45	2,850
Slate	70	2,000	Lime	10	2,860
Lime shell	10	2,010	Slate (white)	40	2,009
Slate	105	2,115	Lime	10	2,910
Sand	50	2,165	Slate (white)	35	2,945
Red rock	53	2,220	Lime	5	2,950
White slate	40	2,260	Slate (white)	50	3,000
Lime stone	8	2,268	Lime shells	10	3,010
Red rock	72	2,340	Slate	20	3,030
Slate (white)	30	2,370	Lime shells	30	3,060
Red rock	40	2,410	Slate	55	3,115
White slate	20	2,430	Lime shells	1	3,116
Red rock	55	2,485	Slate	11	3,127
Slate (white)	35	2,520	Lime	15	3,142
Red rock	30	2,550	Slate	23	3,165
Lime	10	2,580	Lime	10	3,175
Lime (bk.)	20	2,580	Sand	7	3,182
Slate (white)	10	2,590	Slate	28	3,210
Lime	5	2,595	Lime and slate	155	3,365
Slate (bk)	10	2,605	Water at		3,365

STRUCTURE.

There are few surface indications of the underground structure in Garfield County. Rock outcrops are scarce and most of the outcrops are cross-bedded sandstones, on which dip and strike readings are not accurate. These sandstones vary rapidly in horizontal extent. In fact, in some cases the sandstone is replaced by shale within a few hundred feet, horizontally.

The general attitude of the rocks at the surface in Garfield County is that of a westward-dipping monocline. There are local variations in this general west dip. Anticlinal structure has been worked out from surface indications near Garber and Covington, in the eastern part of the county. In the western part of the county it is hard to find sufficient surface indications of the underground structure. Where there are not sufficient surface indications of the underground structure explorations for structure should be carried on with the aid of the diamond drill.*

DEVELOPMENT.

Snider** reports that a deep well was drilled near Enid some years ago without favorable results. The city of Enid finished a deep test early in 1916. This well, which is located in the NW. cor. sec. 30, T. 23 N., R. 6 W., and was put down to a depth of more than 3,000 feet at a cost of more than $20,000, was dry. It was put down without regard to structure.

The latter part of 1916 has seen considerable drilling in Garfield County. A well was put down in the NE. cor. sec. 25, T. 22 N. R. 4 .W., by Sinclair Oil & Gas Company. Reports said that 1.000,000 cubic feet of gas were encountered in this well at a depth of 880 feet, and oil encountered at a depth of 1,100 feet. The initial flow of oil was given as 150 barrels per day. The gravity test of the oil was given as high as 45.7° Baume. Later reports gave the daily production of this well from 25 barrels to 100 barrels. The oil sand was reported to have had a thickness of 12 feet.

The Sinclair Oil & Gas Company began an offset to the above well in November, 1916. About December 1, 1916, approximately 3,000,-000 cubic feet of gas were encountered at a depth of 887 feet. On December 14 the hole had reached a depth of 1,107 feet and had encountered the oil sand. The same company started a well in the NW. cor. sec. 30, T. 22 N., R. 3 W., as an offset to the first well drilled in this area. Reports of December 13, 1916 show that it had encountered about 5,000,000 cubic feet of gas at a depth of 800 feet.

Several wells have been started in the vicinity of the Sinclair production in T. 22 N., R. 4 W.

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*Burton, Geo. E., Practicability of using diamond drill in exploring for oil and gas structure, in press.

**Snider, L. C., Petroleum and Natural Gas, p. 174.

J. R. Smith and others are drilling a well in the southwest corner of sec. 33, T. 23 N., R. 8 W.

SUMMARY.

Garfield County is in proved oil and gas territory. The bringing in of a well located on favorable structure has demonstrated that geology is an aid to oil and gas exploration. While the production as reported for the initial well has not been so very great, the fact that it is found in a shallow sand is encouraging. There are good chances for production from deeper sands.

The surface rocks are Permian. They are composed of red sandstone and shales in the southern and western parts, and of calcareous sandstone and shales in the eastern and northern parts. A good many of the sandstone hills are covered with black-jack oak. There is enough lime in the surface rocks in the northern and eastern parts of the county to make an excellent soil.

GARVIN COUNTY.

LOCATION.

Garvin County is located in the south-central part of the State. It extends from T. 1 N. to T. 4 N. inclusive, and from R. 4 W. to R. 3 E. inclusive. It is made up of 20 whole townships and parts of 4 others. The entire area is approximately 814 square miles.

TOPOGRAPHY.

Most of the county lies within the Redbeds Plains. The extreme eastern part is in the Sandstone Hills region. In this region are found the characteristic tree-covered sandstone hills with intervening shale valleys. That part of the county found in the Redbeds Plains is gently rolling. The high divides are very much dissected with deep canyons, giving a local type of topography almost approaching bad-lands.

The surface range in elevation is from 787 feet to 1,250 feet, a difference of 463 feet. The lowest point is where Washita River flows out of the county near the SE. corner of sec. 36, T. 1 N., R. 1 E. The highest point is somewhere near the NE. cor. of sec. 33, T. 3 N., R. 3 W., about $4\frac{1}{2}$ miles east and $1\frac{1}{2}$ miles south of Purdy.

Garvin County is drained by Washita River and its tributaries.

GEOLOGY.

Rocks of Permian and Pennsylvanian age are found at the surface. The Permian rocks are for the most part alternations of shales and sandstones, though toward the lower Permian the sandstones become somewhat calcareous. The Pennsylvanian rocks cover the eastern part of the county and consist of alternating sandstones and shales.

The following log will give an idea of the underground formations:

Log of Reform School Well. NW. 1/4 sec. 33, *T.* 3 *N., R.* 1 *E.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface clay	10	10	Rock	4	718
Soft sand rock	15	25	Red gumbo	6	724
Hard sand rock	45	70	Shale	40	764
Salt water sand	10	80	Shale	36	800
Soft dry sand	32	102	Blue lime	4	804
Pack sand, dry	44	146	Red shale	60	864
Hard gumbo	12	158	Blue lime	12	876
Pack sand, dry	26	184	Red shale	15	891
Pack sand, dry	12	196	Gypsum	57	948
Shale	17	213	Shale	37	985
Hard gumbo	10	223	Rock	17	1,002
Hard sand rock	11	234	Lime rock	23	1,025
Gumbo	8	242	Red shale	20	1,045
Pack sand	16	258	Flint rock	15	1,060
Hard shale	19	277	Red shale	10	1,070
Rock	3	280	Lime rock	12	1,082
Hard shale	100	380	Red shale	18	1,100
Soft shale		423	Lime rock	24	1,124
Shale gumbo	18	441	Blue sand	11	1,135
Gumbo	7	448	Flint rock	3	1,138
Sand rock	18	466	Red shale	76	1,214
Shaly gumbo	20	486	Flint rock	2	1,216
Shale	63	549	Shale	11	1,227
Red gumbo	12	561	Soft sand rock	15	1,242
Shale	35	596	Blue gumbo	14	1,256
Shale	34	630	Hard flint rock	3	1,259
Sand	4	634	Sand rock	42	1,301*
Lime rock	6	640	Sand and salt water	16	1,317
Shale	74	714			

*Show of oil and gas.

STRUCTURE.

The formations lie in a monoclinal fold which dips toward the northwest. There are variations in this dip. In sec. 3, T. 3 N., R. 1. W. a calcareous sandstone ledge shows a slight south dip. In sec. 10, T. 3 N., R. 1 W. a calcareous sandstone ledge shows about a 3° dip to the south. While the writer did not examine in detail all the outcropping in this vicinity, these south dips, together with the fact that the normal dip is to the northwest, seem to indicate anticlinal structure between Rush Creek and Washita River. Detailed work wou'd, no doubt, show up structure favorable for the accumulation of oil and gas.

DEVELOPMENT.

Some drilling has been done in Garvin County, though no important production has been found to date.

In the NW. 1/4 of sec. 33, T. 3 N., R. 1 E., on land owned by the State Reformatory School, a dry hole was put down.

C. B. Schaffer put down a well in the SE. cor. of the NW. 1/4 of sec. 33, T. 2 N., R. 3 W. This well was drilled to a depth of 2,000 feet and was a dry hole. In the NE. 1/4 of sec. 16, T. 1 N., R. 3 W., lubricating oil was struck at a depth of 47 feet in a well which was being put down in search of water. Following is the analysis of this oil as reported by the Chemistry Department of the University of Oklahoma:

Analysis of oil from well in NE. ¼ sec. 16, T. 1 N., R. 3 W.

Gravity Baume (23° C.)	23.3°
Boiling point	120 C.
Gasoline oils	4.21 per cent.
Kerosene	5.77 per cent.
Light lubricating oils	3.26 per cent.
Heavy lubricating oils	86.76 per cent.
Flash point	230° F.
Fire test	235° F.
Sulphur	.61 per cent.
Phosphorus	Trace.

SUMMARY.

Not enough geological work has as yet been done to determine the relation of the Permian to the underlying Pennsylvanian. Whether they are conformable as they are in the north-central part of the State, or whether unconformable, will have a bearing on the accumulation of oil or gas. If they be conformable, then the problem is fairly simple for the accumulation would be expected in structure, indication of which might be found on the surface.

If, however, there be an unconformity the problem becomes more complex. The accumulation may be found in structure in the Permian which is near or over the ends of oil or gas-bearing strata of Pennsylvanian. Under favorable conditions the oil and gas may have migrated great distances along the unconformable contact of Permian and Pennsylvanian. These problems should be kept in mind and with all the drilling and interest centered in the county great care should be taken in preserving accurate logs of the wells. The solution of some of these problems will be made from the well logs. The present activity in drilling will be watched with a great deal of interest.

GRADY COUNTY.

LOCATION.

Grady County is located a little west and somewhat south of the center of the State. It extends from T. 3 N. to T. 10 N. inclusive, and from R. 5 W. to R. 8 W. inclusive. It includes 28 entire townships and parts of 4 others. The total area is approximately 1,115 square miles.

TOPOGRAPHY.

Most of Grady County is within the Redbeds Plains. A strip about 10 miles wide along the western county line is in the Gypsum Hills. The general slope of the surface is toward the southeast. The Redbeds Plains region is characterized by gently rolling prairie plain topography. In the Gypsum Hills region the surface is broken and rough, gypsum-capped hills and escarpments being common.

The county is drained by Canadian and Washita rivers and streams tributary to them.

GEOLOGY.

The surface rocks in Grady County are Permian except along the stream valleys, where Recent sands and gravels are found. The Permian is made up of shales, sandstones, and some gypsum. Most of the shales and sandstones are red in color. This red color varies greatly in shade in different horizons and from place to place in the same horizon. All gradations from vermilion to maroon or very deep red-brown have been observed. The sandstones are usually comprised of very fine rounded grains and are cross-bedded and occur oft times in lenticular masses. They often grade horizontally into shales within very short distances. The shales are fine-grained, slightly consolidated, and very plastic. Some of the shales are siliceous. These are usually of a duller red color than the plastic shales. Associated with the gypsum beds are white to greenish sandstones and shales.

STRUCTURE.

The Permian strata lie in the Prairie Plains monocline, which, in Grady County, dips at a very flat angle to the west. There may be local variations in this general west dip. There are very few reliable outcrops and the problem of determining the underground structure is therefore very difficult or impossible of solution. Some of the drainage is, no doubt, initial, and some of the streams are synclinal. Anticlinal structure would be expected between streams in close proximity. This method of determining structure is not very reliable in itself as it is hard to pick out the stream which occupies the synclines. It may be that the *size* of the stream may be indicative of whether it be synclinal. Core drilling would confirm or disprove any supposed anticlinal folding between streams and would also solve the problem of the relation of the size of streams to the folding.

DEVELOPMENT.

A well was put down two years ago in the SW. cor. of sec. 6, T. 5 N., R. 8 W. to a depth of 1,670 feet and abandoned.

SUMMARY.

The productive Pennsylvanian strata found farther east, no doubt, underlies Grady County, though at great depths. These great depths, together with the character of the Permian strata, make drilling too expensive at the present time. For this reason the county will have to be placed in territory unfavorable for the production of oil or gas.

GRANT COUNTY.

LOCATION.

The north line of Grant County is a part of the Oklahoma-Kansas boundary line. Its east line almost coincides with a north-south line drawn through the center of the State. The county extends from T. 25 N. to T. 29 N. inclusive, and from R. 8 W. to R. 3 W. inclusive. It includes 24 entire townships and parts of 6 others. The total area is approximately 1,008 square miles.

TOPOGRAPHY.

Grant County lies within the Redbeds Plains. The topography is that of a more or less rolling prairie plain, broken by the valley of Arkansas River. The entire county is drained by Arkansas River and streams tributary to it.

GEOLOGY.

The surface rocks are Permian, except along the valley of the Arkansas and some of its larger tributaries where Recent sands and gravels occupy the surface.

The Permian formations outcropping in Grant County, named in order from youngest to oldest are: The Enid formation, and the Marion, and Wellington formations.

In the northeastern part of the county there is an area of approximately 44 square miles over which the surface rocks are termed the Marion and Wellington formations. The rocks in this area consist of gray, blue, drab, and yellowish shales with a few ledges of impure limestone.

The Enid formation occupies an area of approximately 655 square miles in Grant County. It outcrops in two rather large areas, one immediately southwest of the Marion and Wellington formations in the northeastern part of the county, and the other in the southern part of the county. These two areas are separated by the overlying Quaternary deposits along and to the north of Arkansas River. The rocks of the Enid formation consist of brick-red clay shales, with interbedded ledges of red and white sandstone.

The Quaternary deposits cover an area of approximately 309 square miles along and to the north of Arkansas River. These deposits consist of alluvium and dune sand.

STRUCTURE.

The general attitude of the Permian strata is that of a gentle westward-dipping monocline.

Structure which may be favorable for the accumulation of oil and gas was found by geologists of the Marland Oil Company, just southeast of the town of Deercreek. In one place on this structure, the strata dip eastward 450 feet to the mile. The strata in this area also show north, south, and west dips. The Marland Oil Company expects to test this structure and have started a well in SW. cor. of the SW. 1/4 sec. 26, T. 27 N., R. 3 W.

DEVELOPMENT.

To February 1, 1917, no production was reported from Grant County. However, several tests are being made. The New York-Oklahoma Oil Company had on January 27, 1917, reached a depth of 2,900 feet at their location in the NW. 1/4 sec. 26, T. 29 N., R. 4 W.; the La Noria Grande Oil & Gas Company on the same date, were at a depth of 2,600 feet, at their location in the SW. 1/4 sec. 10, T. 27 N., R. 4 W., and at a depth of 800 feet at their location in the NW. 1/4 sec. 29, T. 27 N., R. 8 W. Also during the latter part of January, 1917, the Oklahoma Star Oil Company had reached a depth of 1,300 feet in the NW. 1/4 sec. 33, T. 26 N., R. 3 W. The American Petroleum Company has everything in readiness to begin drilling in the SE. 1/4 sec. 34, T. 28 N., R. 7 E. The Devonian Oil Company has made a location in the NW. 1/4 sec. 26, T. 27 N., R. 3 W., while the Kansas Gas & Petroleum Company has made a location in the SW. 1/4 sec. 19, T. 25 N., R. 5 W.

SUMMARY.

Grant County is in probable oil and gas territory. The subsurface Pennsylvanian, which is the oil-producing horizon in the fields to the east, no doubt extends under Grant County. The normal dip of the strata in this area is westward 30 feet to the mile. This would indicate that the horizon of producing sands of the Blackwell field in eastern Grant County lies about 420 feet deeper than the productive sands in the Blackwell area.

GREER COUNTY.

LOCATION.

Greer County is located in the southwestern part of the State. It extends from T. 3 N. to T. 7 N. inclusive, and from R. 20 W. to R. 25 W. inclusive. It consists of 12 entire townships and parts of 12 others. The entire area is approximately 624 square miles.

TOPOGRAPHY.

The Wichita Mountains enter Greer County from due east near the center of T. 5 N., R. 20 W., and trend N. 45° W. to the center of T. 6 N., R. 21 W., where they disappear beneath the Redbeds Plains. These mountains consist of isolated granite knobs, ridges, and peaks which rise abruptly a few hundred feet above the Redbeds Plains. The largest of these granite ridges is Headquarters Mountain near the city of Granite, which occupies an area of about 3 square miles and rises to about 500 feet above the surrounding plain.

All of Greer County outside of the Wichita Mountain area lies in the Redbeds Plains.

GEOLOGY.

The rocks at the surface in Greer County are pre-Cambrian and Permian. The pre-Cambrian consists of granites for the most part. The Permian consists of red clays, shales, sandstones, some calcareous sandstones, gypsum, and dolomite.

Log of Well in W. ½ SW. ½ sec. 24, T. 7 N., R. 21 W.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Red Clay	8	8	Green shale	8	928
Quicksand	10	18	Mixed green and light shale	10	938
Green shale	92	110	Green shale	77	1,015
Brown shale	4	114	Sand rock, oil show	44	1,059
Green shale	20	134	Sand rock, oil showing prominently	12	1,071
Red shale	46	180	Sand rock, soft	6	1,077
Light gray sand rock	5	185	Mixed sand, green and red shale	73	1,150
Shale	135	320	Mixed hard and soft sand rock	30	1,180
Gyp rock	5	323	Coarse sand rock	35	1,215
Green shale	5	328	Mixed sand	25	1,240
Red shale	28	356	Sand rock	176	1,416
Green shale some gas	15	371	Quartz	100	1,516
Red shale	307	678	Sandstone	59	1,575
Green shale	3	681	Mixed green and red shale	15	1,590
Red and green shale	19	700	Gray sand rock, some oil and gas	34	1,624
Hard and soft strata, showing of oil and gas at 750 feet, red and green shale, hard shells	100	800	Gray sand rock	241	1,865
Red and soft green and red shale	50	850	Shale	5	1,870
Conglomerate, salt water	65	915	Sandy shale	90	1,960
Mixed sand and shale	5	920	Sandy shale	25	1,985
Green shale, some gas	15	371	Bituminous sand rock	150	2,135

STRUCTURE.

The Permian strata dip at right angles to, and at a flat angle away from, the axis of the Wichita Mountains, the strata in the northeastern part of the county dipping northeast and those in the southern part dipping southwest. The Cambrian, Ordovician, and Pennsylvanian are supposed to underlie unconformably the Permian, the older rocks bordering the Wichita Mountains and the younger farther away. There may be territory to the north and the south of the Wichita Mountains, where the Permian comes in contact with the ends of oil or gas bearing Pennsylvanian strata that might prove productive of oil or gas. Also, the territory to the north and south of these places might be favorable territory up to the places north and south where the depth of drilling would be too great. Oil or gas may be found in the unconformity between the Permian and the older rocks, even up to the base of the Wichita Mountains. Favorable structure in the Permian may or may not extend down into the Pennsylvanian; also there may be favorable structure in the Pennsylvanian not apparent at the surface.

DEVELOPMENT.

Development for oil began in the vicinity of Granite early in 1901, when a local company drilled a well to a depth of 380 feet on the southern part of the townsite. The drill stopped in granite. During the summer of the same year another well was drilled in the SE. 1/4 of the NE. 1/4 sec. 10, T. 6 N., R. 21 W., to a depth of 168 feet. A little oil was encountered and the well produced 3 or 4 barrels of oil per day when placed on the pump. In an effort to increase the production by shooting, the well was destroyed. A well drilled in the NE. 1/4 sec. 10, T. 6 N., R. 21 W., to a depth of 800 feet was dry. About a year later two wells were drilled in the SE. 1/4 sec. 28, T. 5 N., R. 21 W. to a depth of 900 feet. Showings of oil and gas were reported. In 1903 a well drilled near the first producing well furnished a few hundred gallons of a heavy black oil.

In 1904 the Myers Oil Company began a well in the SW. 1/4 sec. 24, T. 7 N., R. 21 W., about 9 miles north of Granite. This well, which required 3 years in drilling, was abandoned at 2,135 feet. Several showings of oil and gas were reported.

No further development took place until about the close of 1913. One well, begun at the foot of Headquarters Mountains, after drilling in granite for several hundred feet, was abandoned at a depth of 700 feet.

Recently some wells were drilled in the vicinity of Willow and one of them reported a strike of 2,500,000 cubic feet of gas.

SUMMARY.

Greer County is in probable oil and gas territory. The presence of both oil and gas has been proved, but all the production was small. The small production found at Granite was, no doubt, found in or near the unconformable contact between the Permian and older rocks. It may have traveled a considerable distance from its source of origin. This territory is too close to the base of the mountains to find much production. More favorable territory would be at considerable distance north or south of the mountains, provided favorable structure could be found.

HARMON COUNTY.

LOCATION.

Harmon County is located in the extreme southwestern part of the State. It extends from T. 1 N. to T. 6 N., inclusive, and from R. 24 W. to R. 26 W., inclusive. It includes 11 entire townships and parts of 11 others. The total area is approximately 567 square miles.

TOPOGRAPHY.

All of Harmon County lies within the Gypsum Hills region. The topography is that of a level plain, dissected by stream valleys.

GEOLOGY.

The rocks at the surface in Harmon County belong to the Greer formation of the Permian series. They consist of red clays, shales, sandstones, beds of gypsum, and dolomite.

STRUCTURE.

The strata in Harmon County dip at a low angle to the southwest. There may be local variations in this general southwest dip, but no detailed search has been made for them.

SUMMARY.

Harmon County is in uncertain if not in improbable territory. It is not known whether the Pennsylvanian underlies the Permian in Harmon County. The probabilities are that it does. It may be that the influence of the Wichita uplift has been felt in this county and that the Pennsylvanian rocks are near the surface. These are problems that must be solved with the aid of the drill. As long, however, as structure can easily be determined in more favorable territory, and as long as production keeps up in such territory the price paid for crude oil will discourage exploration in Harmon County. Any location for a test well should be made by the aid of all the geological evidence which can be secured.

HARPER COUNTY.

LOCATION.

Harper County is located in the northwestern part of Oklahoma. It is bounded on the north by Kansas, on the east by Woods and Woodward counties, on the south by Ellis County, and on the west by Beaver County. It extends from T. 25 N. to T. 29 N. inclusive, and from R. 20 W. to R. 26 W. inclusive. It includes 22 entire townships and parts of 12 others. The area is approximately 1,075 square miles.

TOPOGRAPHY.

The extreme eastern part of the county is in the Gypsum Hills region, while the remainder of the county is in the High Plains region.

The topography of the Gypsum Hills region has been produced by stream dissection on the Blaine formation. It consists in a general way of a northeastward-facing escarpment whose general trend is varied locally by narrow gulches and canyons.

The High Plains are rolling upland plains, in part covered with dune sand.

The northeastern part of Harper County is drained by Cimarron River and streams tributary to it. The southwestern part of the county is drained by Beaver Creek which is tributary to North Fork of Canadian River.

GEOLOGY.

The rocks at the surface in Harper County named in order from youngest to oldest are Quaternary, Tertiary, and Permian.

The following Permian formations, named in order from youngest to oldest, outcrop: Redbeds of uncertain relation, Woodward formation, Blaine formation, and Enid formation.

The Enid formation occupies an area of approximately 20 square miles in the eastern part of the county. This formation outcrops in the valley of Cimarron River and the valley of Buffalo Creek. This formation in Harper County consists of red clay shale, some inconspicuous ledges of soft sandstone, and beds of whitish and greenish shales.

The Blaine formation occupies a narrow, irregular belt, consisting of about 125 square miles immediately west of the Enid formation outcrops. This formation consists of red shales with interbedded massive gypsum ledges and thin ledges of dolomite.

The Woodward formation occupies an area of about 450 square miles immediately west of the Blaine formation in the northeastern part of the county. This formation consists of shales, sandstones, and dolomites.

Just southwest of Beaver Creek, in the southwestern part of the county, there is an area of about 60 square miles of Redbeds which are not definitely classified. These rocks are composed chiefly of shale with an occasional ledge of sandstone or gypsum.

In the extreme southwestern part of the county there is an area of about 4 square miles where Tertiary rocks are at the surface. These rocks consist for the most part of clay, sand, and gravel. The clay is usually white or pinkish. The sand is of various degrees of fineness and is composed almost entirely of quartz.

The greater part of the Quaternary is dune sand found just northeast of Beaver Creek in a rather wide belt extending in a northwest-southeast direction entirely across the county. Alluvium is found along the valley of Cimarron River, Beaver Creek, and large streams tributary to these two streams. The total area of Quaternary deposits is approximately 416 square miles. The following log of a well located in sec. 33, T. 5 N., R. 28 E., just over the west line of Harper County, in Beaver County, will give a general idea of the underground strata for this general area:

Log of well in NE. corner of SE. ¼ sec. 33, T. 5 N., R. 28 E., Gate Valley Oil and Gas Company.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	5	5	Salt	38	1,288
Sandy clay	20	25	Red rock	2	1,290
Red rock	15	40	Salt	105	1,395
Water sand	8	48	Blue slate	10	1,405
Red rock	35	83	Salt	25	1,430
Water, sand	7	90	Red rock	80	1,510
Red rock	80	170	Blue slate	18	1,528
Water, sand	8	178	Red rock	20	1,548
Red rock	87	265	Blue slate	3	1,563
Sandy lime	3	268	Red rock	14	1,575
Red rock	7	275	Brown slate	25	1,600
Sand	25	300	Red rock	25	1,625
Red rock	50	350	Brown slate	25	1,650
Sandy lime	3	353	Red rock	75	1,725
Red rock	9	362	Blue slate	40	1,765
Lime and gypsum	33	395	Lime	5	1,770
Lime, white	17	412	Blue slate	5	1,775
Blue shale	8	420	Lime	5	1,780
Brown shale	30	450	Blue shale	15	1,895
Sandy lime	17	467	Lime	25	1,820
Salt	100	567	Blue shale	3	1,823
Red rock	5	572	Lime	18	1,840
Salt	13	585	Blue slate	15	1,855
Red rock	35	620	Lime	40	1,895
Salt	10	630	Slate	5	1,900
Red rock	40	670	Lime	5	1,905
Salt	50	720	Slate	10	1,915
Red rock	20	740	Lime	3	1,918
Sand	3	743	Slate	25	1,943
Red rock	97	840	Lime	15	1,958
Sand	2	842	Salt	17	1,975
Red rock	18	860	Lime	15	1,990
Sandy lime	5	865	Salt	7	1,997
Red rock	25	890	Shale	18	2,015
Sand	2	892	Salt	5	2,020
Red rock	13	905	Lime	15	2,035
Blue slate	5	910	Salt	5	2,040
Red rock	60	970	Sand lime	10	2,050
Lime	8	978	Salt	13	2,063
Red rock	7	985	Limy shale	24	2,087
Sandy lime	15	1,000	Lime	5	2,082
Red rock	5	1,005	Lime and slate	10	2,102
Lime	10	1,015	Lime	5	2,107
Red rock	30	1,045	Salt	58	2,165
Salt	3	1,048	Lime	5	2,170
Sandy lime	17	1,065	Salt	20	2,190

Log of well in NE. corner of SE. ¼ sec. 33, T. 5 N., R. 28 E., Gate Valley Oil and Gas Company.—Continued.

Red rock	2	1,067	Slate	15	2,205
Sandy lime	13	1,080	Lime	40	2,245
Red rock	5	1,085	Slate	3	2,248
Sandy lime	15	1,100	Lime	117	2,365
Red rock	23	1,123	Sand—lime	5	2,370
Red lime	7	1,130	Salt	25	2,395
Red rock	10	1,140	Lime	109	2,504
Sandy lime	15	1,155	Lime	161	2,665
Red rock	5	1,160	Gray slate	2	2,667
Salt	6	1,166	Sandy lime	83	2,750
Lime, gray	11	1,177	Water sand	15	2,765
Red rock	11	1,188	Slate	5	2,770
Red rock	12	1,215	Water sand	5	2,775
Blue lime	13	1,203	Red slate	5	2,780
Lime	20	1,235	Sandy lime, water	52	2,832
Red rock	15	1,250	Slate	5	2,837

STRUCTURE.

The strata in Harper County lie at low angles with the general dip to the south. There are many local variations in the general dip. No detailed work has been done in this county and specific examples which may lead to the discovery of favorable structure cannot be pointed out.

SUMMARY.

Since the Permian rocks are for the most part barren of carbonaceous material no production is expected in the Permian strata, unless it has migrated there from formations containing carbonaceous material. The Pennsylvanian rocks are the source of most of the oil and gas production in the State. These rocks contain great quantities of carbonaceous material. They no doubt underlie the Permian in Harper County. If we consider the place where the limestones begin to come in as the probable contact between Permian and Pennsylvanian, then according to the log given under "Geology" of Harper County there is a thickness of approximately 1,800 feet of Permian sediments in this area. However, east of this area, in Kay and Noble counties, there are several limestones at the base of the Permian. It may be that the above figure is too small. Anyway, we could say that the minimum thickness of the Permian in this area is 1,800 feet. The depth to which the Pennsylvanian would have to be penetrated in order that productive sands might be encountered is unknown.

HASKELL COUNTY.

LOCATION.

Haskell County is situated in central-eastern Oklahoma. It comprises all of T. 8 N., Rs. 19 E. to 22 E. inclusive; the N. ½ T. 8 N.; all of T. 9 N., R. 18 E.; T. 9 N., Rs. 21 E. to 23 E. inclusive; T. 10 N., Rs. 21 and 22 E.; 4 square miles off the north side of T. 7 N., Rs. 19 to 22 E.; about 8 square miles out of the S. ½ T. 10 N., R. 18 E.; 32 square miles out of each of Rs. 19 and 20 E., T. 9 N.; 3 square miles in the SW. cor. T. 10 N., R. 19 E.; 13 square miles out of the eastern part of T. 10 N., R. 20 E.; 16 square miles out of the southeastern part of T. 11 N., R. 21 E.; 12 square miles out of the southwestern part of T. 11 N., R. 22 E.; and all of T. 10 N., R. 23 E., with the exception of about 5 square miles in the northern part. The total area is about 616 square miles.

TOPOGRAPHY.

The county is very irregular in shape. Along the western two-thirds the Canadian River forms the north and northwest boundary, and along the eastern one-third the Arkansas forms the north and northeast boundary. The drainage of the entire county is northward, through streams tributary to these rivers. Sansbois Creek is the principal stream flowing through the county. Haskell County lies in the Sandstone Hills region. Some parts of the county are very rugged, but in general the differences in elevation are slight, and all the county may be classed as one adapted especially to agricultural pursuits. The lowlands in the valleys of the rivers and their main tributaries are broad, flat, and fertile, and the natural drainage is poor.

In the rougher parts of the county the tops of the majority of the hills are broad and flat, and are nearly all at the same level. The hilltops then may be considered as forming a highland plain into which the streams have cut rather broad, deep valleys. The principal topographic features are the Brooken and Beaver mountain regions, in the western part of the county, and the Sansbois Mountains, along the southern boundary and in the southeastern part of the county. In a few other localities isolated peaks and knobs rise to considerable height above the level of the highland plain. The range in elevation is from 450 to 1,500 feet above sea level. However, the greater part of the county has an elevation ranging between 500 and 700 feet.

GEOLOGY.

The surface rocks of Haskell County, with the exception of the Recent sands and gravels along the streams, are of Pennsylvanian age.

The rocks exposed in order from oldest to youngest are: The Atoka formation, exposed over a small area in the southern part of the county;

the Hartshorne sandstone, rimming a narrow strip of the above formation; the McAlester shale, covering the greater part of the county; the Savanna sandstone, occupying about 60 square miles in the southern and western parts, with some irregular, scattered areas trending in a northeasterly direction through the eastern part of the county; and the Boggy shale, covering about 66 square miles in the southern and western parts. These rocks exposed over the county consist entirely of sandstones and shales with some beds of coal.

ATOKA FORMATION.

The Atoka formation comes to the surface in two small areas in Haskell County. The first is in the east-central part of T. 8 N., R. 22 E., about the town of McCurtain. The second is in the southeastern corner of T. 9 N., R. 23 E., southeast of Cartersville. This formation is brought to the surface by the folding in the Milton anticline. In this fold the rocks are unusually disturbed, and local crumpling has caused the rocks, including coal beds, to be fractured and displaced. In sec. 21, T. 8 N., R. 22 E. a domelike elevation has been formed and the coal crops out around it in a circular or elliptical form. In the north side of this local fold there is a fault, which bears nearly N. 75° E. and S. 75° W., with the strike of the Milton anticline. This fault has displaced the rocks, including the coal, downward toward the south, with respect to the same beds on the north side. The fault being in the strike of the rocks is difficult to trace, and cannot be found except where it intersects beds of hard rocks which are exposed, or by prospecting in mining the coal.

In the area where widely exposed, the Atoka formation is from 4,000 to 7,000 feet thick. This formation consists of shales, with four sandstone groups each about 100 feet thick, and at intervals of about 1,000 feet apart.

This formation contains the gas-producing sands in the Mansfield (Ft. Smith) gas field in Arkansas.

HARTSHORNE SANDSTONE.

The Hartshorne sandstone occurs in a narrow strip, immediately bordering the Atoka in the area given above. This formation consists of sandstones, shaly sandstones, shales, and coal. The thickness of the formation is from 100 to 200 feet. The lower part is thin-bedded and shaly, and grades into the shales of the Atoka. The beds in the upper part of the formation are more massive.

The Hartshorne sandstone is the gas-producing horizon in the Poteau field.

McALESTER SHALE.

Lying above the Hartshorne sandstone is the McAlester shale, a formation estimated at 2,000 to 2,500 feet thick; consisting principally of shale, but with some lenticular sandstone and coal beds, of which at least two are workable. This formation covers the greater part of the county, except the higher topographic areas and the axes of the principal structural folds.

SAVANNA FORMATION.

The Savanna formation outcrops over irregular areas, forming the rugged surface between the McAlester and Boggy shale areas. The Savanna consists of three sandstone groups separated by shales. The upper sandstone division is about 200 feet thick, while the others are thinner. In all the divisions the beds are more massive toward the top. The shale between the lower and middle sandstone is from 300 to 400 feet thick, and that between the middle and upper sandstone is from 450 to 530 feet thick. The shales are generally more sandy than those of the McAlester and Atoka formations.

The heavy sandstone in the Brooken and Beaver mountains and the northern slope of the Sansbois Mountains, and in the structural ridges along Sansbois Creek belong to the Savanna.

BOGGY SHALE.

The Boggy shale forms the surface in the extreme southern part of the county in the Sansbois Mountains, and in the northwestern part, in the vicinity of Brooken, and Enterprise, in Brooken Mountains. The formation consists of a great thickness of shale estimated at 3,000 feet, with thin beds of sandstone irregularly distributed through it. The shale generally exceeds the amount of sandstone in the formation, but the upper slopes of the mountains are covered with sandstone boulders, giving the impression that sandstone is extremely abundant in the formation.

STRUCTURE.

The relation of the structure to the topography is intimate. All of the larger hills or mountains are synclinal, and many of the smaller features are also related to the structure.

Several folds of importance are found in this county. The general course of the folds is in a northeast-southwest direction. The synclines are broader than the anticlines.

The principal folds named in order as they occur across the county, from the northwest corner to the southwest corner, are as follows: The Porum syncline; the Enterprise anticline, which forks in the eastern part of T. 9 N., R. 19 E. to form the Vian anticline, which follows the course of the Canadian River, and extends across the Arkansas into Sequoyah County at the junction of the two rivers, and the Kanima anticline, which bears to the south of Stigler and passes through Kanima to Arkansas River; the Cowlington syncline, which extends entirely across the county, dividing it into almost equal parts; the Kinta anticline, which comes in at the west side of the county, passes through Kinta and extends northeastward for a distance of 18 miles and is lost near Ironbridge; the Siloam syncline along the south side of Sansbois

Creek in the central part of the county; the Milton anticline beginning near Lequire and extending past McCurtain, into Leflore County, to Arkansas River; and the Sansbois syncline through the southeastern corner in the Sansbois Mountains. The axis of the Brazil anticline passes parallel to the other lines of structure just to the southeast of the corner of the county. Many other minor foldings no doubt occur over the county, but these have not been mapped in detail.

PORUM SYNCLINE.

From the crest of the Vian anticline the rocks dip gently to the west for 6 or 8 miles into the Porum syncline. The axis of this fold is well defined in the hills west of Porum and it extends to the southwest through Brooken Mountain. To the north of the hills west of Porum the country is almost flat, and exposures are few. The axis cannot be very definitely located but some small hills extending north and slightly east from the large hills are believed to be very near the axis.

ENTERPRISE ANTICLINE.

This fold enters the area from the west, where House Creek crosses the western boundary and extends northeast across Longtown Creek, passing about a mile southeast of Enterprise, and continues to a point about two miles southwest of Whitefield, where it apparently forks. The exposures in this vicinity are not numerous, and it is possible that the eastern branch does not quite join the main anticline, but the exposures found indicate that such a junction does take place, and it is so considered in this report. The dip to the northwest from the axis is 6° or less, and to the southeast is about 8° at the maximum.

VIAN ANTICLINE.

The name Vian is applied to the anticline that forms the northern branch of the Enterprise anticline. It passes near Whitefield and continues along Canadian River to the confluence of that stream with the Arkansas, crosses the latter stream and continues to the northeast, passing west of Vian. This anticline is almost certainly responsible for the Canadian's abrupt turn from an easterly to a northeasterly direction at Whitefield. From this turn of the river northeast to the Arkansas the axis of the anticline lies in the alluvium-covered river valley and its exact location cannot be determined. All that can be done is to draw the line about midway between the bluffs on the opposite side of the river. The dips from this anticline are rather gentle, the majority of the recorded dips being 3 to 5 degrees.

KANIMA ANTICLINE.

Branching from the Enterprise anticline southwest of Whitefield, the Kanima anticline extends almost east, to a point 3 miles south of Stigler, where it turns to the northeast passing about a mile east of the Antioch school house, about one-half mile west of Kanima, and on to the Arkansas River along the west side of Sansbois Creek. The dips are about the same as those on the Enterprise anticline.

COWLINGTON SYNCLINE.

The axis of this fold passes through the hills north of Quinton, through Beaver Mountain, then to the east and northeast through the hills between Pruitt and Shropshire valleys, across Sansbois Creek and through the hills northwest of Keota, then curves to the east, passing a short distance northwest of Cowlington and through Short Mountain.

KINTA ANTICLINE.

The Kinta anticline enters the area from the west at Featherston and extends eastward in the valley of Sansbois Creek past Quinton to near Kinta, turns somewhat to the north and crosses the Ft. Smith & Western Railroad between Lewisville and Kinta. It then continues to the northeast in a somewhat curved course, passing through Shropshire valley, and dies out opposite the northeastern end of the Siloam syncline near Ironbridge. The dips are low, usually less than 5°. Some local disturbances give westward dips near the axis between Quinton and Featherston.

SILOAM SYNCLINE.

The short syncline lying between the southwestern portion of the Milton anticline and the northeastern part of the Kinta anticline is called the Siloam from the church of that name in sec. 14, T. 8 N., R. 21 E. The axis lies in the range of hills on the southeast side of Sansbois Creek between Sansbois and Ironbridge.

MILTON ANTICLINE.

Beginning near Lequire, the Milton anticline extends east and northeast, passing through or near Lequire, McCurtain, Milton, and Bokoshe, and to Arkansas River near Redland. Near McCurtain this fold rises in a dome around which the Hartshorne (Panama) coal outcrops. In this dome the rocks are considerably disturbed and there are several local faults which are shown by the displacement of the coal in the mines, but which are seldom noticeable on the surface. For a short distance west of Lequire the Ft. Smith & Western Railway lies practically on the axis of the anticline. East of Lequire the railroad swings to the north of the axis, but crosses it again about two miles west of McCurtain. From this place to Milton the railroad is approximately one-half mile south of the axis. At Milton the axis swings somewhat to the north and passes nearly midway between the old and new towns of Bokoshe, and extends northeastward about one-half mile west of Redbank Creek to the confluence of that stream with Cache Creek, and on to the Arkansas.

DEVELOPMENT.

Several wells have been drilled in Haskell County. Some gas has been found on the Vian and Kinta anticlines. Other drillings along these same structures have been failures. Some of the wells drilled have been located directly in the syncline or too far down the slope of the steep anticlines.

Owen & Flanagan are reported to have drilled a well in sec. 36, T. 9 N., R. 20 E., and abandoned it at a depth of 2,500 feet. A showing of gas was reported at a depth of 1,100 feet. McGranahan & Longfellow drilled a well in sec. 23, T. 9 N., R. 21 E. The Sam & Bill Oil Company is reported to be drilling a test in sec. 16, T. 9 N., R. 19 E. The Pioneer Producing Company is drilling in sec. 7, T. 9 N., R. 23 E. The Gladys Belle Oil Company is drilling a well in sec. 4, T. 7 N., R. 19 E., and another in sec. 35, T. 9 N., R. 18 E.

In addition to the above named wells which are drilling, about 10 wells have been drilled in the county.

The results of some of the drillings in this county and adjacent territory are summarized as follows:

Gas was found in a well at a depth of about 1,000 feet at Vian in southwestern Sequoyah County. This well is probably located on the Enterprise anticline. Four wells have been drilled at or near Spiro in northern Leflore County. Two wells were gas producers and two were dry holes. The capacities of the gas wells are reported at from 750,000 to 3,000,000 cubic feet per day. A well at Kinta in the southern part of Haskell County is reported to have had a capacity of 2,000,000 cubic feet of gas at a depth of 1,700 feet. At Bokoshe a well was completed and some gas encountered. A well was drilled near Briartown in southeastern Muskogee County, some distance from the axis of the Vian anticline without results. Some gas was found in a well about 4 miles west of Porum on the southern branch of the Warner anticline. A well farther west, about 2½ miles north of Texanna in McIntosh County, was dry.

SUMMARY.

Haskell County can be considered as lying entirely in probable oil and gas territory. The general geology and structural conditions are favorable for the finding of oil and gas.

Several anticlinal folds of importance occur in the county, and many smaller favorable structures may be found by detailed work. It is highly probable that the less prominent structures may prove most productive in this area. In some of the large structures the folding has been very intense and deep-seated, and hence is perhaps too steeply tilted and too much broken to permit the proper accumulation of oil. It seems, however, that the county may be considered very favorable for the finding of gas. The miscellaneous drilling which has been done in the county has not in any manner condemned the territory for further prospecting and conditions warrant further investigation.

HUGHES COUNTY.

LOCATION.

Hughes County is located a little south of the east-central part of the State. It extends from T. 4 N. to T. 9 N. inclusive, and from R. 8 E. to R. 12 E. inclusive. It includes 19 entire townships and parts of 7 others. The total area is approximately 790 square miles.

TOPOGRAPHY.

Hughes County is in the Sandstone Hills region. The topography is made up of alternating sandstone hills and shale valleys. The difference between the elevation of hill and valley is as much as 400 feet in places. The divide between the Canadian and Red River drainage extends in an east-west direction across the southern part of the county. The northern two-thirds of the county is drained by the Canadian and North Canadian rivers and their tributaries; the southern one-third by Clear Boggy Creek.

The surface elevation ranges from 575 feet to 1,100 feet, a distance of 535 feet. The lowest point is where the east county line intersects Canadian River in sec. 13, T. 8 N., R. 13 E. The highest point is in sec. 27, T. 8 N., R. 11 E., about 3 miles north of Lamar.

GEOLOGY.

GENERAL STATEMENT.

The surface rocks in Hughes County are Pennsylvanian. These rocks are sandstones, shales, conglomerates, and limestones. The shales predominate, though sandstones are quite numerous.

BOGGY SHALE.

The Boggy shale is the lowest formation exposed, and covers a small area in the southeast corner of the county. It lies above the Savanna sandstone, and consists of a great thickness of shale and irregularly distributed thin-bedded sandstones. To the casual observer it appears to be more of a sandstone than shale, but in reality the sandstone makes up less than one-sixth of the entire thickness of from 2,000 to 3,000 feet. This is due to the fact that the sandstones weather more slowly. The result is, the steeper slopes of the mountains are covered by sandstone boulder, remnants of the sandstone ledges. Exposures of the shale are rare.

THURMAN SANDSTONE.

The Thurman sandstone marks a change in sedimentation. Whereas the older deposits had been fine shales, they are now followed by a deposit of coarse, white chert and quartz. Fifty feet of the total 80 to 250 feet is composed of this conglomerate. The sandstones of the upper part become finer and thinner in texture to the impure fossiliferous limestones. The formation throughout its area of outcrop dips 60 to 100 feet per mile. The harder members make rugged, stony, high points, usually densely wooded.

STUART SHALE.

Above the Thurman sandstone are 100 to 275 feet of thin-bedded shaly sandstone and shales interstratified, called the Stuart shale. The maximum development occurs in the north-eastern portion of the Coalgate quadrangle. The Stuart shale is composed of an upper and lower shale, operated by a sandstone member which varies from 10 to 50 feet. The lower shale is usually 120 feet thick, with a local chert conglomerate lentil at the center, until near the southwest of the Coalgate quadrangle. It is composed chiefly of black and bluish shale. The upper member, from 50 to 120 feet in thickness, is bluish in color. The upper shale outcrops along steep scarps, instead of upon level, grassed prairies, as does the lower member.

SENORA FORMATION.

The Senora formation in the northwest corner of the Coalgate quadrangle measures almost 500 feet in thickness. The thickness decreases toward the southwest. The sediments consist of sandstones and shales interstratified, with the former thickness to the northeast. The sandstones are frequently divided or completely replaced by shale members. Lithologically the shales are bluish clays and brownish sandy shales, while the sandstones are generally fine-grained and gray or reddish-brown in color.

CALVIN SANDSTONE.

The Calvin sandstone is a deposit of thin-bedded sandstones, with some shales, which measures 140 to 240 feet in thickness. The lower 140 feet is composed of massive, rather soft sandstone. The upper 60 to 100 feet takes on more of the character of the overlying formation, being a series of sandstones and shales, with the shales increasing in proportion to the nearness of the other formation. The outcrop of this sandstone is usually very rugged.

WETUMKA SHALE.

Above the Calvin sandstone is the Wetumka shale, composed almost wholly of friable, laminated, clay shales. The central part of this 120-foot formation consists of thin, shaly sandstones.

An absolute line cannot be drawn between the Wetumka and Calvin sandstone, since the shaly beds of the latter grade into the succeeding shales of the former. In some places the single name Wetumka is given to the entire series here discussed under the two names.

WEWOKA FORMATION.

The Wewoka formation consists of 700 feet of massive, brown, friable sandstone, with interstratified, soft, blue clays and an occasional limestone. The separate beds of sandstone are sufficiently large to be mapped were it not for the friable nature of the beds which obscure them. Near the base is a local sand-chert conglomerate, which is best exposed along the bluffs of Boggy Creek valley. In the Canadian valley to the eastward this phase has almost disappeared.

In the 120 feet of shale just above the sandy conglomerate are abundant fossil remains, while the succeeding 110 feet of massive, friable sandstone is free from such remains. The next bed above consists of 130 feet of soft blue, fossiliferous clay shale. Here many shells are perfectly preserved. Other beds occur still higher. A 60-foot sandstone, 45-foot shale, and 100-foot sandstone, complete the section.

HOLDENVILLE SHALE.

Above the Wewoka formation lies the Holdenville shale. This formation consists of 260 feet of friable, blue clay, with local thin beds of shelly limestone and calcareous sandstone. The shales are rarely exposed.

SEMINOLE CONGLOMERATE.

The Seminole conglomerate where fully exposed is about 150 feet thick. A small area, 50 feet thick, of the lower portion is exposed in northwestern Coalgate quadrangle. This part is composed of laminated, subangular chert, with some quartz, cemented together by a fine brown, ferruginous sand. The upper portion consists almost wholly of brown sandstones.

STRUCTURE.

The rock formations lie in a monocline which dips at a low angle to the northwest. This monocline is associated with the Ouachita Mountain uplift. Occasionally the dip to the west is interrupted by gentle folds. As no detailed work has been done in this county specific cases of folding cannot be pointed out.

DEVELOPMENT.

There has been considerable drilling in Hughes County in the past few years. Charles Baugh is reported to have drilled a well in sec. 14, T. 9 N., R. 13 E. in which he had 3,000,000 cubic feet of gas at a depth of 1,150 feet. Don Reisig is reported to have had showings of gas at 450 feet and 1,450 feet in sec. 1, T. 9 N., R. 12 E. The hole is reported as plugged at 2,231 feet. Maxwell is reported as having a show of gas at a depth of 1,900 feet in his well in sec. 13, T. 8 N., R. 11 E. Johns and Cochren's test in sec. 13, T. 8 N., R. 11 E. is reported as dry. The Penn-West Oil Company is reported as having 16,000,000 cubic feet of gas and 5 barrels of oil in its well in the NE. 1/4 of the NE. 1/4 sec. 4, T. 7 N., R. 8 E. The Colonial Oil Company abandoned at a depth of 2,000 feet a well in sec. 34, T. 6 N., R. 10 E.

SUMMARY.

Hughes County is within proved oil and gas territory, although no large accumulations have been found. The fact that the depth to possible oil or gas sands is shallow and that there are several reliable strata on which underground structure can be determined from the surface, makes Hughes County attractive for exploration.

JACKSON COUNTY.

LOCATION.

Jackson County is in the southwestern part of the State. It extends from T. 2 S., to T. 4 N. inclusive, and from R. 18 W. to R. 23 W. inclusive. It contains 12 whole townships and parts of 21 others. Its area is approximately 811 square miles.

TOPOGRAPHY.

Three distinct types of topography are found in Jackson County: (1) Wichita Mountains, (2) Sandstone Hills, and (3) Redbeds Plains. The northeastern part of the county is in the Wichita Mountains. These mountains consist of granite ridges rising a few hundred feet above the surrounding level plain. The Redbeds Plains occupy all the county except the Wichita Mountains region mentioned above, and the Sandstone Hills region in the southeastern part of the county. The county has all the variation in topography of level plains, hills, and low-lying mountains.

GEOLOGY.

The rocks at the surface in Jackson County are Permian and pre-Cambrian. The pre-Cambrian rocks are found in that part of the Wichita Mountains which lies in the northeastern part of the County. They consist of granite and some intruded dikes. The Permian occupies the remainder of the area. These rocks consist of shales, sandstones, and gypsum. The Pennsylvanian rocks are supposed to underlie the Permian in Jackson County. The depth to the Pennsylvanian is supposed to be shallow near the Wichita Mountains, and to increase in depth as the distance southwest of the mountains increases.

The Permian rocks dip at a low angle to the southwest. There may be local variations in this general dip, however, no detailed work for structure has been done by the Survey. There may be structure favorable for the accumulation of oil or gas in Jackson County. Detailed study of the surface outcrops might locate some of these structures. There are, no doubt, folds in the underlying Pennsylvanian which cannot be located from the attitude of the surface outcrops.

DEVELOPMENT.

No production has been reported for Jackson County. A well was drilled near Olustee, and it is reported that oil was encountered, but the report has not been verified.

SUMMARY.

Jackson County is within possible oil and gas territory. The Wichita Mountains have brought the Pennsylvanian rocks near the surface. The central-southern parts of the county should be good territory for exploration. It should be remembered however, that little is known of the attitude of the Pennsylvanian strata and surface indications will not entirely solve the problems of structure. Whatever folding occurs in the Permian, will, in most cases extend down into the Pennsylvanian, but there are, no doubt, folds in the Pennsylvanian which originated during the Wichita Uplift and before the Permian sediments were laid down. Such structures, can be determined by drilling only.

JEFFERSON COUNTY.

LOCATION.

Jefferson County lies along Red River, in the south-central part of the State. It extends from T. 3 S. to T. 8 S. inclusive, and from R. 4 W. to R. 9 W. inclusive. It includes about 15 whole townships and parts of 15 others.

TOPOGRAPHY.

Jefferson County lies in the Redbeds Plains region. The surface is usually level or gently rolling. The topography is similar to that of Cotton County. The chief drainage is through Beaver and Mud creeks to Red River. The range in elevation is from about 1,100 feet on Monument Hill, 3 miles east of Addington, to 733 feet on Red River in the extreme southeastern corner of the county.

GEOLOGY.

The surface rocks of Jefferson County are classified at present as Permian Redbeds. Possibly some Cretaceous and Pleistocene or Recent may occur. Formerly the whole area was considered a part of the Redbeds. Recent investigation by members of the Oklahoma Survey and others has not only caused the previous assumption to be doubted, but has proved that in certain localities the evidence points overwhelmingly toward a belief in the presence of Cretaceous sediments. The Permian Redbeds in the western part of the county are similar in character to those described by Munn in his reconnaissance report on the Grandfield district, included under "Cotton County," and also as described by Wegemann*.

They consist of shales, sandstones, and conglomerates, and are correlated by Wegemann with the Wichita formation. The shales are of many colors and shades, usually red. The sandstones are composed principally of grains of quartz and several other minerals in subordinate amounts. They are cross-bedded in many cases. The conglomerates are composed of roughly spherical pebbles cemented together, and bear a close resemblance to concretions. The conglomerates are

*Wegemann, C. H., Bull. U. S. Geol. Survey No. 602, 1915, pp. 12-13.

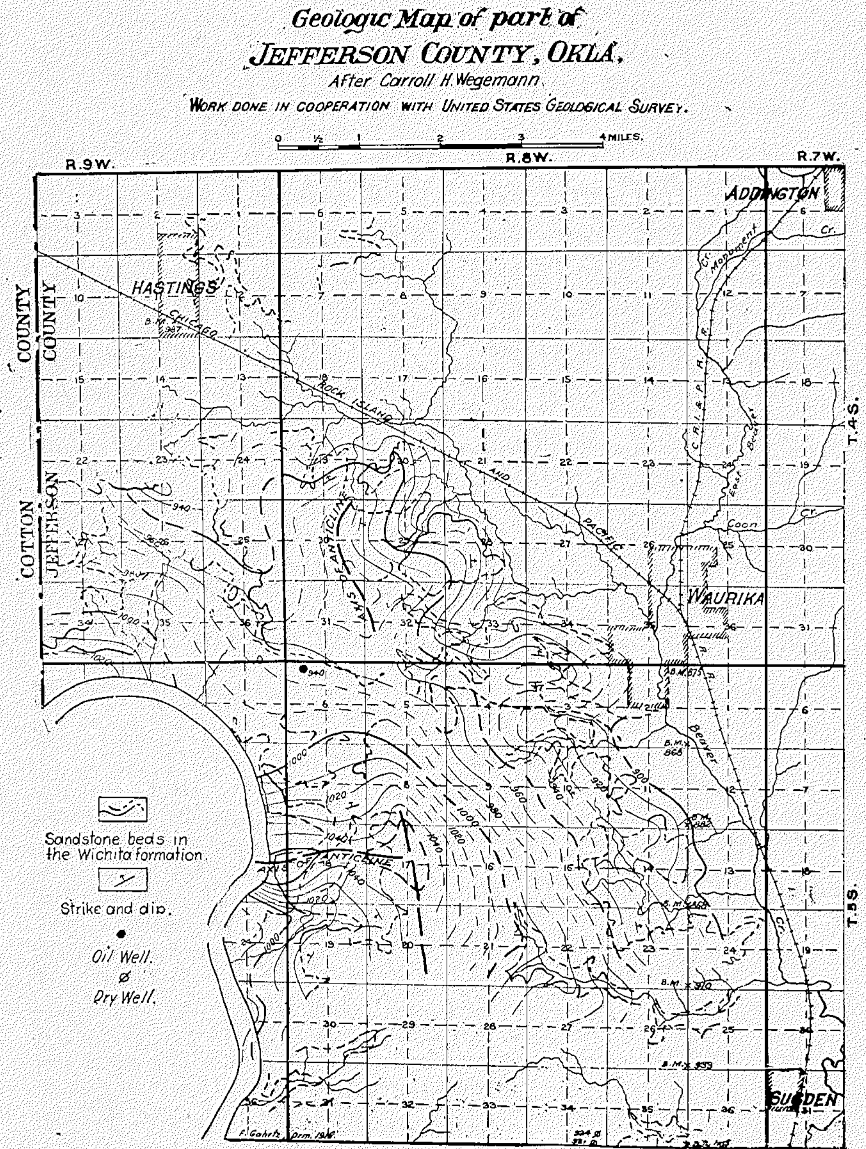
Geologic Map of part of
JEFFERSON COUNTY, OKLA.
After Carroll H. Wegemann.
WORK DONE IN COOPERATION WITH UNITED STATES GEOLOGICAL SURVEY.
4 MILES.
R.9W.
R.8W.
R.7W.
T.4S.
T.5S.
COTTON COUNTY
JEFFERSON COUNTY
ADDINGTON
HASTINGS
WAURIKA
SUGDEN
CHICAGO ROCK ISLAND AND PACIFIC
C.R.I.&P. R.R.
Beaver
Coon Cr.
AXIS OF ANTICLINE
Sandstone beds in the Wichita formation.
Strike and dip.
Oil Well.
Dry Well.
F. Gahrtz Drm. 1918.

Figure 5.

associated with beds of sandstone and in some places are interstratified with shale.

The Cretaceous sediments are scattered irregularly throughout the county. At the present time a field party of the Oklahoma Geological Survey is mapping the contact of the Cretaceous and older formations in that section of the State. The results and data are not complete and hence are not available at this time.

STRUCTURE.

The dip of the surface rocks in general in this county is to the south or southwest. In the area west of the Chicago, Rock Island & Pacific Railway, C. H. Wegemann of the United States Geological Survey, in cooperation with the Oklahoma Geological Survey, has worked out the structure and the results are set forth in Bulletin No. 602 of the United States Geological Survey. The same can be obtained by writing to that Survey at Washington, D. C. A portion of the publication is included in this report. In the northeastern part of the county the structure in the NE. ¼ of T. 3 S., R. 5 W. has been mapped in detail by C. H. Wegemann* and a portion of his report is given under the heading "Stephens County."

Outside of the area of these reports no structural data are available at present.

DETAILED SURVEY OF SPECIAL AREA.

The following is a portion of the Wegemann report* on anticlinal structure in parts of Cotton and Jefferson counties.

ANTICLINAL STRUCTURE IN PARTS OF COTTON AND JEFFERSON COUNTIES, OKLAHOMA.

GENERAL STATEMENT.

Reports on adjoining areas.—The "Red Beds" area of northern Texas and southern Oklahoma has until recently received but little attention from geologists making explorations for oil, not because it was thought that the rocks contain no oil but rather because the delineation of structure, one of the controlling factors in the accumulation of oil, was considered an almost hopeless task in such beds. Recent investigations, however, have shown that the task, though difficult, is by no means hopeless. It is possible to determine with more or less accuracy the structure of the strata at many places throughout the "Red Beds" region, and thus to point out localities favorable or unfavorable to the accumulation of oil. It is with this object in view that the State surveys and United States Geological Survey are making examinations of areas in this region in which the rocks may possibly contain oil. In 1912 the University of Texas

*Wegemann, C. H., Bull. U. S. Geol. Survey, No. 621-C, 1915, pp. 31-42.

*Wegemann, C. H., Anticlinal structure Cotton and Jefferson counties, Oklahoma: Bull. U. S. Geol. Survey, No. 602, 1915.

published a report on the geology of the oil and gas fields of Wichita and Clay counties, Tex.,* the area considered including the Electra, Burkburnett, and Petrolia fields, lying immediately south of Red River, which here forms the boundary between Texas and Oklahoma. In the fall of the same year the United States Geological Survey, in cooperation with the Oklahoma Geological Survey, made an examination of about 360 square miles lying north of Red River in southeast Tillman and southwest Cotton counties, the results of which were published by the United States Geological Survey.*

Location and extent of the area examined.—The present report is the result of examinations made in the summer and autumn of 1913. The area covered, about 270 square miles, lies in Oklahoma north of Red River and east of the Grandfield district. It is limited on the north and east by the line of the Chicago, Rock Island & Pacific Railway, which passes through the towns of Ryan, Waurika, Hastings, and Temple. South of the area across Red River is Clay County, Tex., which comprises the eastern part of the territory covered by the bulletin published by the University of Texas, above cited.

Settlement and industries.—Although this part of the country has been open to settlement by white men but a few years, there is little Government land remaining. Stock raising, which only a few years ago was the principal industry, has given place almost entirely to farming. The rolling plains country, which is practically treeless, is divided into farms, most of which contain 160 acres. The roads follow the section lines. The principal product of the country is cotton, although much corn is raised. Several failures of the corn crop, owing to prolonged drouht, have turned the attention of settlers to the raising of kaffir corn and other crops better suited to the climate.

The largest town in the area is Waurika, the county seat of Jefferson county. Ryan, Hastings, and Temple are smaller, but each supplies a considerable area. All four towns are on the Chicago, Rock Island & Pacific Railway. There are three country stores in the area, two at "the corners" known as Taylor, west of Cache Creek and one belonging to C. Y. Wilson, 10 miles due west of Waurika.

DRAINAGE AND TOPOGRAPHY.

Streams and their relation to structure.—Red River, the largest stream in this general region, forms the southern boundary of the area here described. It is remarkable for the great width of its channel in comparison with the width of its immediate valley, which is unusually narrow for a stream of its size; also for its quicksand and for the great variation in the amount of water it carries, the channel at many places being entirely

*Udden, J. A., and Phillips, D. McN., A recommaaissance report on the geology of the oil and gas fields of Wichita and Clay counties, Tex.: Texas Univ. Bull. 246, 1912.

*Munn, M. J., Reconnaissance of the Grandfield district, Okla.: U. S. Geol. Survey Bull. 547, 1914.

dry during midsummer and carrying a rushing torrent of water charged with red mud at the advent of the autumn rains.

The area here considered is drained by three streams, which flow into Red River and which, named in the order of size, are Cache Creek, Beaver Creek, and Whisky Creek. East Cache Creek, which heads northeast of the Wichita Mountains and crosses the western part of the area from north to south, is joined by Deep Red Run and West Cache Creek, the latter heading in the south flank of the Wichita Mountains. Beaver Creek, which heads east of the Wichita Mountains, parallels Cache Creek, lying 6 to 10 miles east of it, and flows nearly southward along the east side of the area. It has no large branches, such as those of Cache Creek. Whisky Creek is a small stream, not more than 12 miles long, which lies midway between Cache Creek and Beaver Creek in their lower courses.

The fall of Red River for the 39 miles of its course along the border of this field is 111 feet, the average fall in this stretch being 2.85 feet to the mile. The width of the channel, as marked by the borders of the stream at high water or by the width of the belt of barren sand at times of drought varies considerably from point to point along its course. Opposite the mouth of Cache Creek it is 3,500 feet wide, but in the great bend 6 miles southwest of Waurika it is contracted to a width of about 800 feet. The cause or causes of this variation in the width of the channel are not certainly known; it is probably due to the combined action of several factors, such as the hardness of the rock strata encountered by the stream at different places, the dip of the rock beds, the direction of the prevailing winds and hence the direction in which the sand of the river bed is drifted at times of low water, and the locations of the mouths of tributary streams, like Cache Creek, which add their load of material to the load carried by the main river.

It seems probable that Red River, a large stream, established its course on a base-level plain and maintained it, having been little affected by subsequent slight and gradual folding, whereas its smaller tributaries were unable to deepen their channels as rapidly as the strata were uplifted across their courses, and thus were compelled to readjust themselves to the folds. The present course of Red River is therefore independent of the structure, following an anticline through part of the area under discussion, whereas nearly all the smaller streams flow in synclines or follow the dip of the rock strata, even though their courses thus determined are directly away from the main stream, as are the courses of the streams in T. 4 S., R. 11 W.

Upland plain.—The channel of Red River has been cut about 100 feet below the level of a gently rolling plain which covers much of southwestern Oklahoma. This plain is apparently the result of base leveling accomplished by streams flowing at grade when the land areas were relatively lower with reference to sea level than at present. Taff* gives the age of this peneplantation as probably Tertiary. This upland surface slopes gently

*Taff, J. A., Geology of the Arbuckle and Wichita mountains, in Indian Territory and Oklahoma: U. S. Geol. Survey Prof. Paper 31, p. 17, 1904.

southeastward at about the grade of Red River. The flood plain of Red River, which in some places is 3 miles wide, as well as the flood plains of tributary streams like Cache Creek and Beaver Creek, represent a surface of plantation now in process of formation.

STRATIGRAPHY.

"RED BEDS."

The stratigraphy of the exposed rocks of the region is comparatively simple. These rocks consist of two series of beds, the older composing part of the Wichita formation of the Permian "Red Beds" and the younger the more recent deposits, represented by surface soil, the upland gravels of old river terraces, and the alluvium of the present flood plains. The determination of the stratigraphy of the rocks beneath the Wichita formation, which are not exposed in the area considered, is more difficult, as it involves several unknown factors. It is, however, important in the study of the accumulation of oil in the area, inasmuch as these underlying rocks probably constitute the principal source of the oil found in adjoining fields.

DIVISIONS OF THE "RED BEDS."

The "Red Beds" were originally divided by Cummins* into three divisions which, from base to top, are the Wichita, the Clear Fork and the Double Mountain. Of these, the Wichita only is present in the area here described, the higher divisions being found farther west. According to Cummin's description, the Wichita is composed of sandstones, clay beds, and a peculiar conglomerate. The sandstones are of various colors; the clays are red and bluish and are in places copper bearing, as are also those of the Clear Fork formation. There are iron concretions in the red clays, and the peculiar conglomerate is composed of clay or clay ironstone with a ferruginous matrix. The Clear Fork formation consists of limestones, clay and shale beds, and sandstones. The sandstones are not so abundant as in the Wichita. The clays are red and blue. There is a conglomerate like that in the Wichita, but it is less abundant. A few beds of gypsum are present. The Double Mountain formation, which overlies the Clear Fork, is said to consist of sandstone, limestone, sandy shale, red and bluish clays, and thick beds of gypsum.

WICHITA FORMATION.

In the area covered by this report the Wichita formation consists of beds of shale and sandstone and thin layers of shale conglomerate. The formation contains no limestone, although some of the sandstone beds are very calcareous. The stratigraphic thickness of the rocks exposed in the area here described is about 280 feet. The "Red Beds," however, extend to a depth of about 1,000 feet below the surface, as is shown by the logs of deep wells drilled in the vicinity of the field. How much of the Wichita formation has been removed by erosion it is impossible to say.

*Cummins, W. F., The Permian of Texas and its overlying beds: Texas Geol. Survey First Ann. Rept., pp. 83-197, 1800. Geology of northwestern Texas: Texas Geol. Survey Second Ann. Rept., p. 400, 1890.

Shale.

The individual beds of shale of the Wichita formation exposed in this field range in thickness from a few inches to 42 feet, and one bed of red shale, recorded at a depth of 100 feet below the surface in well No. 1 of the Riverside Oil Co., is 101 feet thick.

The shale is of many colors and shades. In some beds the color ranges from red to gray, in others from green to purple; in still others it is almost black. Much of the shale, especially where it is exposed to weathering, has a mottled appearance, the colors being red and light gray or even white. The change of color does not invariably conform to the bedding, which, though finely developed in certain strata, especially near sandstone beds, is not usually pronounced. Under the miscroscope a thin section of finely laminated shale closely associated with sandstone is seen to consist of dark-red amorphous material, particles of quartz, slender laths of a colorless mineral having parallel extinction (sericite?) and a greenish to bluish, highly refracting mineral. The red amorphous material increases in amount near the lamination planes to the practical exclusion of the other minerals. Very few of the particles of quartz in the section examined have a diameter of more than 0.02 millimeter, and the average diameter of the larger particles is 0.017 millimeter.

Scattered through the mass of the shale, in some places arranged along the bedding planes, there are concretionary masses, which are of various form and range in size from small grains to masses a foot or more in diameter. The material of these concretions, if such they really are, consists of shale resembling in most respects that in which they are embedded. The cementing material is calcium carbonate, but the masses contain considerable amounts of iron oxide and also of manganese oxide, which occurs in some places as dark brown or black dendritic forms penetrating the concretion from the surface toward the center. The concretions do not show concentric structure and are as variable in shape as they are in size. Some of them are almost round, have smooth surfaces, and resemble closely the pebbles of the concretionary conglomerate described below; others are flat, their longest diameter lying parallel to the bedding of the shale; still others are rounded in outline and have extremely rough surfaces, being covered by a deposit of calcium carbonate built out in a sharp edged network, as if the shale around the concretion had been broken by innumerable cracks which were filled by the deposit. Munn* referred to these forms as "clay-limestone concretions" and this term will be employed in the present report.**

Sandstone.

The sandstones of the Wichita formation are composed principally of grains of quartz and very subordinately of grains of feldspar and zircon.

*Munn, M. J., Reconnaissance of the Grandfield district, Okla.: U. S. Geol. Survey Bull. 547, p. 19, 1914.

**For theories in regard to the formation of concretions, see Gardner, J. H., The physical origin of certain concretions: Jour. Geology, vol. 16, pp. 452-458, 1908. Also Todd, J. E., Concretions and their geological effects: Geol. Soc. America Bull., vol. 14, pp. 353-368, 1903.

Muscovite and biotite were found in 7 of the 12 thin sections of sandstone examined, and in all these slides only three grains of tourmaline were observed. Most of the grains of feldspar are weathered and, so far as could be determined, all are plagioclase. The grains of zircon are considerably smaller than the grains of quartz, being, in the sections examined, about one-third as large. Inclusions of apatite, rutile, and zircon occur in some of the quartz grains.

The grains of sand are almost invariably angular, their angularity increasing with decrease in size. Well-rounded forms are rare, being found only in grains whose diameter is greater than one-tenth of a millimeter, the lower limit to rounding by the action of water. Since eolian agencies are capable of rounding sand grains of smaller diameter than one-tenth of a millimeter, the fact that the finer particles of the sands of the Wichita formation are not rounded but invariably angular indicates at least that wind action has had little to do with their deposition.

The principal cementing material of the sandstones is calcite, but silica occurs in subordinate amounts. The relation of these two cements will be shown later. In the calcite-cemented sandstones iron oxide stains are common, and in a few specimens are so pronounced that the sandstone has a distinctly red color. Iron oxide was found to be more than a stain in the calcite cement in only one specimen, in which it formed practically all the cementing material. The sandstone beds vary considerably in thickness from place to place, variations of several feet having been noted within horizontal distances of only a few yards. The greatest thickness measured for any one sandstone is 32 feet in the SE. ¼ SE. ¼ sec. 15, T. 5 S., R. 8 W. The average thickness is about 12 feet.

The sandstones are of two different types, which for convenience will here be termed the normal and the fine-grained sandstones. The two types differ in size of grain, cement, bedding, thickness, regularity, and in the associated conglomerate, the differences being due mainly to variations in the conditions under which they were deposited. There are many gradations between the two types, but the characteristics of the extremes are markedly distinct. The normal type exceeds the fine-grained both in absolute amount of sediment and in the persistence of its beds over considerable areas. It is the important rock in geologic work as it furnishes the only key horizons in the field for the correlation of strata between outcrops and for the determination of structure.

The difference in size of the grain of the two types is shown by the measurements given below. These sizes were determined by a series of Howard & Morse "Standard" sieves. The grains ranging in size between 0.5 and 0.25 millimeter pass through a 30-mesh sieve with an effective opening of 0.231 millimeter. The grains measuring 0.25 to 0.125 millimeter pass through a 60-mesh sieve and are caught on a 120-mesh sieve with an effective opening of 0.120 millimeter. The grains measuring 0.125 to 0.0625 millimeter pass through the 120-mesh sieve and are caught on a 200-mesh sieve with an effective opening of 0.071 millimeter. Grains measuring less than 0.0625 millimeter pass through the 200-mesh sieve.

The first two specimens of sandstone are of the normal type, in which most of the grains range in diameter from 0.0625 to 0.25 millimeter. The third specimen represents the fine-grained type, in which most of the grains are smaller than 0.0625 millimeter.

Size of grains in sandstone of Wichita formation.

Diameter in millimeters.	1	2	3
	Per cent.	Per cent.	Per cent.
Less than 0.0625	22	9	57
0.0625 to 0.125	44	24	26
0.125 to 0.25	34	67	17

1. Sandstone containing nodules of copper, normal type, from SW. ¼ SE. ¼ sec. 35, T. 4 S., R. 10 W.

2. Sandstone containing concretions of manganese, normal type, from NE. ¼ SW. ¼ sec. 3, T. 5 S., R. 8 W.

3. Sandstone of fine-grained type, from NE. ¼ NW. ¼ sec. 3, T. 5 S., R. 8 W.

The cementing material differs in the two types of sandstone. The normal or medium-grained type is for the most part cemented by calcite; the fine-grained type is cemented principally by siliceous material, presumably quartz. A part of the cement of the normal type does not disintegrate in cold dilute hydrochloric acid and is probably quartz, as is apparent also from the examination of thin sections under the microscope. In like manner the cement of the fine-grained type is not all silica, as is shown by its effervescing on the application of hydrochloric acid. The cause for this difference in cementing material between the two types of sandstone is not clear. It appears to bear a direct relation to the size of the grains of the sandstone and may in some manner be controlled by the rapidity of the circulation of water through the rock, which would be greater in the coarser-grained material, or by the amount of rock surface exposed to water action, which would be greater in the finer-grained sandstone.

The two types of sandstones differ in bedding. The normal type shows the action of rather swift current during its deposition—conglomerates are associated with it, it shows almost everywhere cross-bedding, and where it does not the horizontal bedding is more pronounced than that in the fine-grained type is not as a rule associated with conglomerate and shows little or no cross-bedding, and where it does not the horizontal bedding is more pronounced than that in the fine-grained type. The fine-grained type is not as a rule associated with conglomerate and shows little or no cross-bedding. In one exposure, in the NE. ¼ sec. 19, T. 5 S., R. 8 W., leaf impressions were found in this type of sandstone.

The normal sandstones are the most conspicuous beds of this region and average 10 to 15 feet in thickness. The fine-grained sandstone is usually found in comparatively thin beds, rarely if ever exceeding 6 feet in thickness and generally occurring as thin sandy layers or streaks in the red shales. Being less firmly cemented than the normal type, it does not resist the action of weathering so well, and being thin it is not generally conspicuous in exposures. It is therefore impossible to trace the beds of the fine-grained type for any considerable distance or to make observations on their continuity, but it is believed from the study of single exposes that these beds vary greatly in thickness from place to place and are generally lenticular.

A common characteristic of the normal type of sandstone is its content of manganese minerals (oxides of manganese), which discolor the rock along the bedding planes and occur in concretionary masses. At certain localities copper minerals in small amounts form part of the cement of the normal sandstone. These minerals do not occur in the fine-grained sandstones, possibly because they are less permeable to water solutions than the coarser sandstones.

The presence of so few minerals other than quartz among the sand grains, and these minerals only the most resistant ones, indicates a high degree of assortment of sediment, which is found only in beds deposited at some distance from the source of the material or in beds formed of material that had been agitated by water for a considerable time. The fineness of the sand grains, even in the normal type of sandstone, also shows that the assortment is of high order, and the extreme fineness of grain of the fine-grained sandstone is even more remarkable.

In summary: The sandstones of the normal type are composed of sand grains between 0.25 and 0.0625 millimeter in diameter, are cemented with calcite, and show cross-bedding, greater thickness of beds, and greater uniformity over large areas than those of the fine-grained type, are associated with conglomerates, and generally contain manganese or copper minerals. The sandstones of the fine-grained type are characterized by thin lenticular beds, absence of cross-bedding, and extremely fine grain, the grains measuring less than 0.0625 millimeter in diameter.

Conglomerate.

Associated with the beds of normal sandstone and at some places interbedded with the shale are beds of conglomerate, which range in thickness from a fraction of an inch to 3 or 4 feet. The conglomerate is composed of roughly spherical pebbles, which bear a close resemblance to concretions and may, in fact, be concretionary in origin. Because of this resemblance and for the lack of a better descriptive term the rock will be referred to in this report as concretionary conglomerate. This use of the term conglomerate may be open to question, but it can not lead to confusion, as the rock, no matter what its origin, is conglomeratic in texture and has been described as conglomerate in several geologic reports.*

*Cummins, W. F., The Permian of Texas and its overlying beds: Texas Geol. Survey First Ann. Rept., p. 187, 1890. Munn, M. J., Reconnaissance of the Grandfield district, Okla.: U. S. Geol. Survey Bull. 547, p. 23, 1914. Udden, J. A., assisted by Phillips, D. McN., A reconnaissance report on the geology of the oil and gas fields of Wichita and Clay counties, Tex.: Texas Univ. Bull. 246, p. 29, 1912.

The concretions range from fine grains to pebbles 2 inches in diameter, and some specimens of the conglomerate include subangular fragments of shale, the largest an inch in length. The so-called concretions are in part "mud lumps" formed by the rolling of masses of mud along the bottom in currents overloaded with fine sediment.*

Some of the concretions show concentric structure to a slight degree, and many of them contain grains of sand, which are larger and more numerous than those in the finer-grained shales of the Wichita formation. The arrangement of the sand grains in some specimens also suggests concentric structure, indicating that the grains may have been taken up from the bottom by rolling balls of mud. It is apparent that the water currents which deposited the conglomerate although swift, as shown by the cross-bedding and the size of the concretions, did not transport the material for any considerable distance, as the shale fragments mingled with the concretions are subangular in outline. No foreign material other than fragments of bone or bits of coal representing fossil wood are found in the conglomerate, which appears to be composed entirely of material derived from the Wichita beds themselves.

TERRACE GRAVELS, ALLUVIUM, AND SAND DUNES.

On many of the upland surfaces along the streams there are gravel deposits, which range in thickness from a few inches to several feet. The pebbles consist of quartzite, limestone, and rhyolite porphyry, the last named being generally broken along joint planes into angular forms. Fragments of silicified wood are common. The largest pebbles found are 5 inches in diameter and many of the pebbles are embedded in coarse sand, the whole deposit being slightly consolidated by calcium carbonate. The gravels appear to be stream deposits, representing material brought from the Wichita Mountains by the present streams at former stages of their development. These deposits, however, may be in part composed of reworked material derived from a widespread sheet of upland gravels that covers large areas in Oklahoma and northern Texas.**

The flats along all the streams are formed of alluvial deposits laid down by the streams, particularly at times of flood. Similar material is being deposited by the streams at the present time.

Along the course of Red River there are deposits of drifting sand known as dunes. During midsummer the channel of the river becomes practically dry and broad stretches of fine sand are exposed to the action of the wind, which pile it high upon the river banks, the mounds of sand shifting before the wind like drifts of snow. Such deposits have been formed on the alluvial flat 2 miles west of the mouth of Cache Creek within the memory of the present settlers.

*See, also, Gardner, J. H., The physical origin of certain concretions: Jour. Geology, vol. 16, pp. 452-458, 1908.

**Munn, M. J., op. cit. p. 28.

STRUCTURE.

CHARACTER OF THE FOLDS.

The dip of the strata throughout the region is comparatively low. At two or three localities it is 50 or 60 feet in a quarter of a mile, but generally it does not exceed 10 or 15 feet in that distance. The dip is by no means constant in direction, the folds being most irregular, as would be expected in rocks so plastic as the "Red Beds" shales.

In secs. 25 and 26, T. 5 S., R. 8 W., there is some evidence of faulting, but if faults occur in this locality they are probably of small displacement. Owing to the nature of the exposures throughout the region faulting is difficult to detect and it may be more common than has been supposed.

The best exposed and perhaps the largest anticline in the field is crossed by Red River near the east side of T. 5 S., R. 9 W. Its crest, which extends approximately east and west, crosses sec. 13 of this township at about the east quarter corner. The east-west fold extends eastward for about 2 miles from Red River, where, in sec. 17, T. 5 S., R. 8 W., it is brought to an end by a north-south fold, the axis of which extends northward into sec. 8 and southward for an unknown distance across sec. 20 and probably into sec. 29. From this north-south fold the beds dip east and northeast toward the valley of Beaver Creek. On the north and northeast flanks of this anticline are two minor domes, one of which lies in the NE. ¼ sec. 31, T. 4 S., R. 8 W., and in adjoining sections, and the other in secs. 3 and 4, T. 5 S., R. 8 W.

South of the axis of the principal anticline, in sec. 13, T. 5 S., R. 9 W., there is a small syncline, which is produced by the change in the direction of the anticlinal axis from east to north. The continuation westward of the principal anticline can not be determined because of the lack of exposures. In the south half of T. 4 S., R. 11 W., and in most of fractional T. 5 S., R. 11 W., the dip is prevailingly to the north, the beds dipping away from an anticlinal axis which lies somewhere south of Red River in Texas. In sec. 12, T. 5 S., R. 11 W., a slight reversal of dip is indicated by elevations taken on a prominent bed of sandstone exposed in the river bluff, and it is possible that the axis thus defined represents the principal axis of the anticline. The anticline, wherever its axis, may perhaps be connected with that in sec. 13, T. 5 S., R. 9 W., 10 miles farther east, or may be entirely distinct from it. Because of the absence of exposures the exact relations of the features of the structure in this region are difficult to determine.

In secs. 1, 9, 16, 30, 31, and 32, T. 5 S., R. 12 W., dips to the northwest are indicated by Munn on his map of the Grandfield district,* and the anticlinal axis in Texas south of T 5 S., R. 11 W., may swing from an east-west to a northeast-southwest direction toward the Burkburnett oil field. There is no indication in T. 4 S., R. 11 W., of the presence of the Devol anticline mapped by Munn unless the minor fold noted in the NW. ¼ sec. 19 represents the last vestige of it.

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*Munn, M. J., Reconnaissance of the Grandfield district, Okla.: U. S. Geol. Survey Bull. 547, pl. 4.

The northerly dip holds throughout the south half of T. 4 S., R. 11 W., and Deep Red Run and West Cache Creek may occupy the axis of a syncline which is a continuation of that mapped by Munn* as the Deep Red syncline. This is presumably indicated by the southwest dip of the beds in the west-central part of T. 4 S., R. 10 W., and by the pronounced dip in the same direction shown by exposures in sec. 27 of that township. The strike of these beds and of those in T. 4 S., R. 11 W., is northwest rather than west, and the synclinal axis west of T. 4 S., R. 11 W., therefore probably swings to the southeast. The syncline must die out farther east, as there is no indication of it along the great bend of Red River in the northeastern part of T. 5 S., R. 9 W., unless it be represented by the flattening of the dip in this locality. Besides the pronounced dip to the southwest in sec. 27, T. 4 S., R. 10 W., there is in sec. 12 of the same township a pronounced dip to the northeast, the intermediate area being occupied apparently by a broad anticline which extends northwestward at least to the southwest corner of T. 3 S., R. 10 W., and apparently dies out toward the southeast, for no traces of it can be seen in the outcrops in the southeast quarter of T. 4 S., R. 9 W. No trace of this syncline can be found in the vicinity of Temple or farther northwest, and it appears to die out toward the southeast like the other features of structure above mentioned, being represented in the S. ½ sec. 23, T. 4 S., R. 9 W., by a very shallow syncline, which amounts to a little more than a flattening of the dip. The shape and extent of the anticlinal fold toward which the beds in secs. 8, 9, 16, and 17, T. 4 S., R. 9 W., appear to rise could not be determined.

TIME OF THE FOLDING.

The date of the folding which produced the structure just described can only be inferred, the inference being drawn from the relation of the drainage of the region to the structure. Red River flows for a considerable distance near the crest of an anticline and probably established its course before the folding took place cutting down its channel more rapidly than the folds rose across its course. The smaller streams, however, which deepened their channels more slowly, were unable to keep pace with the folding and were consequently diverted into the synclines. The course of West Cache Creek across T. 4 S., R. 11 W., offers an excellent example of such adjustment. The fact that in this township and in the one to the south practically no streams enter Red River from the north is probably due to the influence of the structure on the drainage, the small streams having been thus diverted to the north, into Cache Creek, rather than having taken their natural courses to Red River.

Had the folding of the region taken place prior to the formation of the upland peneplain the course of the minor streams would probably not have exhibited so minute an adjustment to the folds. The folding, therefore, doubtless occurred later than the peneplanation, which is regarded by Taff as Tertiary. The warping of the strata may have occurred when the whole area was uplifted at the beginning of the present cycle of erosion. In many areas the present streams have changed the topography but little since the warping of the strata took place, and it

*Op. cit., pp. 32, 33; also pl. 4.

may therefore be inferred that the movement was comparatively recent The direction of the stresses that produced the warping is indicated by the fact that the principal folds lie parallel to the Wichita-Arbuckle uplift, as if the beds had been bent by forces acting against the rigid mass of the mountains, or at least perpendicular to the major axis of the mountain uplift.

SUMMARY.

In a large proportion of the oil fields of the world the accumulation of the oil is controlled principally by the structure of the rocks in which it is contained. In northern Texas and Oklahoma the structure is unquestionably one of the controlling factors, the oil in all the fields explored having accumulated along the axes or on the flanks of anticlines, domes, or monoclines. Even the accumulations that apparently lie in synclines, such as that in part of the Glenn pool* are probably controlled by the monoclinal structure on which the shallow synclines are superimposed.

That other important factors enter into the problem there is no doubt. The presence of water in the same stratum that contains the oil, the direction of movement of this water, the size of the grains of the containing rock, the thickness and continuity of the bed, the nature of the overlying and underlying strata—all these things and probably many more are factors in oil accumulation; but they are in general effective only in the presence of favorable structure. In geologic work in oil fields structure is the most readily determined of the factors involved in the accumulation of oil and in many fields is the only factor that can be determined.

From what has just been stated, the scope and limitations of geologic work in discovering oil pools are apparent. In most fields a study of the rocks may determine localities at which the structure is most favorable to the accumulation of oil; but only the drill can determine whether oil is present at these localities, for the absence of other unknown factors may have prevented its accumulation. If in any field it is not present at localities where the structure is favorable, there is small probability of finding it at places in that field where the structure is unfavorable.

In testing an anticline for oil it is generally conceded that the first hole should be put down on the axis, or as near to it as practicable. If oil is encountered, the extent of the pool may be determined by properly spaced holes bored along the axis and at right angles to it. If gas is encountered along the axis, a fuel supply is thus obtained for further drilling and oil may be sought on the limbs (the sloping sides) of the fold, for oil and gas are generally, although not invariably, associated.

Salt water is usually found in the oil-bearing "sand" on the flanks of the anticline below the oil zone. Not infrequently several "sands" lie at intervals one above another. One "sand" may contain salt water, whereas a lower "sand", separated entirely from the upper by intervening shale, may bear gas or oil.

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*Smith, C. D., The Glenn oil and gas pool and vicinity, Okla.: U. S Geol. Survey Bull. 415, pp. 34-48, 1914.

In considering the possibility of obtaining oil in an area that has not been tested by the drill the amount of dip of the rocks necessary to produce an accumulation of oil is a factor in the problem which it is difficult to estimate. In the area under discussion there is one anticline which, with reference to the syncline of Beaver Creek valley, on its east, is at least 160 feet high, the strata on its flanks having a dip of 60 or 70 feet to the mile, and in certain small areas considerably more than that amount. There are also several minor anticlines or domes, some of which are but 30 or 40 feet high. Which, if any, of these anticlines has been sufficient to effect an accumulation of oil is a problem whose answer can be surmised only by comparing the conditions here with those in adjoining fields.

In the Petrolia field, which lies about 10 miles south of the area under consideration, the structure is reported by Udden and Phillips* "to be an irregular, elongated dome some 200 feet high and having an area of 6 or 7 miles." The dip of the rocks is represented on Plate II of the same report as about 200 feet to the mile. Of the Electra field the same authors* write: "It is situated either on the crest of a very wide and flat anticline or else close to the south edge of a structural terrace where flat-lying beds soon begin to dip to the south." This southerly dip is said to be about 15 feet to the mile, which is very low in comparison to the structure in the Petrolia field.

In the Healdton field, which lies 25 miles east of the area under discussion, the producing structure is a broad dome or anticline bearing on its surface several minor domes, the whole being 4 miles long by 1¾ miles broad. The dip on the steepest flank of the fold is about 250 feet in half a mile, a dip much greater than any reported from other fields in this general region.

In the Cushing field** in northern Oklahoma outside the "Red Beds" area the dip of the rocks exceeds 150 feet to the mile.

The dip in the Glenn pool*** does not exceed 100 feet to the mile, and in many productive areas in northern Oklahoma is 50 feet to the mile, or even less.

In the area covered by the present report the anticline that is exposed in the east-central part of T. 5 S., R. 9 W., and extends into T. 5 S., R. 8 W., affords by far the most promising location for drilling. It is not so pronounced as the Healdton anticline, being rather comparable in the degree of dip of its slopes to the Petrolia dome. Its dip exceeds that found in most of the fields in the northern part of the State, but it is smaller in areal extent.

The most promising locations for test wells lie along the anticlinal axis indicated on the map in sec. 13, T. 5 S., R. 9 W., and sec. 18, T. 5 S., R. 8 W. Practically all of sec. 17 offers promising territory. Probably

*Udden, J. H., and Phillips, D. McN., op. cit., pp. 103-104.

**Structural map of the Cushing oil field, published by the Oklahoma Geol. Survey, Bull. 18, pl. 3, 1914.

***Smith, C. D., The Glenn oil and gas pool and vicinity, Okla.; U. S. Geol. Survey, Bull. 541, pl. 3, 1914.

the E. ½ sec. 20 and possibly the E. ½ sec. 29 are crossed by the axis, but exposures are so few that exact determinations are impossible. In the south-central part of sec. 8 there is some indication of the extension of the axis to the north, which, however, is lost in secs. 6 and 7. A small subsidiary dome, the axis of which lies near the line between secs. 31 and 32, T. 4 S., R. 8 W. and is continued northward across the E. ½ sec. 30, is in line with the north-south fold in T. 5 S., R. 8 W., and may be considered a continuation of it. Its crest represents fair territory for testing, although probably not so good as that near the top of the large fold. Such minor structures on the flanks of large folds are believed to interrupt the course of the oil as it rises up the dip toward the major crest and tend to collect it. The flanks of the small dome here, however, are very short in comparison with the flanks of the major fold and hence the "gathering ground" from which the oil is collected toward the small dome is much smaller than that tributary to the major structure. For this reason the possibilities of finding oil or gas are much better in the major structure than in the subsidiary folds. The small fold in the NW. ¼ sec. 3, and the NE. ¼ sec. 4 is probably of only minor importance, and should not be tested unless oil is found in the dome northwest of it, just described.

The constant rise of the beds toward the south in the south half of T. 4 S., R. 11 W., and the existence of the same structure in the north tier of sections in T. 5 S., R. 11 W., indicate the probable presence of an anticlinal axis somewhere to the south. The axis noted in sec. 12 of this township may possibly be this principal axis, but the exposures are not sufficient to establish this fact. It may be merely a subsidiary structure on the side of the major anticline. It seems more probable that the anticlinal crest toward which the beds in Tps. 4 and 5 S., R. 11 W., rise is situated somewhere south of Red River, in Texas. Munn's map of T. 5 S., R. 12 W.,* shows a pronounced dip to the northwest in secs. 9, 16, 30, 31, and 32, and there is no indication of a large fold crossing T. 5 S., R. 12 W., from east to west. Therefore the fold that appears to lie south of Red River opposite T. 5 S., R. 11 W., is probably a dome or a plunging anticline that dies out to the west. It is possible, however, that the axis bends to the southwest, in the general direction of the Burkburnett oil field.

No data could be obtained from surface exposures as to the relation of the probable structure just described to the anticline exposed in sec. 13, T. 5 S., R. 9 W., but the land on the Texas side of Red River directly west of the middle of sec. 13, T. 5 S., R. 9 W., and in line with the anticlinal axis exposed in that section should be good territory for at least half a mile west of the river.

In T. 4 S., R. 10 W., the dips to the northeast in sec. 12 and to the southwest in sec. 27 indicate the presence of an arch between them in the east-central part of the township, but outcrops in this area are so few that it is impossible to tell whether the structure is a single broad arch or a series of small, ineffective folds. The structure appears to extend northward into sec. 32, T. 3 S., R. 10 W.

In the northwestern part of T. 4 S., R. 9 W., there appears to be a gradual rise of the beds toward the NE. ¼ sec. 9, but the structure is so poorly exhibited in the outcrops that statements can be made only with great reserve. The possibility of finding oil in such minor structures as the two last named appears doubtful. They should not be tested unless the exploration of the more promising folds is successful.

DEVELOPMENT.

There has been some drilling in Jefferson County in addition to that mentioned in Wegemann's report. In T. 4 S., R. 8 W., Dallas, Texas parties are reported to have drilled a well on the J. J. Hunter farm in sec. 26. Nothing is known concerning the outcome. A. D. Allen and others encountered a showing of gas at a depth of 830 feet in their test in sec. 11. The Ingalls Oil & Gas Company is reported to have encountered showings of gas and oil at 300 and 450 feet respectively in their test in sec. 10. In sec. 8, T. 5 S., R. 8 W. the Mutual Benefit Oil Company completed a dry hole at a depth of 2,365 feet. In T. 4 S., R. 7 W. W. W. Tarbell and associates encountered a slight showing of oil and gas at a depth of 1,695 feet in a test in sec. 22. In T. 4 S., R. 6 W. Apple and Franklin are drilling a well in sec. 22, and at a depth of 1,640 feet they encountered a strong flow of salt water. In T. 5 S., R. 6 W. three wells have been drilled, the outcome of which is not known. In T. 8 S., R. 6 W., a test well was drilled near Fleetwood but nothing is known concerning it. In T. 3 S., R. 5 W., the Nippon Oil Company completed a dry hole at a depth of 2,200 feet. In T. 3 S., R. 4 W., owing to its proximity to the Healdton field, there has been considerable development which is discussed under the heading "Carter County" in connection with the Healdton field. In T. 5 S., R. 4 W., A. B. Butler drilled a test in sec. 25, near Atlee. The well was discontinued at a shallow depth as a dry hole.

In T. 6 S., R. 4 W., a dry hole was completed in sec. 19, near Grady. The following is a log of this well:

Baker, No. 1, sec. 19, T. 6 S., R. 4 W., near Grady.

Character of rock.	Thickness. Feet.	Depth. Feet.	Character of rock.	Thickness. Feet.	Depth. Feet.
Surface soil	5	5	Sand (salt water)	30	630
Red clay	45	50	Sandy blue shale	230	860
Blue shale	50	100	Sand (salt water)	28	888
Red rock (Cover)	200	300	Blue shale	72	960
Blue shale	20	320	Dry sand	7	967
Water sand (fresh)	30	350	Blue shale	263	1,230
Blue shale	150	500	Sand (salt water)	15	1,245
Red rock	50	550	Blue shale (bad cave	175	1,420
Blue shale	50	600	Sand (salt water)	15	1,435

SUMMARY.

Jefferson County in general is considered favorable territory for encountering oil and gas. Outside of the area considered in Wegemann's report nothing has been done in the way of field work to determine structure favorable for the occurrence of oil and gas. The Pennsylvanian formations, the source of the oil of the Healdton field, probably underlie the surface rocks of this county at various depths. The fact that practically all of the tests so far drilled have resulted in failures does not necessarily condemn the territory. A large percentage of them have been located without regard to structure, in which case the discovery of a field would be accidental. Another thing responsible for the failure of many tests is, that they have not been drilled deep enough to be considered thorough. It is true, however, that some wells have been drilled on favorable structure and resulted in nothing but a few showings of oil and gas. The results of these few tests are rather discouraging, but it must be remembered that all anticlinal and other structures favorable for the accumulation of oil and gas are not always found to be productive. Dry holes are sometimes drilled in the midst of productive areas. Only a few of the tests drilled in the area mapped by Wegemann in the western part of Jefferson County would be considered tests on favorable structure. One of these wells, that of the Mutual Benefit Oil Company in sec. 8, T. 5 S., R. 8 W., was abandoned at a depth of 2,365 feet. However, this well was not located on the highest point of the structure as mapped by Wegemann. A more favorable test could be made in the SE. cor. of sec. 13, T. 5 S., R. 8 W.

Taking everything into consideration, Jefferson County is in favorable territory and it is probable that in future drilling new fields may be discovered.

JOHNSTON COUNTY.

LOCATION.

Johnston County, located in the south-central part of the State, lies between T. 1 S. and T. 5 S. inclusive, and from R. 4 E. to R. 8 E. inclusive. It covers an area of about 656 square miles, the northern two-thirds of which lie in the Arbuckle Mountains, the remainder in the Coastal Plains.

TOPOGRAPHY.

The major features of the Arbuckle Mountains have been considered by J. A. Taff in the Atoka and Tishomingo folios and in Professional Paper No. 31 of the United States Geological Survey. Supplementary to these general discussions and more specific in their nature are the following two publications:

A report on the Geological and Mineral Resources of the Arbuckle Mountains, Oklahoma, by Chester A. Reeds, Bulletin No. 3 of the Oklahoma Geological Survey, and Granite of Oklahoma, by C. H. Taylor, Bulletin No. 20 of the Oklahoma Geological Survey, in cooperation with the United States Geological Survey. These works are available and may be referred to for information concerning the region as a whole.

In Johnston County the southern boundary of the Arbuckle region is not well defined topographically, but may be delimited by means of the geological formations. Accordingly it lies north of a curved line drawn through the town of Sylvan, southeastward through Ravia, to Tishomingo, thence east and north through Milburn and Fillmore to the NE. cor. sec. 1, T. 3 S., R. 8 E., coinciding east of Tishomingo approximately with the Chicago, Rock Island & Pacific Railroad. This area, covering fully two-thirds of the county, is one which may be said to be in a stage of maturity. The western part of the county, north of the Washita River, and the 35 or 40 square miles of territory northwest of Wapanucka, in the northeastern corner of the county, are the most deeply dissected regions. The streams here have steep gradients, are relatively straight, have few and short tributaries, and occupy narrow, V-shaped valleys with steep slopes. They are actively engaged in sawing their way down to lower levels, using as tools the hard materials which weather from the slopes. The higher elevations, those more than 1,000 feet above sea level, are very gently rounded or almost flat in some places and all rise to about the same altitude. The tops of these hills are remnants of an old peneplain which was once continuous over the whole Arbuckle region and which has been reduced by weathering and stream erosion to its present condition. The creeks, by their process of headward erosion, or lengthening of the stream channels, have not yet reached all the land but eventually the higher flat areas, the remnants of this old plain, will also be gullied and cut into steep-sloped ridges and short divides. It is during this stage in the reduction of a land surface to sea level that the topography may be said to be mature and to have its maximum relief. The north-central part of the county lies above the 1.000-foot contour and is a part of the old peneplain which is being dissected.

The central part of the county north of Tishomingo, and eastward to the county line, in the valleys of Rock Creek, Pennington Creek, and Blue River, has a lower altitude; the hills are not so high nor the slopes so steep. This area has all been completely dissected by the small creeks, the peneplain cut into sharp ridges and steep slopes and these later reduced to broad-topped, rounded hills much reduced in elevation. Hhese areas are in a stage of later maturity and will, in the last stages of development after the hills have been almost completely eroded away, pass into a stage of old age, which is characterized by a flat, featureless plain over which the crooked streams meander aimlessly about finally to reach the sea. While a stage of old age is far removed from the present condition of the topography of the Arbuckle Mountains the tendency is in that direction and will in the end be attained, provided the processes are allowed to go on long enough.

South of the Arbuckle Mountains, along the Washita River, a condition of old age is rapidly approaching. The country here is flat and the river has frequently shifted its channel, formed cut-offs, and has left ox-bow lakes on its flood plains. The low hills that once bordered the river have been undercut by this lateral shifting of the river and the materials carried down stream to the sea or temporarily deposited on the flats to be removed later.

The southern part of the county has no high hills or deep valleys but is, in general, a gently undulating plain—a part of the Cretaceous—Red River Plain province.

The drainage of the entire county is southeastward and is carried by some eight or nine streams which flow parallel to one another and discharge their waters directly into Washita River, Blue River, and Clear Boggy Creek.

GEOLOGY.

GENERAL STATEMENT.

A complete but concise report upon the geology of this county and the adjacent territory, together with detailed topographic and geologic maps of the same, may be found in the Atoka and Tishomingo folios. These may be had from the Director of the United States Geological Survey, Washington, D. C., for 25 cents a piece.

With these excellent works available at so low a cost it seems unnecessary to outline in detail the geology of this county. However, a few general statements are given to sum up the geological conditions.

Briefly, the Tishomingo granite is the oldest rock, it outcrops almost entirely across the county, from east to west; has its greatest areal development north of Tishomingo, where it outcrops over more than 100 square miles of territory, and it undoubtedly underlies an area of Cretaceous rocks to the southeast almost as great; it is a firm, close-textured rock of medium grain; is a good building stone; and originated from the solidification of a molten magma which came into the region in pre-Cambrian times.

Dikes of diabase, dark gabbro, and other rocks cut the granite, but their distribution is local and their total bulk relatively of no importance. The dikes are necessarily younger than the granites, since they penterate the latter, but are also very old—pre-Cambrian.

The Paleozoic rocks, embracing the Reagan sandstone, Arbuckle limestone, Woodford chert, Sycamore limestone, Caney shale, Glenn formation, and the Franks conglomerate, vary in age, in the order named, from Cambrian to Pennsylvanian. These old sediments outcrop over the whole of the northern and western portions of the county and lie upon the central granite core, away from which the rocks dip in all directions, usually at high angles. A dozen or more faults have, however, caused the areal distribution of each separate formation to be somewhat irregular and have brought about sudden contrary dips at frequent intervals. About 125 square miles of the territory in the north-central part of the county is underlaid by the Arbuckle limestone, the southern side of which has been faulted down against the granite. This area lies almost horizontal or is gently undulating with dips of 5° to 10°.

The faults extend invariably in an east-southeasterly direction and are all normal faults.

In the southern part of the county the Cretaceous deposits lap up upon the granite and Paleozoic sediments with a dip to the south of one-half degree. With the exception of a few square miles of limestone (the Goodland and the Kiamichi formations) south of the Washita River, south of Tishomingo, and a second small area, south and southeast of Emet, the Cretaceous deposits in this county are the Trinity sands.

GRANITE.

The surface area of the granites of the Arbuckle Mountain region comprises about 100 square miles. All of the commercial granite of the region lies on the southwestern flank of the exposed portion of the Arbuckle uplift. This district is not mountainous in the sense of being of high elevation, but consists of a gently rolling plain, which slopes to the south at a low angle. The granite is of two chief types, a coarse-grained and a fine-grained, pinkish-gray biotite-granite. The two types are much alike except in texture. Granite is exposed in the East and West Timbered Hills, but has neither the areal extent nor the quality to be of commercial value.

REAGAN SANDSTONE.

The Reagan sandstone is a coarse sandstone with shales and sandstones in the upper part. The basal member, which is variable in occurrent and thickness, is arkosic and granitic. Above this member is a coarse quartz sandstone, with occasional overlying green and red sands and shales. The thickness varies from a few feet to 500 feet. The upper calcareous layers contain Middle Cambrian fossils.

ARBUCKLE LIMESTONE.

The Arbuckle limestone has here much the same character that it has farther west. These sediments are chiefly massive limestones, which aggregate 4,000-6,000 feet in thickness. The limestone is white to light blue, with many layers of thin, dark-colored shale near the base. Abundant fine white quartz-conglomerate is found near the contact with the Reagan sandstone. This limestone covers an area of 385 square miles. Owing to the orogenic movements of Pennsylvanian time, it has been broken and highly faulted over large areas. Its faulted and unfaulted contracts with igneous and sedimentary rocks measure 134 and 122 miles respectively. The exposures are broad, treeless, and rolling, forming rocky uplands.

SIMPSON FORMATION.

The Simpson formation consists of three massive, pure sandstone members separated by shales, siliceous limestone, and sandy shales. The thickness varies from 1,200 to 2,000 feet. The sandstones are white or light gray, with the grains small but fairly uniform. The shales are friable and chiefly glauconitic. The limy layers have preserved the lower Ordovician fauna rather poorly, while in the sandstones and shales fossil remains are very rare or entirely wanting.

This formation is of special economic value as a source for good glass sand, rich asphalt deposits, and possibly undiscovered oil pools. It is impossible to say definitely as to the possibilities for encountering oil in a formation which is so closely folded, which has undergone such severe crumpling and faulting, as is evidenced by slickensides in the calcareous members. It is probable that from a formation in which there are such large asphalt deposits a large amount of the volatile hydrocarbons has escaped. It might be possible, however, to find areas in which the oil is still retained. In fact, it has been rumored that a small amount of oil has been found in some shallow wells drilled into the Simpson.

The Simpson formation outcrops are much scattered over this uplift, occurring chiefly in long narrow bands. One of the longest of these begins at a point 6 miles west and 1½ miles north of Tishomingo, and extends northwest to the middle of the north line of T. 3 S., R. 3 E. Here it is faulted out. In sec. 31, T. 2 S., R. 3 E., it again appears, and continues in a north and westerly direction to a few miles south of Hennepin. Other outcrops of importance occur in the eastern one-half T. 2 S., R. 3 E.; southeast of Sulphur for 6 or 8 miles; around the town of Hickory; north and east of Roff; and the eastern tier of sections of T. 1 S., R. 6 E., along with the southwestern three-fourths of T. 1 S., R. 7 E. The outer limits of this area extend northward and southward for a short distance into the adjoining townships. This area is just north of Belton and east of Connerville. Further investigation may show that certain portions of the areas mentioned, as well as some not enumerated, would be worth drilling. In most cases it is probable the hole drilled would not need to be very deep in order to test out one of the three sands present.

Four hundred feet down from the top of this formation is a 90-foot sandstone; 400 feet below this a 100-200 foot sandstone; and several others lower down, varying from 5 to 100 feet. The character and thickness of these sands, connected with the fact that some oil has been found, and that asphaltic deposits covering large areas and over 100 feet thick have been prospected within them, all indicate that further investigation should be made.

VIOLA LIMESTONE.

Five hundred to 700 feet of limestone lie above the Simpson formation. This has been subdivided into upper, middle, and lower, because of differences, lithologically and paleontologically. The lower part contains many chert nodules; the middle is dense and fine, with its lower part buff shale; and the upper is coarsely crystalline limestone. This stone is crushed for ballast crushed stone, chicken feed, etc., at Fitzhugh. Large, rounded, grassed hills characterize Viola topography.

SYLVAN SHALE.

The Sylvan shale is black to greenish in color. Its thickness is from

60 to 300 feet. The Ordovician fauna is not very abundant. Outcrops occur in wooded valleys.

HUNTON FORMATION.

Reeds, after working over this formation carefully, has subdivided it into four parts, as follows:

	Feet.		Feet.
Bois d'Arc limestone	0- 90	Av.	60
Haragan shale	0-166	Av.	100
Henryhouse shale	0-223	Av.	90
Chimneyhill limestone	0- 53	Av.	35

The Bois d' Arc of Reeds* equals the upper Hunton of Taff**, the Haragan and Henryhouse shales equal middle Hunton, and the Chimneyhill is equivalent to the lower Hunton. The faunas are distinctive and well preserved.

WOODFORD CHERT.

Conformable above the Hunton lies the Woodford chert. The few fossils at the base point to probable Devonian age. No fosils have been found within the formation, which is made up of alternating cherty layers, shale, and small concretions. Numerous blackjack mark the outcrops.

SYCAMORE LIMESTONE.

The Sycamore limestone is apparently a lentil occurring only in the western portion of the mountains. At the western extremity the thickness is 200 feet, in the middle 50 feet, and toward the northeast it disappears entirely. The rock is light bluish to yellow or buff, with joint planes frequent. Near the middle are two carbonaceous shaly members separated by limestone from which a limited fauna closely related to that of the Caney has been collected.

CANEY SHALE.

The Caney shale is estimated as being as much as 1,600 feet thick. The basal part is marked by black carbonaceous shales, with some calcerous and argillaceous segregations. These concretions are often fossiliferous. The fauna is probably Mississippian.

GLENN FORMATION.

The Glenn formation includes all of the shales and sandstones above the Caney in the Pennsylvanian. The town of Glenn, from which the sediments take their name, is located in the Ardmore quadrangle on the outcrop. The Glenn is composed chiefly of friable, blue clay shales and thin-bedded, brownish or drab sandstone. Rarely, outcrops of calcareous material are found. Owing to the fact that the beds are generally difficult to keep separate and distinct, information concerning structure within this formation is limited. It is also practically impossible to say as to the thickness because of this lack of data. The best that can be said is that these sediments are comparatively thick. Fossils are fairly abundant, and those at the base have been identified as being of Pennsylvanian age.

The formation dips south away from the center of the mountains. It is quite probable that this same series of shales, sandstones, and calcareous layers may lie under the Healdton, Wheeler, and Loco fields. If so, the supposition favors this formation as being the productive horizon.

FRANKS CONGLOMERATE.

The Franks conglomerate is the youngest formation exposed over any part of this area. It ranges in thickness from zero to several hundred feet, and covers outcrops of rocks from lower Ordovician or possibly Cambrian age to Pennsylvanian. The component particles, which are usually light gray, buff, or pinkish in color, vary in size from comparatively fine sand to pebbles 3 inches in diameter. The Franks conglomerate lies unconformably upon older formations.

CRETACEOUS ROCKS.

In the southern part of the county the Cretaceous deposits lap upon the granite and Paleozoic sediments with a dip to the south of one-half degree. With the exception of a few square miles of limestones (the Goodland and the Kiamichi formations) south of the Washita River, south of Tishomingo, and a second small area, south and southeast of Emet, the Cretaceous deposits in this county are the Trinity sands.

DEVELOPMENT.

It is known that asphalt and bituminous rocks occur at several localities over the county. Oil Creek, through the western part of the county, was so named because of the oil seepages along its course. Prior to 1898 two wells were drilled south of Tishomingo in the Washita River valley. One of these wells was in the SE. cor. sec. 22, and the other in the SE. 1/4 sec. 17, T. 4 S., R. 6 E. Both wells gave showings of oil.

In 1915 three wells were drilled about two miles to the south of Mannsville. One of these encountered a very heavy asphaltic oil at a depth of 130 feet. The other two wells were drilled to depths of 800 and 1,000 feet respectively, but nothing of value was found. The surface rocks in this area are Cretaceous.

Two other wells have been drilled in Johnston County, both to the northwest of Wapanucka. One of these is located in sec. 5, T. 2 S., R. 8 E. It was begun on the Caney shale, near the base of the Carboniferous system, and drilled to the top of the Simpson formation, the approximate equivalent of the Trenton limestone of the Ordovician system. The depth of the well is 2,860 feet and produced a showing of oil at a depth of 1,800 feet. It was drilled in 1915 by Robert Galbreath. The second well was drilled in sec. 4, T. 2 S., R. 8 E. Its depth is 2,100 feet and it is a dry hole. Oil seepage to the west was the cause of the excitement.

SUMMARY.

The two wells mentioned above were drilled along the western side of the great syncline, whose strata in this locality dip eastward at an angle of about 10°. One-half mile north of these wells is a fault line bearing east-northeast, south from which the rocks dip at an angle of 60° to 70°.

The Zahn-Galbreath location in sec. 23, T. 1 S., R. 7 E., is northwest of these wells, where the strata change in the direction of dip from 5° east to 15° northwest. The fault line to the north swings southeast in this township and range but is not continuous south of sec. 16. Three miles south of this location is an east-west fault which extends almost across the county. It is not known what the thickness of the cap of Simpson shales and sandstones in this locality is but it is probably less than 1,000 feet, below which it would not seem advisable to drill. The Arbuckle limestone underlies the Simpson formation and is not generally regarded as a likely source of oil or gas.

KAY COUNTY.

LOCATION.

Kay County is located in the extreme north-central part of the State. It is included in the northern tier of counties in Oklahoma bordering Kansas, and extends from T. 25 N., to T. 29 N. inclusive, and from R. 2 W. to R. 5 E., inclusive. It includes 19 whole townships and parts of 12 others. The total area is approximately 979 square miles.

TOPOGRAPHY.

The eastern part of Kay County lies in the Sandstone Hills region and the western part lies in the Redbeds Plains region. In the Sandstone Hills region there are several beds of limestone. This part of the county is very broken, the streams having cut incisions in the alternating limestone and shales. The limestones make conspicuous eastward-facing escarpments in many localities. The western part is characterized as a peneplain.

The average elevation in the county is about 1,100 feet, the highest points being northwest of Newkirk and in the vicinity of Hardy, and the lowest in the southeast corner of the county where Arkansas River crosses the boundary.

Arkansas River and its tributaries drain the entire county. Salt Fork of Arkansas River and Chickaskia River drain the western part of the county, while Arkansas River and Beaver Creek drain the eastern part.

GEOLOGY.

GENERAL STATEMENT.

Kay County lies in the non-red Permian area with the exception of the southwestern corner, which is in the Permian Redbeds. The oldest formations occur in the eastern part of the county and to the west are succeeded by younger. The rocks consist of alternating limestones and shales with an occasional lenticular mass of sandstone in the eastern and central portions of the county, and principally shales with a few thin sandstones in the western portion.

In this area the light-colored sediments of the Permian which consist of the usual gray and white limestones, and shales of various colors, are very similar lithologically to the Pennsylvanian formation to the east and are separated from the Pennsylvanian on paleontological grounds. The non-red Permian merges into the well-known Redbeds to the west.

In this report a brief description is given of the subsurface and surface formations of Kay County, in order, from oldest to youngest.

SUBSURFACE FORMATIONS.

Note. Detailed descriptions of the subsurface formations are given under the heading of "Geology" of Nowata, Washington, and Osage counties.

CHEROKEE FORMATION.

The Cherokee formation, which is the basal part of the Pennsylvanian series, is the principal oil and gas producing horizon in the northeastern fields, and is thought to be continuous from its outcrop in Craig, Rogers, and Wagoner counties to Kay County.

FORT SCOTT FORMATION.

The Fort Scott formation (Oswego lime) lying above the Cherokee, contains the well-known Wheeler sand of the Cushing field and is thought to be the productive horizon of the deep wells in the Blackwell field.

OTHER FORMATIONS.

The Labette shale, Pawnee limestone, Bandera shale, Altamont limestone, Nowata shale, Lenapah limestone, Coffeyville formation, Hogshooter limestone, unclassified series of shale and sandstones, Dewey limestone, Wilson formation, Buxton formation, Oread limestone, Elgin sandstone, and undescribed series in western Osage County,* succeeding each other stratigraphically from oldest to youngest, make up the remainder of the subsurface formations. The total thickness of the subsurface section is probably 3,000 feet.

SURFACE FORMATIONS.

The surface formations are of lower Permian age with the exception of the Recent sands and alluvium.

*Note. This undescribed series in western Osage County as quoted from Heald is given under "Osage County."

WREFORD LIMESTONE.

The Wreford limestone, which is the lowest limestone exposed in this area, lies above an unclassified series of sandstones and shales exposed in western Osage County. In Kansas, where it has a thickness of 40 feet, this limestone is typically exposed and has been traced southward across the Kansas line into Oklahoma. The Wreford is exposed near the eastern edge of Kay County. It contains an abundance of chert. There are three members, the lowest one being more siliceous and cherty than the others. The following section** shows the character of this formation.

Section of Wreford limestone half a mile east of Hardy, Okla.

	Feet.
Limestone, blackish gray on weathered surface, light buff to brownish gray on fresh surface; in several slabby beds 2 to 6 inches thick; top bed is massive, 12 to 16 inches thick, hard and dense; lower beds break into slabby lenticular pieces. Fossiliferous; considerably limonitized; has many echinoid spines; is in places full of smooth cylinderical holes half an inch to 3 inches in diameter. Above this is a mass of shale and limestone	4
Limestone, buff, hard, dense massive; full of chert; yellowish brown on weathered surface. About 25 per cent of the rock is chert, in irregular nodules and layers, lens-shaped concretions roughly parallel to bedding most common; chert is fossiliferous.	3
Shale, limy, yellow-gray to green-gray; looks sandy but no grains distinguishable; bedding regular; fossiliferous	2
Limestone, light buff on both weathered and fresh surfaces compact; full of fossils, which are locally replaced by glassy or milk-white calcite; in two beds with a 1-inch shale parting; the many crystalline fossils give the rock a spotted appearance	3
	12

MATFIELD SHALE.

The Matfield shale, lying above the Wreford, consists of about 70 feet of coarse arenaceous shale with numerous thin beds of red sandstone. The coarse, red, sandy material predominates. The outcrop is a narrow band near the base of the prominent escarpments of the Fort Riley limestone. The sand 275 feet below the top of the Herington limestone, in the Ponca City field, has been referred by Ohern to the sandstone associated with the outcrop of Matfield shale. No formation composed of thin-bedded sandstones with intercalated beds of sand-shale is known to outcrop to the north of the field. The shallowest sand of the Newkirk field is probably at this horizon.

FORT RILEY LIMESTONE.

The Fort Riley in this area consists of about 52 feet of limestone, massively bedded in the lower part, with lenses of chert present. The Fort Riley of Kansas is underlaid by the Florence flint with a thickness of 20 feet, while the Fort Riley itself is 40 feet thick. In the Kay

**Heald, K. C. Bull. U. S. Geol. Survey, No. 641-B 1916, part II.

County region the Florence flint has not been identified. It is possible, however, that the flint lenses of the lower Fort Riley may be its equivalent. The upper portion of the Fort Riley is made up of alternating beds of hard, resistant limestone, and thin shales and shaly limestones.

The 70 feet of shale lying immediately below has aided in making the escarpments of this limestone probably the most conspicuous of any in this region. These are best shown along the crest of the Newkirk anticline southeast of Newkirk and south of the Arkansas River. To the north of the river good exposures are common along the smaller streams.

DOYLE SHALE.

Lying above the Fort Riley limestone is a mass of clay shales with occasional arenaceous layers. The thickness varies from 22 feet in the north to about 35 feet in the southern part. Red colors are common, but are probably not more abundant than the lighter colors. Owing to the occurrence of the Doyle on a bench above the Fort Riley its outcrop is of too great extent to be proportional to its thickness.

WINFIELD LIMESTONE.

The Winfield limestone which succeeds the Doyle shale below, is from 10 to 15 feet thick, the average being about 12 feet. Lithologically, the limestone is massive, gray, with the upper layers more arenaceous and platy. This feature, with the fact that near the base is a 1-foot layer abundantly supplied with small brachiopods, serves to distinguish this limestone readily.

In passing eastward from the outcrop of the Herington the first limestone encountered is the Winfield. It, too, is well exposed west of the axis of the Newkirk anticline, only outliers being found to the east.

UNCAS SHALE.

Immediately above the Winfield limestone is a 50-foot shale termed the Uncas shale. In Kansas the equivalent is a series of thin-bedded, porus, limestone beds, followed by 35 feet of shale, lying between the Winfield and Herington limestones. This limestone is known as the Luta limestone. Detailed study of these formations by Ohern fails to reveal the presence of this limestone. The Uncas shale, so named provisonally from the town of Uncas, is composed of alternating red and light-colored clays. Ohern* gives the following section, and notes that the 3-foot limestone may be, possibly, the Luta limestone of Beede:

*Ohern, D. W., Bull. Okla. Geol. Survey, No. 16, 1912, p. 10.

Section 3 miles southeast of Newkirk.

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

HERINGTON LIMESTONE.

The Herington is the highest prominent limestone exposed in this region. It is 18 to 20 feet thick, with massive beds below and thin beds above. The basal part is honeycombed, where the formation has been long exposed, thus causing a characteristic marking. Characteristic outcrops of the Herington occur along the west side of the Newkirk anticline, from Ponca City north to the Arkansas River, as a prominent escarpment.

UNCLASSIFIED SERIES.

Lying mainly west of the Atchison, Topeka, and Santa Fe Railway is a great series of shales with an occasional arenaceous or calcareous layer. These shales extend westward to the contact with the Permian Redbeds. Generally they are gray, yellow, buff, or reddish, friable clay shales. The calcareous members which have been studied in the region of Blackwell are usually buff in color and porous, as if the result of deposition by percolating water. The repeated change from beds of this character to pure limestone with fossils and back again to a limestone composed of a network of calcite veins, rather tends to disprove this idea. Three of these calcareous layers are typically displayed 6 or 8 miles northeast of Blackwell, around the headwaters of tributaries to Bitter Creek. Elevations over this western area range from about 950 to 1,150 feet above sea level. This is the highest and least studied of the non-red Permian formations. The upper portion of the following log shows the character of the sediments:

William Bucholtz No. 1, in SE. ¼ sec. 11, T. 27 N., R. 1 W.

Character of rock	Thickness.	Depth.	Character of rock	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface soil	15	15	Blue slate	5	285
Sand and gravel	3	18	Lime	5	290
Blue slate	12	30	Red rock	5	285
Slate and shells, water	10	40	Lime	10	305
Blue slate	15	55	Blue slate	30	335
Red rock	10	65	Red rock	35	370
Blue slate	10	75	Lime	2	372
Red rock	5	80	Blue slate	18	390
Blue slate	10	90	Sand—water	10	400
Lime	10	100	Blue slate	5	405
Blue slate	20	120	Lime	10	415
Lime	10	130	Blue slate	10	425
Soft cave	20	150	Red Rock	5	430
Lime	10	160	Lime	5	435
Blue slate	5	165	White slate and shells	25	460
Lime	5	170	Sand	10	470
Blue slate	5	175	Lime—shell and slate	5	575
Lime	15	190	Red rock	30	505
White slate	15	205	Lime	35	450
Lime	7	212	Red rock	15	555
White slate—shells	28	240	Lime	10	565
Blue slate—shells	15	255	Slate	5	570
Lime	25	280	Lime	25	595

William Bucholtz No. 1, in SE. ¼ sec. 14, *T.* 27 *N., R.* 1 *W.*—Continued.

Character of rock.	Thick-ness.	Depth.	Character of rock.	Thick-ness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Red rock	37	632	Blue slate	45	830
Lime	18	650	Sand	5	385
Blue slate	5	655	Slate	12	847
Red rock	10	665	Sand—water and gas	13	860
Lime	10	675	Black shalte	10	880
Red rock	35	710	Lime	10	880
Lime—shells and slate	50	760	White slate	2	882
Red rock	25	785			

STRUCTURE.

GENERAL STATEMENT.

The normal dip of the surface formations in Kay County is about 30 feet per mile to the west and south. In many places there are reversal dips to the east, which with the west dips form the normal type of folding anticlines and synclines. The anticlinal folds usually have a steeper dip to the east. The anticlines, as a rule, extend in a northeast-southwest direction. However, some o fthem throughout their course vary in direction. The accompanying structural map of Kay County shows the location, character, and development of these anticlines. Foldings in the form of anticlines have been mapped in the following localities: West of Hardy, northeast and southeast of Newkirk, west and southwest of Ponca City, west of Kildare, and northeast of Blackwell. All of these folds are marked by topographic highs. The description of the different anticlines, together with a general discussion of the conditions and development, are taken up in the following paragraphs.

KAW ANTICLINE.

GENERAL STATEMENT.

The Kaw anticline was named and mapped by L. E. Trout, I. Perrine, and others of the Marland Oil Company, during the winter of 1914-1915 and revised by L. E. Trout and assistants in 1916. Elevations for the determination of the structure were made on the Fort Riley limestone.

LOCATION AND EXTENT.

This anticline is located in the north central part of T. 28 N., R. 4 E. and eastern part of T. 29 N., R. 4 E. The axis of the anticline extends from the north-central part of sec. 9, T. 28 N., R. 4 E. in a general northeast direction for about 3 miles to the NE. corner of sec. 34, T. 29 N., R. 4 E., then continues through section 26, first to the northeast, then to the north, to the E. 1/2 of section 23. It may continue in a northeast direction through section 13, but has not been mapped farther than section 23. The highest point on this anticline is in the NW. 1/4 of sec. 3, T. 28 N., R. 4 E., and near the south-central edge of sec. 34, T. 29 N., R. 4 E. The anticline plunges to the south toward Arkansas River, and to the north it also plunges about 30 feet, forming a dome at the southern terminus of the anticline. At the high point mentioned above there is a southeast dip of 70 feet, but northward throughout the remainder of the course no east dip of any consequence is noted, the anticline appearing to grade into a structural terrace.

DEVELOPMENT.

Only one well has been drilled on this structure. A well was drilled in the NE. 1/4 of sec. 4, T. 28 N., R. 4 E., to a depth of 3,485 feet and was abandoned. Five million cubic feet of gas were encountered at 1,900 feet. The Ponca and Newkirk sands were absent or too thin to be recognized as sands. A sand 219 feet thick, thought to be the Bartlesville, was encountered at 3,248 feet. All of the sands were limy and tight, and were dry, with the exception of a few layers which were porous and contained oil. It appears that in this case even though there is favorable structure that the condition of the sands is of equal if not greater importance. Other locations might be made on this structure which would be productive should the sands become porous.

It is worth noticing that both the Ponca City and Newkirk anticlines have displayed the same features ,and dry holes have been drilled on or nea rthe top of the highest points on these folds, while to either side good producers are secured. As in this case, the sands were either absent or too thin to serve as a reservoir for oil and gas.

STRUCTURE NORTHEAST OF NEWKIRK.

GENERAL STATEMENT.

A small dome, surveyed by L. E. Trout of the Marland Oil Company, is located within secs. 8, 17, 18, and 20, T. 28 N., R. 3 E. Topographically this structure is marked by the highest hill within the region, the apex of the dome and the maximum point of elevation above sea-level being practically coincident.

GEOLOGY.

Within the region mapped in determining the limits of this structure the Herington, Winfield, and Fort Riley limestones outcrop. In some parts of the area a thin, white, shelly limestone occurs about 13 feet above what has been considered the Herington limestone proper.

STRUCTURE.

The dome itself would be of small importance, but when other facts are considered it seems well worth investigation. The area of close contours is wholly covered by sec. 17; S. 1/2 sec. 8; W. 1/2 sec. 18; and a small part of the W. 1/2 of sec. 16 and the NW. 1/4 sec. 19, all in T. 28 N., R. 3 E. The highest point on the dome has an elevation 1,195 feet above sea level, and the lowest 17 feet below, to the eastward.

DEVELOPMENT.

During the past year a deep well was completed in the NE. 1/4 sec. 8, T. 28 N., R. 3 E. to a depth of about 3,500 feet. This well is situated almost in the bottom of the syncline which strikes east and west through the N. 1/2 sec. 8, and cannot in any sense be considered as a test of the region to the south. This well proved one fact that is significant, which is, that sands are present and of such a porous character that they are capable of containing oil and gas.

A well is being drilled near the center of sec. 17, T. 28 N., R. 3 E., by the Marland and Sinclair oil companies. At 400 feet a volume of 2,000,000 cubic feet of gas was encountered. Drilling will be continued. This location is near the apex of this structure.

It would appear that in sec. 17, with an east dip of 17 feet, and being within 4 miles of known production, and in a region which is marked by an increase of dip as the drill passes downward that this small fold is well worth drilling.

PONCA CITY ANTICLINE.

GENERAL STATEMENT.

The general conditions of this area are described fully by Ohern* and Garrett. In the bulletin containing their discussions of the area the Newkirk anticline is mapped as being continuous with the Ponca City anticline. Later work has shown that there is as least one cross synclinal fold between the two, making the separation more complete than was thought at first.

LOCATION AND EXTENT.

The Ponca City anticline is located in the northwestern part of T. 25 N., R. 2 E. The axis of the anticline extends from near the center of section 17 in a general northeast direction to the NW. 1/4 sec. 3. The highest point on the structure has an elevation of about 1,000 feet above sea level. The structural contours taken from the lower 1,500-foot sand shows an east dip of at least 90 feet. Several saddles on the anticline are also noted in the SE. 1/4 sec. 9, and in the SW. 1/4 sec. 4. As stated in the preceding paragraph, field work by several members of this Survey during the past summer points to the conclusion that there is a cross-synclinal fold in sec. 26, T. 26 N., R. 2 E., which in a way would separate the Ponca City and Newkirk anticlines. It is also thought that there is another cross fold in secs. 33 and 34, T. 26 N., R. 2 E., which is probably the north terminus of the Ponca City anticline.

GEOLOGY.

The Herington and Winfield limestones are exposed in this area, the former in secs. 8, 18, and 19, T. 25 N., R. 2 E., and the latter in secs. 26, 27 and 34, T. 26 N., R. 2 E., and sec. 3, T. 25 N., R. 2 E. A limestone exposed along Arkansas River in sec. 11, T. 25 N., R. 2 E. is probably the Herington.

*Ohern, D. W., and Garrett, Robt. E., Bull. Okla. Geol. Survey No. 16, 1912.

The following logs of wells in this region are characteristic of the formations encountered in drilling:

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

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Sandy soil	19	19	Lime cavings	43	1,315
Gravel	40	59	White sand (water)	19	1,334
White clay (water)	10	69	Slate and shells	33	1,367
Red rock	12	81	Hard lime	18	1,385
Gritty slate	8	89	Soft dark lime	10	1,395
Red rock	21	110	Soft black shale	23	1,418
White shale or clay	42	152	Red rock	15	1,433
Lime shell	9	161	White sand	17	1,450
White shale or clay	44	205	Black slate	10	1,460
Red rock	26	231	Very hard sand	56	1,516
Lime shell	3	234	Black shale	6	1,522
Red rock	60	294	Fine hard sand	7	1,529
Brownish lime	4	298	Soft shale	20	1,549
Hard black slate	28	326	White sand (water)	28	1,577
Reddish lime	24	350	Blue shale	3	1,580
Red rock	35	385	Gritty lime	5	1,585
Gritty slate	20	405	Black slate	53	1,638
Red rock	22	427	Sandy lime	25	1,663
White shale	8	435	Soft black shale	22	1,685
Brownish lime	8	443	Red shale	5	1,690
Hard grayish lime	22	465	White sand	15	1,705
Red shale	35	500	Black slate	3	1,708
Lime shell	12	512	White sand	28	1,736
Red rock	58	570	Black shale	20	1,756
Red sand	23	593	Lime shell	7	1,763
Hard white lime	5	598	Soft black shale	36	1,799
Red shale	27	625	White sand (water)	39	1,838
White sand	35	660	Soft shale	4	1,842
Red shale	42	702	Gritty gray lime	10	1,852
White sand	34	736	Black shale	6	1,858
Black slate	6	742	Slate and shell	22	1,880
Hard lime	38	780	Soft black shale	5	1,885
White slate	50	830	Red shale	7	1,892
Grayish lime	24	854	White lime	30	1,922
Black slate with shells	18	872	Soft black shale	13	1,935
Black slate with hard shells	24	896	Soft red shale	15	1,950
			White lime	28	1,978
Black slate	6	902	Red rock cavings	22	2,000
Slate and shells	21	923	Hard gray lime	15	2,015
Reddish tinted slate	37	960	Lime shell	3	2,018
Gritty shell in black slate	45	1,005	Sandy lime	19	2,037
			Brown shale	3	2,040
White and black sand	12	1,017	White sand	5	2,045
Black slate	45	1,062	White shale	13	2,058
Slate and shell	4	1,066	White sand	30	2,088
Soft slate	85	1,151	Black shale	20	2,108
Lime	4	1,155	Hard lime	6	2,114
Very soft slate	75	1,230	Black slate	49	2,163
Hard white sand	6	1,236	Hard shell	3	2,166
Soft black slate	24	1,260	Black slate	14	2,180
Dark soft shale	12	1,272	Hard white sand	10	2,190

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

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Red brown shale	4	2,194	Dark shale	3	2,303
White slate	5	2,199	Very white sand	59	2,362
Very hard white lime (water)	43	2,242	Dark black shale	43	2,405
Black slate	26	2,268	Dark lime	6	2,411
Dark lime	11	2,279	Blue shale	54	2,465
Black shale	3	2,282	White shale	20	2,485
White sand (salt water)	18	2,300	Dark blue shale	35	2,520
			White sand	56	2,576

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

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	6	6	Shale, white	70	930
Red clay	30	36	Sand (oil showing)	15	945
Sand	10	46	Sand, broken	7	952
Red rock	70	116	Slate	10	962
Shale	10	126	Lime	5	967
Lime	4	130	Shale	23	990
Sand and gas	8	138	Lime	5	995
Shale	7	145	Shale	65	1,060
Red rock	10	155	Lime	5	1,065
Lime	5	160	Shale	35	1,100
Red rock	3	163	Lime	20	1,120
Lime	10	173	Shale	5	1,125
Red rock	5	178	Lime	10	1,135
Lime	10	188	Shale	5	1,140
Shale	27	215	Sand	5	1,145
Red rock	50	265	Shale	5	1,150
Lime	10	275	Sand	10	1,160
Shale	5	280	Shale	25	1,185
Red rock	25	305	Lime	35	1,220
Sand and gas	21	326	Shale	65	1,285
Red rock	25	351	Lime	10	1,295
Lime	5	356	Shale	25	1,320
Shale	38	394	Sand and water	22	1,342
Lime	4	398	Shale	28	1,370
Red rock	41	439	Lime	5	1,375
Lime	5	444	Shale	30	1,405
Red rock	6	450	Lime	20	1,425
Lime	8	458	Shale	8	1,433
Red rock	10	468	Lime	8	1,441
Shale	39	505	Shale	30	1,471
Sand and gas	25	530	Lime	20	1,491
Shale	46	576	Shale	3	1,494
Lime	11	587	Lime	3	1,497
Shale	5	592	Slate	6	1,503
Lime	25	617	Shell	3	1,506
Shale	58	675	Red rock and slate	14	1,520
Red rock	5	680	Sand, broken	11	1,531
Lime	35	715	Oil sand, good (gas)	11	1,542
Shale	5	720	Sand, broken, & slate	6	1,548
Lime	50	770	Lime	2	1,550
Shale	90	860			

Margaret Primeaux No. 1, in sec. 4, T. 25 N., R. 2 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	4	4	Lime	9	758
Clay	40	44	Slate	2	760
Sand and gravel	6	50	Lime	25	785
Lime	20	70	Slate	74	859
Red rock	45	115	Shell	9	868
Shell	5	120	Slate	35	903
Red rock	40	160	Shell	3	906
Lime	5	165	Slate	26	932
Slate	10	175	Lime	3	935
Red rock	59	234	Sand	15	950
Sand (gas)	20	254	Slate	25	975
Red rock	10	264	Lime	10	985
Slate	5	269	Slate	60	1,045
Lime	5	274	Black shale	15	1,060
Slate	13	287	Lime	10	1,070
Red rock	12	299	Slate	60	1,130
Lime	45	345	Shale	15	1,145
Red rock	20	365	Slate	75	1,220
Gas sand	12	377	Lime	15	1,235
Slate	2	379	Slate	25	1,260
Lime	4	383	Lime	15	1,275
Slate	30	413	Red rock	4	1,279
Red rock	42	455	Lime	2	1,281
Lime	10	465	Slate	10	1,291
Red rock	2	467	Lime	15	1,306
Lime	6	473	Slate	12	1,318
Red rock	69	542	Lime	2	1,320
Gas sand	12	554	Red rock	2	1,322
Red rock	18	572	Sand (gas)	10	1,332
Lime	4	576	Slate	20	1,352
Slate	17	593	Lime	10	1,362
Lime	5	598	Slate	35	1,397
Lime	42	640	Lime	15	1,412
Slate	5	645	Slate	10	1,422
Red rock	6	651	Lime	8	1,430
Slate	8	659	Slate	5	1,435
Lime	10	669	Lime	8	1,443
Red rock	10	679	Lime	17	1,460
Lime	26	705	Lime	27	1,487
Slate	8	713	Slate	6	1,493
Lime	10	723	Lime	3	1,496
Sand	20	743	Slate	10	1,506
Break	2	745	Sand	20	1,526
Sand (little gas)	4	749	Black slate	4	1,530
			Oil Sand	19	1,549

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

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

DEVELOPMENT.

The Ponca City field is the principal development on and near this anticline. In 1905 the Ponca City Oil, Gas & Mineral Company, a local company, drilled the first well in this area. During 1906, 1907, and 1908, the company sold 178,000,000 feet of gas for household purposes. Gas was encountered in the first well at a depth of 500 feet. The chief activity lay in sec. 34, T. 26 N., R. 2 E., and in those sections lying immediately to the north and east. As a result of the small production of wells in this locality the company went farther northeast in 1909 and drilled several wells, ranging up to 5,000,000 cubic feet daily capacity. This gas also was secured from the 500-foot sand. For several years the efforts to bring about a marked development seemed discouraging. The wells range from 500 feet to 2,576 feet in depth. In June, 1911, the first oil well of importance, known as the Willie Cry well, came in at about 725 barrels per day. Later the well was shot with 20 quarts of nitroglycerine and was reported to have averaged 125 barrels per day for the first four months. It produced over 35,000 barrels in 16 months. A number of companies immediately entered the field and development proceeded more rapidly, so that by the end of 1912 there were 30 wells producing oil, the maximum capacity being 1,200 barrels, and the average about 34 barrels per well. Several wells in the 1,500-foot sand made as much as 500 or even 700 barrels natural. The total output for 1913 was 722,358 barrels, the average monthly production being 1,996.5 barrels.

About 25 per cent of all the wells drilled were dry, as a result either, of very shallow drilling, or a "dry streak" near the apex of the structure. Some wells were drilled no deeper than the 500-foot mark, and only a few below the 2,000-foot mark. Another possible reason for these dry holes is that at least one-half were drilled a considerable distance from the main pool, and so may really be classed as "wildcat" wells.

The total number of wells drilled in the Ponca City region is about 140. Of this number, 36 came in dry, 21 were gas wells, some of which were later deepened and produced oil, and 14 were abandoned for one reason or another without testing out thoroughly. This leaves 69 oil wells, part of which have since been abandoned. The present production is approximately 600 barrels daily, all of which is handled by the Ponca City Refining Company.

SANDS.

The Ponca City field is underlaid by 6 sands producing either oil or gas or both. They are discussed in descending order.

1. The shallowest sand of any consequence occurs at about 275 feet below the top of the Herington limestone. The thickness varies from 10 to 20 feet in different wells. It is an unimportant horizon.

2. The next producing stratum occurs at approximately 375 feet below the top of the Herington. It varies in thickness, the maximum

being 25 feet and the average about 17 feet. In a few wells this sand produces gas in paying quantities, but little or no oil.

3. The most important gas-producing stratum lies 175 feet below the sand just discussed, at a depth of 550 feet. Most of the early wells were drilled to this sand and no deeper. Several of the wells yield as much as 7,000,000 cubic feet of gas per day. The sand, as revealed by drillings, is from 25 to 49 feet, light-colored, coarse, and very porous. Ohern, Beede, and others consider this horizon the same as the gas-bearing formation at Dexter, Arkansas City, Elmdale, and Council Grove, Kansas.

4. About 975 feet below the upper surface of the Herington limestone is a fourth sand. This sand produces both oil and gas. The maximum thickness is about 50 feet, and the average approximately 35 feet. The productive horizon is apparently within the Elgin sandstone, which has been discussed along with the other Pennsylvanian rocks.

5. The fifth productive sand lies about 1,330 feet below the top of the Herington limestone. In certain wells it yields as much as 6,000,000 cubic feet of gas per day. A considerable portion of the field's production comes from this stratum. It appears that in areas where the sand is thin, 15 feet or less in thickness, that gas is found, while in other areas where the thickness measures 35 to 40 feet oil is encountered. This holds true for some wells at least, though it cannot be said whether it is a rule possible of general application. The sand lying at a depth of 112 feet at Blackburn may be tentatively correlated with this sand, which is possibly a part of the upper Buxton formation.

6. Lying 220 feet below the 1,330-foot sand is the deep productive sand.It is productive of both oil and gas and is the best oil-bearing horizon. The sand varies from 15 to 20 feet. Several wells in this sand flowed as much as 10 barrels natural per hour when first drilled in. This sand is correlated with the 500-foot sand of the Cleveland field, which probably occurs within the Buxton formation.

7. In the 101 Ranch well, drilled in the NE. 1/4 sec. 25, T. 25 N., R. 1 E., a 56-foot sand was encountered at 2,520 feet, which gave a showing of oil. This sand then lies 970 feet below the 1,500-foot sand of the main pool. At Ralston a 70-foot sand is said to be the equivalent of the 56-foot sand found on the 101 Ranch. In this well the 70-foot sand has been tentatively correlated with the Cleveland sand of the fields to the east. It is reasonable to suppose that the same sand, or an equivalent, underlies the Ponca City field. In the fields of northeastern Oklahoma the Cleveland sand is thought to occur at the base of the Coffeyville formation. It follows, then, that the Coffeyville or its equivalent must be the horizon in the Ponca field.

Fohs and Gardner* of Tulsa have placed the Bartlesville sand at

*Fohs, Julius, and Gardner, James H., Supplement to the Fuel Oil Journal, Houston, Texas, August, 1914.

3,625 feet, the Nemire at 3,495 feet, Oswego or Wheeler at 3,211 feet, the Peru at 3,042 feet, and the Cleveland sand at 2,716 feet. All of the sands used in this correlation were encountered in wells in Tps. 25 and 26 N. R. 2 E. The same persons mention 12 sands above the Cleveland, making a total of 17. They occur at the following depths below the surface: 275, 450, 550, 975, 1,210, 1,350, 1,550, 1,710, 2,015, 2,160, 2,310, and 2,520 feet. Not all, however, can be found in any one well or set of wells in one locality.

CHARACTER OF OIL.

The oil obtained has a deep olive-green color. From information furnished to parties in the field the gravity ranges from 43° to 47° Baume. The base is paraffin.

FUTURE DRILLING.

It seems that the limits of the productive area within the shallow sands of the Ponca City field have been fairly well defined, although a number of inside locations are yet to be drilled.

Most of the best producing wells of the great oil fields are deep. In Oklahoma the "big pay" sands, except for the north and northeastern shallow pools, are fairly deep. In the Cleveland field the sands are at 1,400, 1,600 and 2,400 feet; in the Cushing field, at 1,400, 1,700, 1,800, 2,200, and 2,700 feet. These wells, however, are not deep as compared with some recently drilled. Near McDonald, 10 miles west of Pittsburg, Pa., one well reaches a depth of 5,860 feet, or over 1¼ miles. In the Santa Maria field of California a large number of wells are 4,000 and more feet deep. The fact that the deep wells of the Ponca City field are good producers and long lived will certainly bring about this deep drilling. In the Ponca City field a test cannot be considered thorough until it has reached the Tucker sand. It is safe to say that all wells should be drilled from 3,600 to 4,000 feet before being finally abandoned. The recent discovery of oil in the Blackwell field, northwest of Ponca City and Newkirk, at a depth of 3,365 feet adds much strength to this reasoning. Tests should be completed whether oil or gas is encountered at a shallower depth or not.

NEWKIRK ANTICLINE.

LOCATION AND EXTENT.

The Newkirk anticline, so named from the town of Newkirk, is located in the east-central part of T. 26 N., R. 2 E., NW. 1/4 T. 26 N., R. 3 E., T. 27 N., R. 3 E., and SE. corner T. 28 N., R. 3 E. The axis of the anticline extends from the north-central part of sec. 24, T. 26 N., R. 2 E., in a general northeast direction to the NW. corner sec. 4, T. 26 N., R. 3 E., where it continues in a north direction for 2 miles, then in a general northeast direction again to the SW. 1/4 sec. 35, T. 28 N., R. 3 E.

The upfolding is much more pronounced at the northern end of the structure in sec. 2, T. 27 N. and sec. 35, T. 27 N., R. 3 E. The eastern slope of the anticline at this point has a dip of at least 160 feet. The highest point on this fold, which is along the line between sec.

2, T. 27 N. and sec. 35, T. 28 N., R. 3 E., has an elevation of 1,340 feet above sea level, based on the Herington limestone. Southward from this point the elevation on the axis of the anticline becomes lower throughout its course.

GEOLOGY.

The formations outcropping in this area range from the Wreford limestone up to the Herington limestone. The reader is referred to Plate I of Bulletin No. 16 of the Oklahoma Geological Survey, which shows the different formations and the location of their outcrops. The structure contours of this anticline are based on elevations taken on the Herington limestone.

DEVELOPMENT.

The development on and near this structure and also in the vicinity of Newkirk is taken up in this connection.

The early development, which began about the same time as in the Ponca City field, was in and about the town of Newkirk in the southwestern part of T. 28 N., R. 2 E. The real development of the Newkirk anticline began after the appearance of Bulletin No. 16 of the Oklahoma Geological Survey.

The first wells drilled varied in depth from about 600 feet to 2,200 feet. The gas showing was small, 100,000 to 200,000 cubic feet per day, and nearly all of the wells were drowned out by salt water within a comparatively short time. In September, 1913, the first well was started on the anticline mapped by the State Geological Survey. This well. located near the center of sec. 2, T. 27 N., R. 3 E., was brought in as a 100-barrel producer. The development which followed resulted in two "dusters" before any other producers were drilled. Since that time other wells have been brought in from time to time until more than 115 wells have been drilled. Of this number at least 32 are dry. Most of these are dry because they are too far from the axis of the anticline, although a few "dusters" have been drilled in the midst of production. About 500 barrels is the largest producer. Though development has undoubtedly been much retarded through the lack of pipe line facilities the production reached a total of 2,500 barrels per day during April of 1914. Of this amount, 1,000 barrels per day were handled by the Ponca City Refining Company's pipe line which extends to the field. Seven hundred barrels were purchased by the Great Western Refining Company. The only important producing sand is that found at the 900 foot level. Some have estimated the average initial production as high as 200 barrels. A notable difference between the Ponca City and Newkirk fields is in the length of life of wells. In the former pool wells drilled four years ago are still producing 75 to 100 barrels per day, while in the latter area production is declining rapidly, and the field is destined for early abandonment unless deeper pay sands are found.

SANDS.

The sands encountered in the Newkirk field are in almost all cases similar to those of the Ponca City field. The 900-foot sand, which is probably the horizon of the Elgin sand, is the only productive horizon of importance and most of the wells are drilled only a few feet below this level. The same sand is encountered in the Ponca City field at a depth of 975 feet. The following logs show the sands and associated formations encountered in this area:

Well No. 3, in SE. ¼ sec. 25, T. 28 N., R. 2 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface	17	17	Lime	34	375
Sheet water sand	7	24	Shale	5	740
Blue shale	5	29	Lime	15	755
Light shale	25	54	Sandy shale	281	1,036
Shale	41	95	Lime	20	1,056
Red rock	22	117	Shale	58	1,114
Lime	13	130	Lime	11	1,125
Blue shale	10	140	Shale	40	1,165
Red rock	40	180	Lime	15	1,180
Lime	3	183	Shale	7	1,187
Red rock	10	193	Lime	5	1,192
Shale	17	210	Sandy shale	79	1,271
Sandy shale	7	217	Lime	5	1,276
Blue shale	10	227	Shale	5	1,281
Lime	3	230	Flinty lime	14	1,295
Sandy shale	70	300	White lime	5	1,305
Red rock	25	325	Shale	15	1,320
Sandy shale	10	335	Lime	15	1,335
Lime	5	340	Shale	17	1,352
Blue shale	10	350	Water, sand	23	1,375
Red rock	10	360	Sandy shale	15	1,390
Lime	30	390	Hard lime	5	1,395
Blue shale	5	395	Shale	30	1,425
Red rock	20	415	Sandy shale	15	1,440
Blue shale	5	420	Gas sand dry	8	1,448
Red rock	32	452	Shale	62	1,510
Lime	5	457	Lime	10	1,520
Red rock	7	464	Shale	20	1,540
Lime	26	490	Lime	5	1,545
Red rock	20	510	Block shale	10	1,555
Lime	5	515	Lime	15	1,570
Blue shale	5	520	Shale	20	1,590
Lime	10	530	Lime	8	1,598
Sandy shale	30	560	Shale	19	1,617
Mud vein	49	609	Gas sand dry	16	1,633
Gas sand	10	619	Block shale	3	1,636
Shale	10	629	Gas sand dry	5	1,641
Lime	21	650	Black shale	4	1,645
Shale	12	662	Gray sand	23	1,668
Lime	21	683	Shale	10	1,678
Shale	18	701	Water sand	5	1,688

Murdock No. 8, S. of N. line of N. ½ SW. ¼ sec. 2, T. 27 N., R. 3 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface		65	Lime, white, hard	20	745
Lime, white, hard	20	85	Slate, soft	55	800
Mud, red, soft	100	185	Lime, hard	30	830
Lime, white, soft	15	200	Slate, soft	40	870
Mud, red, soft	80	280	Lime, hard	30	900
Slate, white, soft	20	300	Sand, light	20	920
Mud, red	65	365	Lime, white, hard	20	940
Lime, white, hard	40	405	Slate, white, soft	10	950
Slate, white, soft	100	505	Lime, white, hard	5	955
Shale, brown	100	605	Slate, white, soft	28	983
Sand, brown	20	625	Lime, white, hard	17	1,000
Slate, white	100	725	Sand, soft, oil	30	1,030

Isaac Booth No. 1, in sec. 35, T. 29 N., R. 3 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil		5	Lime	10	755
Red rock	10	15	Slate	70	825
Lime	40	55	Lime, white, hard, some oil	10	835
Red rock	20	75	Shale	35	870
Lime	15	90	Lime	10	880
Red rock	10	100	Shale	20	900
Lime	20	120	Lime	20	920
Slate	20	140	Shale	5	925
Lime	30	170	Lime	10	935
Red rock	45	215	Shale	5	940
Lime	10	225	Lime	2	942
Red rock	50	275	Shale	23	965
Lime	20	295	Lime	5	970
Shale	45	340	Shale	10	980
Lime	10	350	Lime	5	985
Red rock	20	370	Red rock	5	990
Lime	70	440	Shale	14	1,004
Shale	4	444	Lime	4	1,008
Lime	51	495	Slate	6	1,014
Slate	15	510	Sand	3	1,017
Lime	20	530	Slate	9	1,026
Slate	6	536	Sand	2	1,028
Lime	9	545	Slate	4	1,032
Slate	45	590	Sand	14	1,046
Lime	15	605	Slate	11	1,057
Slate	140	745	Water at 1055 feet.		

FUTURE DRILLING.

In the Newkirk district, as in the Ponca City field, too much cannot be said against the policy of shallow drilling. Here, as in the field to the south, no test can be considered as thorough until the bit has reached a depth of 3,700 or 3,900 feet. Along the axis of the fold to the south excellent opportunity is offered for further exploration.

During the past summer a well was drilled in on sec. 9, T. 26 N., R. 3 E., which had an initial capacity of 5,000,000 cubic feet of gas (estimated). The report has recently come to the office of the Survey that three or four other producing wells have been drilled on this section. This production is due to a local change of dip to the north. Other small domings or terraces on the Newkirk anticline may prove of great value. Deep drilling may also reveal a greater reward than is anticipated.

STRUCTURE WEST OF PONCA CITY.

GENERAL.

Near the center of T. 26 N., R. 2 E. there are indications of folding. L. E. Trout of the Marland Oil Company has mapped a small anticline in this area. A complete outline of the fold cannot be determined from surface indications on account of insufficient outcrops. The axis of the anticline apparently passes through the W. 1/2 of secs. 7, 18, and 19. There is at least an east dip of 20 feet in the N. 1/2 of sec. 18.

To structural contours were determined from elevations taken on an unnamed limestone which is stratigraphically above the Herington limestone.

A well is being drilled in the SE. 1/4 sec. 13.

It is possible that this small fold is a branch of a main fold to the northwest. To obtain more details of the structure in this area, where outcrops are lacking, it is suggested that a series of diamond core drill holes, if properly spaced, would be of great value.

STRUCTURE WEST OF KILDARE.

GENERAL.

In the west-central part of T. 27 N., R. 2 E. an east dip of 30 feet has been found by geologists of the Marland Oil Company. This dip is measured from the SW. cor. sec. 18 to the NW. cor. sec. 21, the latter place being the bottom of a syncline. An east dip in an area where the normal dip is to the west is an indication of folding. The apex of the anticline cannot be determined from surface indications, but it appears that the area in sec. 18 is near the apex and for that reason would be considered favorable territory for oil and gas accumulation. On account of insufficient rock outcrops complete details of the structure are not obtainable. The area mentioned above is worthy of further investigation.

STRUCTURE NORTHEAST OF BLACKWELL.

GENERAL.

The geological survey of this area was carried on during the summer of 1914 by L. E. Trout, Harvey Loomis, Robert Goodrich, and George H. Myers, all of whom were members of this Survey at that time. The work was in charge of L. E. Trout and under the direction of C. W. Shannon, director of the Oklahoma Geological Survey.

LOCATION AND EXTENT.

Several folds are located in Tps. 27 and 28 N., Rs. 1 W. and 1 E., northeast of Blackwell. The easternmost anticline is located in Tps. 27

and 28 N., R. 2 E. The axis of the anticline extends from the SW. 1/4 sec. 21, T. 27 N., R. 1 E. in a general north direction to the NE. corner of sec. 33, T. 28 N., R. 1 E., where it probably continues northeastward toward Middleton for an unknown distance. The shape of this anticline is that of the regular type of the Kay County anticline, the axis plunging to the south or southwest. The highest point of elevation as far as can be determined is about 1.115 feet and is in the SW. 1/4 sec. 22, T. 28 N., R. 1 E. The elevation on the axis gradually decreases to the southward, but in sec. 16 and the N. 1/2 of sec. 21, T. 27 N., R. 1 E. the axis flattens as far as the center of sec. 21, where it abruptly plunges to the south. At its southern terminus there is an east dip of at least 30 feet. The dip on the east limit of this anticline in secs. 3 and 4, T. 27 N., R. 1 E., and secs. 33 and 34, T. 28 N., R. 1 E., is to the southeast, varying from 30 to 60 feet per mile.

A well-defined syncline has been determined to the east of the anticline, and also one to the west, the latter separating this anticline from another farther west.

The westernmost anticline is located principally in T. 28 N., R. 1 E. The axis of this anticline extends from the NE. 1/4 sec. 1, T. 27 N., R. 1 W., in a northeast direction to the east-central part of sec. 29, T. 28 N., R. 1 E., where it continues in a general north direction to near the center of sec. 17. Here the anticline branches, the east branch extending northeast into the N. 1/2 of sec. 9, T. 28 N., R. 1 E., and the west branch extending northwest into sec. 1, T. 28 N., R. 1 W. This anticline is similar to the one mentioned above, with the exception of the change in direction and branching features of the axis. Considerable development has been carried on to the west of this anticline, and also near the northern extension of this structure. The highest point in elevation on the southern end of this anticline is in the east central part of sec. 29, T. 28 N., R. 1 E., which is on an unnamed limestone above the Herington limestone. The southern terminus of the anticline is in the N. 1/2 of sec. 1, T. 27 E., R. 1 W. The east branch of the northern part of the anticline probably extends farther north through sec. 9, T. 28 N., R. 1 E., than has been mapped. Its terminus has not been determined, owing to lack of field work. The northern terminus of the west branch probably extends through sec. 35, T. 29 N., R. 1 W. The highest point, 1,170 feet, on the whole structure as far as can be determined, is in the SE. 1/4 of sec. 8, T. 28 N., R. 1 E., which is on the same horizon as mentioned above.

GEOLOGY.

Within the limits of the Blackwell field the outcropping formations are chiefly shale. Interbedded with these are three or four limestone layers of more or less persistence, which, with the shales above and below, were used as the horizon for contouring the surface structure.

The limestone ledges, though characteristically buff, porous, gypsiferous, and honeycombed, are sometimes replaced by a white massive, fossiliferous bed. It is sometimes one and then another that has this distinction so that at best any mapping that may be done will be more or less inaccurate. Added to the difficulty caused by this unusual transformation is the fact that the surface is of such a character that outcrops are not of such frequency as could be desired. Also, the three beds of gypsiferous limestone are so similar that on gentle slopes where only one or two ledges appear it is practically impossible to be absolutely positive as to their exact position in the section.

DEVELOPMENT.

The Blackwell oil and gas field, which is associated with the structure already described, extends northeast from the edge of the town to within 2 miles of the Kansas line, having a length of about 11 miles. It lies in Tps. 27, 28, and 29 N., Rs. 1 W. and 1 E.

The first wells in the Blackwell field were drilled by local parties. Much trouble was experienced in drilling through the Redbeds, so that some of the first wells were abandoned. However, indications of gas were found. Some of the early wells had an initial daily capacity of 200,000 to 5,000,000 cubic feet of gas. In 1912 the field as developed was nearly a mile wide and extended north slightly east for a distance of 10 miles. Most of the wells brought in up to this time were gas producers. During this year out of a total of 37 wells drilled 21 produced gas.

During 1913 development continued intermittently, but in 1914 a number of good gas wells and one oil well added stimulus to development.The gas wells ranged in initial daily capacity from 250,000 to 35,000,000 cubic feet. The only oil well of any importance so far completed was drilled on the Gus Swenson farm in sec. 32, T. 29 N., R. 1 E. The initial daily production was reported at 600 barrels from a sand at a depth of 3,360 feet. Considerable activity followed the completion of this well with the result that about 15 locations were made in a short time. Drilling, however, was rather slow on account of the depth, and trouble encountered in drilling through the gas-bearing formations. The next oil well to be completed was that of the Spencer Oil Company, known as the Alberta No. 1, northwest of the Swenson well. The production which was reported from 250 to 700 barrels per day, was obtained from the Swenson sand at a depth of 3,380 feet. The gravity of the oil was reported to be 37 1/2° Baume. In this well 30 feet of sand, yielding 4,000,000 cubic feet of gas per day and a "break" were encountered above the real oil producing sand. The drill penetrated the oil sand only 20 feet. Three months after the well had been completed it was producing about 400 barrels per day. A large gas well was completed on the Wolfe farm in sec. 6, T. 28 N., R. 1 E., 2 miles southwest of the Alberta well, at a depth of 3,260 feet. This sand is probably the same as the deep sand in the Swenson and Alberta wells. The drill penetrated only 20 feet of the sand, which yielded about 30,000,000 cubic feet of gas and had a great rock pressure of 1,460 pounds.

The next deep well to be completed was the B. B. Jones well in the southwest corner of the Gus Swenson farm, NE. 1/4 sec. 32, T. 29 N., R. 1 E. The productive sand was encountered at a depth of 3,373 feet. The initial daily production was reported at 1,000 barrels. The log of the original Swenson well is as follows:

Gus Swenson No. 1, in NE. ¼ NE. ¼ sec. 32, T. 29, R. 1 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	5	5	Shale	95	1,210
Clay (water)	9	14	Lime	20	1,230
Shale	12	26	Slate	60	1,290
Gyp	4	30	Lime	10	1,300
Shale	16	46	Slate	120	1,420
Gyp, lime	8	54	Lime	24	1,444
Shale	25	79	Sand (water & gas)	36	1,480
Lime	3	82	Lime	20	1,500
Shale	19	101	Shale	110	1,610
Lime	4	105	Lime	20	1,630
Red rock	18	123	Shale	10	1,640
Shale, limy	140	263	Lime	3	1,643
Red rock	34	297	Shale	97	1,740
Shale	30	327	Lime	10	1,750
Lime	5	332	Sand, gas	25	1,775
Shale	14	346	Red rock	15	1,790
Lime	4	350	Shale	10	1,800
Sand, gas	20	370	Sand (water)	25	1,825
Shale	65	435	Shale	15	1,840
Lime, sand (water)	7	442	Red rock	60	1,900
Red rock	15	457	Lime	40	1,940
Shale	41	498	Shale	20	1,960
Lime	3	501	Sand—oil showing	25	1,985
Slate	26	527	Sand, water	2	1,987
Lime	10	537	Slate	13	2,000
Shale	20	557	Lime	7	2,007
Sand, gas	33	590	Slate	83	2,090
Shale	22	612	Lime	10	2,100
Lime	7	619	Red rock	10	2,110
Slate	21	640	Lime	105	2,215
Red rock	21	661	Slate	63	2,278
Shale	6	667	Sand—oil showing	15	2,293
Slate	2	669	Slate	5	2,298
Lime	5	674	Sand, water	12	2,310
Shale	41	715	Slate	345	2,655
Sand (Blackwell gas?)	27	742	Sand, oil	32	2,687
Shale	28	770	Sand, water	63	2,750
Sand (water)	26	796	Slate	5	2,755
Shale	80	876	Lime	10	2,765
Lime	9	885	Sand (water)	15	2,780
Red rock	17	902	Lime	20	3,000
Shale	18	920	Shale	50	3,050
Sand, gas	22	942	Sand—oil showing	20	3,070
Lime	3	945	Lime	130	3,200
Sand (water)	55	1,000	Shale, slate	100	3,300
Red rock	30	1,030	Sand, water	30	3,330
Shale	70	1,100	Slate	25	3,355
Lime	15	1,115	Sand, gas	10	3,365
			Oil sand (still in sand)	20	3,385

By January 1, 1916, over 24 wells were drilling with the intention of going down to the Swenson sand. Eighteen of these are within a radius of 3 miles of the Alberta well. Heberling and Banty abandoned their test in sec. 29, T. 29 N., R. 1 E. at a depth of 3,450 feet, and encountered only a showing of oil in the Swenson sand. The fourth large producing well was completed by B. B. Jones in sec. 32, T. 29 N., R. 1 E., a quarter of a mile west and a little north of the original Alberta well. The initial daily production was reported at 3,465 barrels at a depth of 3,357 feet. In comparing the elevation of the Swenson sand in this well and the Alberta No. 1, the former is about 20 feet higher, and indicates that it is higher on the structure than the latter. The daily production of oil in the Blackwell field in March, 1916 was approximately 2,000 barrels from 5 producing wells: Forty others were drilling at various depths from 100 to 3,200 feet. Seventy-five rigs were up or being constructed.

In December, 1916, the Duluth-Oklahoma Oil Company's well No. 3 on the Wolfe farm in sec. 6, T. 28 N., R. 1 E., was completed and had a reported initial daily production of 4,000 barrels. Within a week the daily production decreased to 1,600 barrels. Some of the other large producers have shown the same tendency, and in addition showed some water. The Kay and Kiowa Oil & Gas Company completed a well on the Curry farm, which was reported to have produced 30 barrels per hour on initial flow at a depth of 1,950 feet. This production in a shallow sand will probably stimulate much activity in developing this sand.

Near the close of 1916 the Blackwell field had an average daily production of about 4,000 barrels. The total production for the year is estimated at about 640,000 barrels.

It appears that the whole area surrounding sec. 32, T. 29 N., R. 1 E., will receive considerable future development, and that it will receive a thorough testing.

SANDS.

The number of sands in this field varies considerably in different wells. The Stalnaker well in sec. 11, T. 34 N., R. 2 E., showed 11 sands in a total depth of 2,397 feet with some gas at five different horizons. The original Swenson well in sec. 32, T. 29 N., R. 1 E., showed 20 different sands, 7 of which produced gas in small quantities and 4 of which showed oil.

The following log shows the sands and associated formations encountered in the southern part of the field:

Well No. 12, *in SW.* ¼ *sec.* 13, *T.* 26 *N., R.* 1 *W.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	2	2	Sand (little gas)	25	685
Clay	6	8	Red rock	20	705
Shale	3	11	Sand	15	720
Brown mud	6	17	Slate	32	752
Red rock	3	20	Cap rock	17	769
Slate	12	32	Gas sand	14	783
Gravel (water)	4	36	Slate	12	795
Lime	5	41	Lime	5	800
Slate	12	53	Black shale	5	805
Gyp rock	8	61	Lime	30	835
Slate	15	76	Sand (dry)	20	855
Lime	8	84	Lime	25	880
Slate	2	86	Sand (dry)	15	895
Lime	12	98	Slate	15	910
Slate	22	120	Lime	5	915
Lime	5	125	Slate	10	925
Slate	2	127	Lime	10	935
Lime	7	134	Slate	15	950
Slate	9	143	Sand, small show gas	25	975
Lime	4	147	Slate	45	1,020
Slate	38	185	Lime	3	1,023
Lime	10	195	Slate	12	1,035
Slate	29	224	Shale	10	1,045
Lime	3	227	Lime	5	1,050
Slate	5	232	Slate	6	1,056
Lime	18	250	Sand (dry)	24	1,080
Slate	10	260	Sand (water)	25	1,105
Red rock	25	285	Slate	24	1,129
Slate	20	305	Lime	6	1,135
Lime	10	315	Slate	15	1,150
Slate	25	340	Lime	5	1,155
Lime	12	352	Slate	20	1,175
Brown shale	15	367	Lime	8	1,183
Lime	5	372	Sandy shale	60	1,243
Sand	15	387	Lime, little water	17	1,260
Lime	15	402	Slate	2	1,262
Red rock	3	405	Lime	12	1,274
Lime	10	415	Slate	10	1,284
Slate	5	420	Lime	5	1,289
Red rock	25	445	Slate	5	1,294
Slate	10	455	Red rock	5	1,299
Lime	10	465	Lime	9	1,308
Slate	5	470	Slate	5	1,313
Lime	10	480	Lime	24	1,337
Slate	4	484	Slate	3	1,340
Red rock	5	489	Sandy lime	25	1,365
Lime	8	497	Slate	10	1,375
Sand (water)	23	520	Sandy shale	10	1,385
Red rock	20	540	Slate	10	1,395
Lime	20	560	Lime	7	1,402
Red rock	10	570	Slate	23	1,425
Lime	20	590	Lime	25	1,450
Red rock	20	610	Black sandy shale	35	1,485
Lime	10	620	Slate	5	1,490
Slate	12	632	Sand	3	1,493
Lime	18	650	Brown shale	6	1,499
Slate	10	660	Sand, (water)	7	1,506

The Duluth-Oklahoma Oil Company's well on the J. E. Myers farm in sec. 1, T. 28 N., R. 1 E., showed the following sands:

Gas sands.	Production*.	Rock pressure per square inch.	Depth.
		Pounds.	
First	8,000,000	300	692
Second	1,000,000		785
Third	15,000,000		940
Fourth	2,000,000		1170
Fifth	20,000,000		1350
Sixth	20,000,000		1900
Seventh	20,000,000		2600
Eighth	30,000,000	1260	3200
Total	116,000,000		3200

*Estimated.

The log of the Spencer Oil Company No. 1 on the Alberta farm in sec. 32, T. 29 N., R. 1 E., showed 14 sands, 9 of which yielded gas. The log of this well is as follows:

Log of Alberta No. 1, SE. ¼ sec. 32, R. 29 N., R. 1 E.

Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*
Soil	55	55
Gypsum	15	70
Blue slate	30	100
Lime	10	110
Slate	30	140
Lime	15	155
Slate	45	200
Lime	25	225
Slate	25	250
Red rock	25	275
Slate	15	290
Lime	10	300
Slate	25	325
Lime	8	333
Slate	7	340
Sandy lime (gas and water)	30	370
Red rock	35	405
Shells and slate	15	420
Lime	15	435
Slate	15	450
Lime sand	35	485
Red rock	30	515
White shale	5	520
Shale	5	525
Red rock	35	560
Lime	10	570
Red rock	20	590
Lime	30	620
Red rock	25	645
Lime	35	670
Red rock	20	690
Lime	35	755
Blue shale	5	760
Lime (gas at 775)	95	855
Slate	95	950
Lime	10	960
Shale	40	1,000
Lime	25	1,025
Blue shale	25	1,050
Lime	10	1,060
Blue shale	110	1,170
Lime	70	1,240
Lime	70	1,240
Shale	20	1,260
Lime	20	1,280
Shale	5	1,325
Lime	10	1,335
Slate	40	1,375
Lime	35	1,410
Slate	15	1,425
Sand (gas, 10 mil. feet, water)	20	1,445
Shale	45	1,490
Lime	10	1,500
Shale	75	1,575
Lime	25	1,600
Shale	10	1,610
Lime	35	1,645
Shale	5	1,650
Lime	50	1,700
Blue shale	35	1,735
Sand (gas)	15	1,750
Shale	40	1,790
Sand	15	1,805
Shale	60	1,865
Lime	40	1,905
Red rock	30	1,933
Sand (some gas)	30	1,965
Red rock	10	1,975
Slate	25	2,000
Lime	5	2,005
Slate	30	2,035
Lime	10	2,045
Slate	5	2,050
Lime	30	2,080
Slate	30	2,110
Sand	15	2,125
Slate	60	2,185
Lime	15	2,200
Slate	80	2,280
Sand (showing of oil)	10	2,290
Slate	15	2,305
Sand (water)	70	2,375
Sand	25	2,400
Shale	250	2,650
Sand (gas 2 million feet)	15	2,665
Sand, oil	10	2,675
Sand (water at 2700	75	2,750
Lime	15	2,765
Slate	35	2,800
Lime	30	2,870
Slate	15	2,885
Slate	45	2,930
Lime	50	2,980
Shale	50	3,030
Sand (oil showing)	30	3,050
Lime	130	3,180
Lime, caprock	100	3,280
Sand, gas	25	3,305
Sand, oil	15	3,320
Shale	40	3,360
Sand, oil	25	3,385

In comparing this log with that of the original Swenson well, it is said that 16 sands are shown in the latter. The productive horizons in both are the same—the Swenson sand. In many cases drillers have failed to report showings of gas at different horizons, and the character of the gas-bearing formations as reported also differ, making it difficult to correlate the different sands. In general, then, the following sands are encountered.

Table showing the different sands in the Blackwell field.

Name.	Character.	Thickness.	Average depth.	Correlation.
Sand	Gas	20	225	
Sand	Gas	30	350	
Sand	Gas	20	450	
Sand	Gas	25	555	
Blackwell	Gas	20	750	275-foot sand at Ponca City
Sand	Gas	30	940	470-foot sand at Ponca City
Sand	Gas	15	1060	550-foot sand at Ponca City.
Newkirk	Water and gas	30	1450	975-foot sand at Ponca City
Sand	Gas	20	1740	
Sand	Water	25	1800	
Ponca	Gas	20	1930	1550-foot sand at Ponca City
Sand	Showing of oil	20	1970	
Sand	Gas, showing of oil	15	2700	
Sand	Water	50	2300	
Sand	Gas, showing of oil water	90	2640	Layton of Cushing
Sand	Water	25	2775	
Sand	Gas, showing of oil	30	3010	Cleveland
Sand	Gas, showing of oil, water	30	3275	Peru
Swenson	Oil	25	3360	Oswego (Wheeler)

As shown by the above table the Swenson sand has been tentatively correlated with the Oswego (Wheeler sand of the Cushing field). The Bartlesville sand, if continuous to this area, would probably be encountered at a depth of not less than 3,800 feet, if the above correlation is correct, and the Tucker about 4,000 feet. All of the above correlations were based on the total thickness of a general section from the basal part of the Cherokee formation to the top of the Herington limestone.

This interval measured across northern Oklahoma would be approximately 3,500 feet. The interval between the Herington and the surface horizon in the Blackwell field is at least 300 feet.

FUTURE DRILLING.

In prospecting for oil by deep drilling the only territory which has received much consideration is that in the vicinity of sec. 32, T. 29 N., R. 1 E. In this development the most productive wells have been drilled in the above section. To the northeast of this area no encouraging results have been obtained, while to the south conditions appear to be very favorable. The production is associated with structure; however, it does not appear to be very definite according to the surface structure as shown on the accompanying map of Kay County. Then if the surface structure conforms to the deep underground structure the area covered by the two anticlines as outlined in the description of the Blackwell structure would be favorable territory for future development. The area near the axis and probably that down the slope a short distance appears to offer the best inducements.

In the E. 1/2 of sec. 8 and the W. 1/2 of sec. 9, T. 28 N., R. 1 E., the surface structure shows a structural high on an anticline. This area should be very favorable territory for oil and gas, especially gas, on account of its being on the crest of the structure. A similar type of structure has been found in the eastern part of section 30 and the western part of section 29, of the same township.

The easternmost anticline, as previously described, also offers many possibilities. The shallow gas wells north of Blackwell along Bitter Creek are quite a distance down the western slope of the westernmost anticline. Taking into consideration this fact, and that the territory farther to the east up the dip-slope to the crest of the anticline is more favorable territory for gas at least, then this whole area offers wonderful possibilities for the development of future natural gas resources in the shallow sands. The territory along the axis of the anticline offers still greater possibilities along this line in the deeper sands.

It is not at all improbable that some of the sands just above the Swenson sand may be found to contain oil in commercial quantities. Showings of oil in these sands have been encountered in all of the wells drilled in sec. 32, T. 29 N., R. 1 E., and secs. 5 and 6, T. 28 N., R. 1 E.

The deep wells in this field are very expensive to drill, and encounter much trouble in drilling through the gas horizons and formations. Development has been retarded on this account. To drill deeper than the Swenson sand is a problem yet to be undertaken, as no drill has penetrated more than a few feet below that horizon. The Bartlesville and Tucker sands, which are the best producers in the fields, have never been penetrated farther east, if the correlations previously mentioned are correct. A test, then, to a depth of 4,000 feet would encounter the Bartlesville sand and would be thorough.

The Blackwell field has been only partially developed and from a study of conditions in that area it offers great possibilities for future development.

GAS FACILITIES.

As stated under the above heading on "Future Drilling," the gas facilities of this field are very great. The shallow sands alone yield considerable quantities of gas. The shallow wells range from 650 to 1,500 feet in depth, the main producing sand being encountered at 750 feet. In all there are at least 15 gas sands between the depths of 125 and 3,350 feet. All are not encountered in every well drilled. In the Duluth-Oklahoma Oil Company's well on the J. E. Myers farm in sec. 1, T. 28 N., R. 1 W., 8 gas sands were encountered, yielding a total of about 116,000,000 cubic feet per day initial flow. In practically all of the wells drilled gas is encountered, enough to say that the supply if properly conserved will last for many years to come.

According to an estimate compiled by the Oil and Gas Journal, Kay County produced an initial daily flow of 18,000,000 cubic feet in 1914 and 103,500,000 in 1915, most of which came from the Blackwell field. The volumes in the various sands ranged from 5,000,000 to 60,000,000 cubic feet. In some of the deep wells this gas was conserved by mudding or other processes, so that the production is not as large as it would have been had these been allowed to flow.

When the first deep wells encountered large volumes of gas they were allowed to escape in the air; later, conservation officers took charge of the situation and as a result the gas was saved. The processes of conservation used are the mud process, braden heading, and the California circulating system. The last mentioned process is that of shutting off gas, water, and caving by water pressure against the sides of the hole.

Three or more gas companies are operating in this field. The Blackwell Oil and Gas Company handles most of the gas production. This company supplies the city of Blackwell and manufacturing concerns located at this place. The manufacturing consumers are supplied with gas at 4 cents a thousand cubic feet measured under the air system at .06 gravity. This gives the consumer more heating value than when calculated under the British thermal unit system.

The Enid Natural Gas Company, which supplies Enid, secures most of its supply from the B. B. Jones interests in this field. The Junction Oil Company supplies Bramen with natural gas from the field.

Several other large gas companies are contemplating extensions of their pipe lines to this field.

The heating value of gas from the deep sands in this field is reported to have been determined by the United States Government to be 1.342 B. t. u., and is the best heat producing gas, per thousand cubic feet, of any in the United States, even surpassing the best natural gas in

Pennsylvania. In comparison with the gas used at Fort Worth, Texas, which has a heating value of 738 B. t. u., it has almost twice the heating value.

This field offers special inducement for the location of manufacturing concerns seeking cheap, efficient fuel, for the following reasons:

1. The supply is enormous and will last for many years.

2. Pipe line facilities can probably be secured if desired.

3. The heating value of gas from the deep sands is the highest in the United States.

4. The price to manufacturing concerns is 4 cents per thousand cubic feet, measured under the air system, counting a .06 gravity at that price. The heating value under this system is considered more than if calculated under the British thermal unit system.

5. This field is fairly well located with respect to transportation facilities.

DEVELOPMENT.

The only areas which have received much development are the Newkirk, Ponca City, and Blackwell fields. The development of these fields has been discussed under the structure of the respective areas. Outside of the main fields several wells have been and are being drilled in the vicinity of Tonkawa, Kaw City, and several other towns in Kay County. The following table is a summary of development in Kay County from 1912 to and including 1915:

Well record in Kay County, Oklahoma, 1912-1915, *by years*.

Wells completed.					Initial daily production.	
Year.	Total.	Oil.	Gas.	Dry.	Total.	Average per well.
1912	58	31	7	20	4790	154.5
1913	55	29	3	23	2963	102.2
1914	115	66	5	44	7501	113.7
1915	31	15	11	5	1630	108.7
Total	259	141	26	92	16,885	119.7*

*Average.

Production of petroleum in Kay County, Oklahoma, in 1915, by months, in barrels.

Month.	Daily production.	Monthly production.
January	2450	75,950
February	2200	61,600
March	2400	74,400
April	2395	71,850
May	2350	72,850
June	2300	69,000
July	2200	68,200
August	2200	68,200
September	2600	78,000
October	2500	77,500
November	2450	73,500
December	2400	74,400
Total	2371*	865,450

*Average.

Production of petroleum in Kay County, Oklahoma, in 1916, by months, in barrels.

Month.	Daily production.	Monthly production.
January	2,100	65,100
February	2,300	66,700
March	2,150	66,650
April	2,015	60,450
May	2,560	79,360
June	2,650	79,500
July	2,900	89,900
August	2,400	74,400
September	2,625	78,750
October	4,020	125,620
November	4,540	136,200
December	4,815	149,265
Total	2,923*	1,070,895

*Average.

SUMMARY.

Kay County is in favorable territory. The subsurface geological formations are Pennsylvanian and lower Permian in age; the former is the main oil and gas productive horizon in the fields of this county.

The formations in general have a monoclinal westward dip, but this dip is interrupted in some areas by reversal dips to east or southeast. These areas, in which anticlinal or similar structure occurs, are favorable places for the accumulation of oil and gas.

Three main oil and gas fields having been developed. Kay County is attracting considerable attention at present. The Newkirk and Ponca City fields have been fairly well outlined as far as production in the shallow sands is concerned. There is still opportunity to investigate further oil and gas resources of these fields by deeper drilling. The Blackwell field with respect to gas production has wonderful resources yet uncovered and with respect to oil it is just beginning to be developed. The number of productive gas sands at shallow depths, and the abundance and cheapness of this fuel ought to be very attractive for the location of manufacturing concerns in that area. The development of the oil field is rather slow on account of deep drilling and if continued may result in opening a very important field.

Besides the fields mentioned there are still favorable areas which have not been tested.

KINGFISHER COUNTY.

LOCATION.

Kingfisher County is slightly northwest of the center of the State. Its shape is that of a square whose dimensions are 30 miles by 30 miles. It extends from T. 15 N. to T. 19 N., inclusive, and from R. 5 W. to R. 9 W., inclusive. It includes exactly 25 townships. The total area is 900 square miles.

TOPOGRAPHY.

This county lies entirely within the Redbeds Plains. The topography is that of a gently rolling prairie plain broken by the valley of Cimarron River and dissection by small valleys and canyons. The surface elevation ranges from 960 feet to 1,440 feet—a range of 480 feet. The lowest elevation is where Cimarron River crosses the east county line; the highest is in the southwestern part of the county, in sec. 32, T. 15 N., R. 9 W. Cimarron River and its tributaries drain the entire county.

GEOLOGY.

The rocks at the surface in Kingfisher County are Permian and Quaternary. The Permian rocks exposed belong to the Enid and the Blaine formation. The Enid formation consists chiefly of brick red clay shales, with some interbedded ledges of red and whitish sandstone. It occupies all the surface in Kingfisher County except a belt 10 miles wide along and almost entirely north of Cimarron River, and a very limited area in the extreme northwestern corner of the county. The former is Quaternary and the latter Blaine formation. The Blaine formation consists of massive gypsum ledges interbedded with red and blue clay shales. The Quaternary consists of alluvium and dune sand.

The fact that the dune sand is found north of Cimarron River is interesting. The prevailing wind is from the south. The Cimarron River carries large quantities of sand which it gathers farther west in the sand formations. During dry seasons the sand in the river valley becomes dry, and is easily blown by the strong south winds. It is true, however, that this area is also visited by quite strong winds from the north, but these are usually accompanied by precipitations which rob them of their sand carrying power.

STRUCTURE.

The general attitude of the rocks in Kingfisher County is that of a west-dipping monocline. There may be variations in this general west dip, though the predominance of shales in the Enid formation, and the large amount of Quaternary sand makes the work of locating them difficult.

SUMMARY.

Kingfisher County is within probable oil and gas territory, though the probable great depth to producing sands, together with the lack of surface indications of the underground structure. will cause development to be slow. Several locations for drilling have been reported near Hennessey in sec. 13, T. 19 N., R. 8 W. and in sec. 12, T. 19 N., R. 6 W.

KIOWA COUNTY.

LOCATION.

Kiowa County is located in the southwestern part of the State. It extends from T. 2 N. to T. 7 N., inclusive, and from R. 14 W. to R. 21 W., inclusive. It comprises 25 entire townships and parts of 9 others. The entire area is approximately 1,089 square miles.

TOPOGRAPHY.

The Wichita Mountains trend about N. 50° W. across and through the center of Kiowa County. These mountains consist for the most part of granite ridges, peaks, and knobs. To the north and south of the mountains are found the Redbeds Plains. These plains extend to the very foot of the mountains and, in fact, isolated ridges and peaks are found entirely surrounded by the plains. Near the mountains the plains are level. In the northern part of the county north of Hobart some prominent south-facing escarpments are found. These escarpments are held up by sandstone, calcareous sandstone, and dolomite ledges. The southwestern part of the county is drained by North Fork of Red River and streams tributary to it. The northeastern part is drained by streams tributary to Washita River.

GEOLOGY.

The rocks at the surface in Kiowa County are pre-Cambrian, Lower Paleozoic, and Permian. The Permian rocks exposed in the county have not yet been classified into formations as units. The strata consist of red shales, sandstones, and dolomites. Some of the sandstones are calcareous.

The Lower Paleozoic consists of the Viola limestone, Arbuckle limestone, and Reagan sandstone. These outcrops are very limited and confined to the northeastern parts of the county. They stand up above the surrounding plains and are known as the Limestone Hills.

The pre-Cambrian consists of gabbro, granite, and granite porphyry with the granite predominating.

STRUCTURE.

The Permian strata dip at a small angle away from the Wichita Mountains. In that part of the county north of the mountains the dip is north, while south of the mountains the dip is to the south. The Lower Paleozoic strata exposed in the northeastern part of the county dip at angles ranging from 5° to 20° to the northeast. These dips compared with the flat dips of the Permian indicate an unconformity at the north side of the mountains between the Permian and the Lower Paleozoic rocks. It is supposed that this same condition prevails south of the mountains. It is supposed also that the Pennsylvanian rocks underlie the Permian in Kiowa County, and that they are unconformable, though the difference in dip is not so great. It has been estimated that the lowest Pennsylvanian strata is present beneath the Permian at a distance of 8 1-2 miles northeast of the base of the Wichita Mountains. No figures are available as to its probable distance south of these mountains.

Detailed work may find folding favorable for the accumulation of oil or gas, indications of which may be at the surface. Such folding may or may not extend down into the Pennsylvanian. Also there may be favorable structure in the Pennsylvanian itself, indications of which are not apparent at the surface.

DEVELOPMENT.

The greater part of development in Kiowa County has been confined to the Gotebo field. This field lies in the northeastern part of the county near the town of Gotebo. At the close of 1910 about 42 wells had been drilled. Of this number 12 produced gas, 7 produced oil, and 17 were dry and were abandoned soon after being drilled. The following companies were active in the field during early development: Whitewater Oil & Gas Company, Gotebo Oil, Gas, and Brick Company, Deering Oil & Gas Co., and the New State Oil & Gas Company. The first named company was the most fortunate and has a gas franchise for the town of Gotebo.

Of the 25 wells drilled by Whitewater Oil & Gas Company, 5 were dry and 8 yielded some oil; only 3, however, were of sufficient size to be placed on the pump. The remaining 12 wells produced gas. The best well of this company produced 550,000 cubic feet of gas per day when first drilled. During 1908 the gas used for the wells of the above company amounted to 13,000,000 cubic feet.

Toward the close of 1913 the total number of wells was over 100. During 1914, 37 additional wells were drilled, thus bringing the total up to nearly 150. The following companies were operating a short time ago in this field: Della Dean Oil Company, Thomas Hollis Oil Company, W. B. Badgett, Boylen, et al, and J. A. Ward, West, and Rosser. The production ranges from 2 to 20 barrels per day per well, with an average of about 5 barrels. Production is found at depths ranging from 350 feet to 600 feet. Of the 37 wells completed in 1914, only one was dry and only two produced gas. The limits of the pool during 1914 were not much changed from that of 1909. The total initial production of wells completed was less than 190 barrels. Recently J. F. Nation has been drilling a deep test near the S. 1/4 corner of sec. 21, T. 7 N., R. 16 W. The result of this test is not yet known to the Survey.

Near Hobart several wells have been drilled and some small producers secured. None of the wells were of sufficient size, however, to pay for the cost of development.

SUMMARY.

Nearly all the accumulations of oil and gas in Oklahoma are found in strata within or just above the Pennsylvanian. There is probable unconformity between the Permian rocks and the underlying older rocks. These older rocks probably strike parallel to the axis of the Wichita Mountains and dip at right angles to any away from it, but at a steeper angle than the Permian strata. There may be favorable structure for the accumulation of oil or gas within the Pennsylvanian itself that is not apparent at the surface. Folding in the Permian may or may not extend down into the Pennsylvanian. The maximum production would be expected in favorable structure at or near the place where the Permian is in contact with th ends of oil or gas bearing sands, within the Pennsylvanian, though oil and gas might migrate great distances along the unconformity. It is probable that the lowest Pennsylvanian strata are 8 1/2 miles northeast of the base of the Wichita Mountains and that the productive Pennsylvanian sands are still further northeast. The small products at Gotebo and Hobart proves that there is oil and gas in Kiowa County. The problem is to find a structure favorably located in which there is considerable accumulation.

LATIMER COUNTY.

LOCATION.

Latimer County is situated in the southern part of east-central Oklahoma. It includes all of Tps. 3, 4, 5, and 6 N., Rs. 18, 19, and 20 E.; all of Tps. 5, and 6 N., R. 21 E.; all of T. 6 N., R. 22 E.; the E. ½ of Tps. 3, 4, 5, and 6 N., R. 17 E.; two rows of sections off of the south part of T. 7 N., Rs. 18 and 22 E. inclusive; 12 square miles off of the west side of T. 5 N., R. 22 E.; and all of Tps. 3 and 4 N., R. 21 E., except the east row of sections of each township. The total area is approximately 732 square miles.

TOPOGRAPHY.

Latimer County lies in part of two physiographic provinces—the Sandstone Hills region and the Ouachita Mountains region. The north half of the county is in the most rugged part of the Sandstone Hills. The area is occupied by the Sansbois and other mountains, which consist of massive sandstones and shales. The lowest elevation is in the central-eastern part of the county, along Fourche Maline Creek where the altitude is only 540 feet above sea level, while the highest elevation in the mountains to the north is more than 1,600 feet. The Ouachita Mountain uplift occupies a little more than half of the county, namely, all that part south of the Choctaw fault, which runs just to the south of the Chicago, Rock Island & Pacific Railroad in its course across the county. The Ouachita Mountain region consists of mountain-making sandstones interbedded with great thicknesses of shale. In the western part, near the fault, considerable limestone (Wapanucka) is also found, making conspicuous ridges. The elevations in this section of the county vary from about 540 feet, as above stated, along Fourche Maline Creek, to more than 2,000 feet in the Buffalo Mountains in the southeastern corner of the county. Throughout the south part of the county the elevations run from 800 to 1,500 feet, except in the vicinity of Buffalo Creek, along the south side, and along Jackson Creek in the extreme southeastern corner. The elevations along these streams range from 600 to 750 feet above sea level.

The drainage of the north side of the county is into streams which are minor tributaries to Canadian River. The northeastern part is drained by Brazil Creek, and the center of the county, from west to east, is drained by Fourche Maline Creek into Poteau River. The southern part of the county drains into tributaries of Kiamichi River.

GEOLOGY.

GENERAL STATEMENT.

This county includes parts of two geological provinces. The north half is in the area of Pennsylvanian rocks, and the south half is in the

Ouachita Mountain uplift, which is comprised of rocks chiefly older than Pennsylvanian.

The rocks of the Pennsylvanian area consist entirely of sandstones and shales which contain the principal coal beds of the State. The formations exposed are the Atoka formation, Hartshorne sandstone, McAlester shale, Savanna formation, and Boggy shale.

These formations are briefly described in the following paragraphs, and the extent of the exposed areas in each is given. For a complete discussion of the stratigraphy and a full description of the rocks the reader is referred to the discussion of "Geology" under Atoka, Coal, Haskell, and Pittsburg counties.

ATOKA FORMATION.

The Atoka formation comprises a strip to the center of the county along the Choctaw fault. The strip is from 1 to 3 miles wide, except at Wilburton and westward the outcrop widens to a maximum of 6 or 7 miles.

HARTSHORNE SANDSTONE.

The Hartshorne sandstone extends directly across the county in an east-west line along the northern edge of the Atoka outcrop. A small horseshoe-shaped area in the west side just north of the Choctaw fault is also surrounded by Hartshorne sandstone.

McALESTER SHALE.

The McAlester shale occupies an area of about 60 square miles across the north-central and in the northeastern corner of the county.

SAVANNA FORMATION.

The Savanna formation occupies three irregular areas in the northern part of the county.

BOGGY SHALE.

The Boggy shale occupies 50 to 60 square miles in the northern part of the county.

FORMATIONS SOUTH OF CHOCTAW FAULT.

Along the Choctaw fault zone the Atoka formation, the Wapanucka limestone, and Caney shale occur. Farther to the south the surface rocks consist of the Stringtown shale, Talihina chert, Stanley shale, and Jackfork sandstone. The Jackfork sandstone is the principal mountain-making formation of the region. The Talihina chert also forms many conspicuous hills and ridges. The Potato Hills consist chiefly of the rocks included in this formation.

For a full discussion of the rocks of the Ouachita Mountain region the reader is referred to "Pushmataha County," and the Wapanucka limestone is described under "Pittsburg County."

STRUCTURE.

CHOCTAW FAULT.

The greatly folded belt of the south half of the county is limited abruptly on the north by a very extensive fault. This great displacement is called the Choctaw fault and separates the more gently folded northwestward-dipping rocks on the northwest side from the overthrust southeastward-dipping older rocks of the southeast side. Instead of this being called a distinct fault it will be better to term the immediate locality of the displacement of rocks as a fault zone in which the line of displacement known as the Choctaw fault is the principal line in breaking, while there are many minor faults closely associated with the principal displacement. This fault zone enters the county near the center of the east side and bears west and southwest entirely across the county. The amount of displacement is very great, and in the folded regions on both sides of the mainfault line the rocks are steeply folded and contain many minor faults, many of which have no doubt been concealed by intense folding and overthrust faulting. In practically all cases of faulted folds the overthrust is to the northwest.

STRUCTURE SOUTH OF THE CHOCTAW FAULT.

The southern half of the county, as above indicated, lies to the south of the Choctaw fault, and as described, the entire area is much folded and faulted. Most of the stream valleys are anticlinal, and the rough, mountainous regions consist of massive sandstone comprising the synclinal areas. The dip of the rocks is in most cases sharp, and most of the folds are not symmetrical, and in many cases the folds have been broken by overthrust faulting. In addition to being sharply folded and faulted the formations are badly broken throughout the entire region.

The numerous occurrences of asphalt indicate that at some time oil was present in these formations, but the presence of the asphalt is also proof that the lighter oils have escaped, leaving behind the asphaltic base. It is probable that on account of the great thicknesses of shales some of the oil may have been sealed in. However, the chances for successful development are very slight.

CAVANAL SYNCLINE.

The axis of the Cavanal syncline extends from about Panola in the center of the county, eastward to the north of Redoak, Denman, and Barton, to the county line. From this point the axis extends in an almost direct northeast direction entirely through Leflore County. The broad trough of the syncline is marked by a line of abrupt hills and mountains.

BRAZIL ANTICLINE.

The Brazil anticline is a low fold, the axis of which is from 2 to 4 miles to the north of the axis of Cavanal syncline. The same structure extends into Leflore County, where the axes of the anticline and syncline grow farther apart. From the county line the anticline continues in a northeastward direction until it merges with the Backbone fault and anticline. The entire course of Brazil Creek is approximately on the axis of the structure.

The Latimer County Oil & Gas Company has some gas production on this anticline, about 4 miles north of Redoak. The presence of the gas found and the character of the structure indicate that the area along the axis is favorable for prospecting.

McALESTER ANTICLINE.

The McAlester anticline extends from Pittsburg County into Latimer County for a distance of about 5 miles, where it forks—one branch extending northeast for a distance of about 3 miles—the other branch extending a little south of east for a distance of about 4 miles, where it dies out or enters the Choctaw fault zone about 2 or 3 miles southwest of Wilburton. The fold is not symmetrical, the north slope being much steeper than that on the south. In fact, in places the rocks on the north side are almost vertical.

The reader is referred to "Pittsburg County" for a full description of the McAlester anticline.

SANSBOIS SYNCLINE.

The Sansbois syncline crosses the northwestern part of the county. It enters the west side of the county in sec. 27, T. 6 N., R. 17 E., and the axis extends in a direct line to the northeastward, crossing the county line in section 3, T. 7 N., R. 21 E., thus running a distance of about 25 miles across the county. The syncline is broad and the area embraced in the structure is occupied by the Sansbois Mountains.

DEVELOPMENT.

Only a few wells have been drilled in Latimer County. The Latimer County Oil & Gas Company has some gas production on the Brazil anticline north of Red Oak.

A well was drilled to a depth of more than 1,800 feet in sec. 8, T. 5 N., R. 18 E., near Wilburton, but no indications of either oil or gas were found.

Ringling and Brooks completed a dry hole in sec. 31, T. 3 N., R. 21 E., at a depth of nearly 3,000 feet. This location was in the vicinity of the Potato Hills in the southeastern part of the county, and was made on a sharp fold in the Ouachita Mountains and should be considered an excellent test for tha section of the country. A large volume of salt water was encountered, and at intervals flowed over the top of the casing. The presence of gas was detected and gas could be ignited at the top of the casing. Flakes of carbonaceous material, possibly some form of asphalt, were found at a depth of about 2,500 feet. Some very slight showings of oil were encountered at various depths. A great thickness of gray carbonaceous shale was penetrated in the lower part of the hole. The drilling was discontinued without further showings of either oil or gas.

SUMMARY.

Latimer County is partly in probable oil and gas territory. The rocks are those of the Pennsylvanian area south of Arkansas River in the northern part of the county, and those of the Ouachita Mountains in the southern part of the county. The Ouachita Mountain region cannot be considered as probable oil and gas territory, although it is possible that some deposits of small extent may be found in the region. The northern part of the county is in the probable oil and gas area. The rocks are the Pennsylvanian shales and sandstones, and the structure is favorable for the accumulation in some localities. The eastern part of the McAlester anticline enters the county from the territory where Gaines Creek crosses the county line and extends east about 10 miles to a point 2 or 3 miles southwest of Wilburton, where the fold dies out. At a distance of about 5 miles from the county line the fold sends out a branch to the north for a distance of a few miles. The Brazil anticline is in the extreme northeastern part of the county. This is a low fold with fairly gentle dips. The valley of Brazil Creek should consequently be a favorable locality for prospecting. The extreme eastern portion of the Adamson anticline reaches the northwestern part of the county in the northeastern part of T. 2 N., R. 17 E.

All the structural features in the county are very prominent and the geological formations are readily differentiated. All locations for tests may readily be located from a geological and structural standpoint, and future prospecting in this county should produce some good results.

LEFLORE COUNTY.

LOCATION.

Leflore County is located in the southeastern part of Oklahoma. It extends from T. 1 N. to T. 11 N. inclusive, and from R. 21 E. to R. 27 E. inclusive. It includes 36 entire townships and parts of 18 others. The total area is approximately 1,637 square miles.

TOPOGRAPHY.

Leflore County lies partly in the Sandstone Hills region and partly in the Ouachita Mountains region, the northern half in the former and the southern half in the latter. The topography is in general very rough and broken. The southern part is very mountainous. The most prominent elevations are Poteau, Kiamichi, Winding Stair, Rich, and Sugar Loaf mountains. Sugar Loaf Mountain is a high peak and has a drop of 2,000 feet in elevation in less than 3 miles.

The lowest point in elevation in the county is where Poteau River empties into Arkansas River just before crossing the line into Arkansas. The highest point is the top of Rich Mountain, in the N. ½ sec. 6, T. 2 N., R. 26 E., near Page. It has an elevation of 2,850 feet above sea level, and is one of the highest points in the State. The sandstone ledges are heavy and massive, and because of their resistance to erosion, form the higher hills. The shales, being softer, form the intervening valleys.

The greater portion of the county is drained by Poteau River and its tributaries. Poteau River is in turn a tributary to Arkansas River. Kiamichi River and Mountain Fork and their tributaries drain the extreme southern part of the county.

GEOLOGY.

The geology of Leflore County is somewhat complex. The Choctaw fault is a dividing line between the Ouachita uplift formations to the south and the Pennsylvanian series to the north. Within the central portion north of the Choctaw fault and the northern portion of the county the following Pennsylvanian rocks outcrop: Atoka formation, Hartshorne sandstone, McAlester shale, Savanna sandstone, and Boggy shale. In the northern portion of the county the first three formations named above are combined and known as the Winslow formation.*

South of the region of the Choctaw fault most of the stratigraphy has been worked out by Joseph A. Taff for the United States Geological Survey. The results have not been published. From available data the formations exposed are the Talihina chert of probable Ordovician age, the Standley shale, and Jack Fork sandstone of Mississippian age.

For a full description of geology see Pittsburg, Pushmataha, and Latimer counties.

STRUCTURE.

GENERAL STATEMENT.

The structure in this section of the State is more complex than in any other portion. The Ouachita uplift is responsible for the intense folding and faulting. The structure is more complex to the south of the Choctaw fault than to the north. The most prominent structural features are discussed under separate headings.

Snider** in his report on the geology of east-central Oklahoma has discussed the various structures, and his descriptions are incorporated in the following pages, along with additional data dealing with the structural features of Leflore County.

CHOCTAW FAULT.

LOCATION AND EXTENT.

This fault is the most extensive and prominent structural feature in the State. It enters Leflore County about a mile northwest of the town

*For a more detailed description of the Pennsylvanian series the reader is referred to Part I of this report, pp. 93-95.

**Snider, L. C., Geology of east central Oklahoma: Bull. Okla. Geol. Survey, No. 17, 1914, pp. 11-15.

of Leflore and extends in an east, then southeast direction to Houston, paralleling Fourche Maline Creek and Poteau River. From Houston it extends northeastward to the Arkansas line. Prospecting in the near vicinity of the Choctaw fault is not looked upon very favorably.

POTEAU SYNCLINE.

LOCATION AND EXTENT.

The Poteau syncline just north of the Choctaw fault as described in the report above mentioned is as follows:

This syncline is named from Poteau Mountains which lie in the syncline and extend from near Howe and Heavener eastward to the State line and for a considerable distance into Arkansas. West of the end of the mountains the axis of the syncline crosses the Kansas City Southern Railway between Heavener and Petros Switch and soon turns a little to the north of west and continues across the southern part of T. 5 N., R. 25 E., and T. 5 N., R. 24 E. The syncline ends in a basin-shaped structure near the west line of the latter township.

The chances for the occurrence of oil or gas in the area of this syncline are not very favorable. It is not known whether any wells have been drilled in the area of the Poteau syncline.

HEAVENER ANTICLINE.

LOCATION AND EXTENT.

The Heavener anticline lies to the north of the western portion of the Poteau syncline. The axis extends eastward along Fourche Maline. From this point eastward the axis rises very rapidly for a distance of about 4 miles and then descends as rapidly to a point about 2 miles northwest of Heavener. The Hartshorne sandstone and coal outcrop around the north side and east end of the anticline and make a pronounced loop to the westward on the south side. The rocks exposed in the anticline, therefore, belong to the Atoka formation. Measurements across the upturned edges of the rocks indicate that a thickness of 6,000 to 7,000 feet of this formation have been removed from above the axis of the anticline and the bottom of the formation is not yet exposed. The dips from the axis of the Heavener anticline are quite steep. The general dip to the south is about 30° and to the north and east is from 20° to 40°. The steepest dip observed is about 1 mile directly south of Glendale postoffice, where there is a dip of about 65° almost directly south. This is very near the axis of the anticline since one-fourth mile to the north there is a dip of 40° to the north. The rocks exposed in the axis of this anticline are the lowest in the entire area under consideration.

DEVELOPMENT.

Only one well drilled near this anticline has come to the notice of the writers. C. B. Shaffer is reported to have drilled a test in the NW. cor. of sec. 15, T. 5 N., R. 24 E. From last reports the well had been drilled to a depth of 3,200 feet and had encountered a showing of oil and gas in a 90-foot sand at a depth of 2,520 feet. This location is on the axis of the anticline. Several other locations have been reported but the writers have no data concerning them.

HOWE ANTICLINE.

LOCATION AND EXTENT.

An anticline, called by Taff the Howe anticline, branches from the east end of the Heavener anticline and extends northeast past Howe. Near the Chicago, Rock Island & Pacific Railway east of Howe this anticline branches, one branch continuing to the east past Hartford, Ark., and one continuing to the north to a point about 5 miles east of Poteau where it turns to the northeast and continues across the State line. The name Howe anticline was applied by Taff to the fold near Howe and to both branches as well. The eastward branch of the Howe anticline has been described by Collier* and by Smith** as the Hartford anticline and the northward branch by Smith as the Poteau anticline. These names will be accepted in this report and the name Howe anticline will be retained for the portion between the Heavener anticline and the junction of the Hartford and Poteau branches.

Taff's description of the Howe anticline is as follows:***

On the northeastern side of the Heavener anticline an anticlinal fold, which may be considered as a branch of the Heavener anticline, bears northeastward through the vicinity of Howe. From the location of Howe, nearly upon its axis, this anticline is known as the Howe anticline. A peculiar relation of the Howe to the Heavener anticline is that their axes do not join, yet the folds are not separated by any indication even of a syncline. * * * The crop of the Hartshorne sandstone southwest of Howe does not bear any indication of the effect of a branch fold. The next sandstone above the Hartshorne, however, diverges from the Heavener anticline near Poteau River and bears northeastward beyond Howe, where it crosses the axis of the Howe anticline and turns southward in the Poteau syncline. Between Howe and Monroe the Howe anticline divides into two folds, one of which bears due east between Poteau and Sugarloaf mountains, while the other turns north between Sugarloaf and Cavanal mountains, and then east into Arkansas, north of Sugarloaf Mountian. Both branches of this fold are wide and flat. The valleys occupied by the Howe anticline are eroded in McAlester shale. The grades of the streams are very low and the valleys are practically level plains stretching between the mountains from base to base.

No prospecting or development of importance has been made on this anticline.

HARTFORD ANTICLINE.

LOCATION AND EXTENT.

As has been said, the east branch of the Howe anticline is known as the Hartford anticline from Hartford, Arkansas. This anticline is eroded into a valley in the McAlester shale, so that it is difficult to locate the

*Collier, A. J., The Arkansas Coal Field; Bull. U. S. Geol. Survey, No. 326, 1907.

**Smith, Carl D., Structure of the Fort Smith-Poteau Gas Field, Arkansas and Oklahoma; Bull. U. S. Geol. Survey, No. 541-B, 1913.

***Taff, J. A., Nineteenth Ann. Rept. U. S. Geol. Survey, Part II, pp. 281-282.

axis accurately, but it is almost coincident in Oklahoma with the course oi Sugarloaf Creek. Farther east, in Arkansas, the Atoka formation is exposed near the axis of this anticline and gas has been produced from sands in the Atoka near Mansfield. No drilling has been done on this anticline in Oklahoma.

POTEAU ANTICLINE.

LOCATION AND EXTENT.

From its junction with the Hartford anticline the Poteau anticline extends almost northeast to a point about due east of Poteau where it gradually turns more nearly to the east and crosses the State line into Arkansas in an almost straight east-west direction. It continues into Arkansas for about 12 miles. As is the case with the Hartford anticline the rocks in the Poteau anticline are those of the McAlester shale. Exposures near the country town of Gilmore indicate that the axis passes very near that place, from which fact the anticline has been called by some the Gilmore anticline. The name Gilmore in some respects is preferable to Poteau, since Poteau is well down on the western limb of the anticline and is as near the axis of the syncline (Cavana) as it is to the axis of the anticline. The dip of the rocks away from the axis of the Poteau anticline is not very steep; the dip to the northwest being 3° to 5° and that to the southeast less than that. Gas in considerable quantities has been found in this anticline east of Poteau in the Hartshorne sandstone.

The development will be discussed under the heading "Development" in this county.

SUGARLOAF SYNCLINE.

LOCATION AND EXTENT.

This syncline lies between the Hartford and Poteau anticlines and is named from Sugarloaf Mountains which are very conspicuous topographic features occupying the portion of the syncline near the axis. The mountains are composed principally of the Savanna formation and are topped by Boggy shale. The dip of the rocks into the syncline is low, not exceeding 5° and usually considerably less than that. The strata in the mountains near the axis are practically level. The syncline extends from near the junction of the Hartford and Poteau anticlines northeastward across the State line and for several miles into Arkansas.

CAVANAL SYNCLINE.

LOCATION AND EXTENT.

The Cavanal syncline is a broad trough which extends from the vicinity of Red Oak eastward and northeastward across the State line and for many miles into Arkansas. Potato Peaks and Cavanal Mountain lie in this syncline.

BRAZIL ANTICLINE.

LOCATION AND EXTENT.

The Brazil anticline enters Leflore County from Latimer County, about a mile west of Walls and extends in a northeast direction to about a mile southeast of Bordeaux. The McAlester shale is the lowest formation exposed. There is a dip from 5° to 8° on the southeastern limb of the anticline and from 12° to 18° on the northwestern limb.

DEVELOPMENT.

No development on this anticline in Leflore County has come to the notice of the writers, but in Latimer County the Latimer County Oil & Gas Company has some gas production near the axis of the anticline about 4 miles north of Red Oak.

BACKBONE FAULT AND ANTICLINE.

LOCATION AND EXTENT.

The Backbone anticline extends eastward from a point about two miles south of Bokoshe, eastward past Panama and north of east as far as Greenwood, Arkansas. The anticline is faulted for a considerable portion of its length, the beds on the south side of the fault being thrust over younger beds to the north. The atoka formation is brought to the surface in the axial portion of the anticline, and the Hartshorne sandstone and coal outcrop around it. The dips in both directions from the axis of this anticline (or the fault) are rather steep, ranging from 12° to 20°, or even more.

BOKOSHE SYNCLINE.

LOCATION AND EXTENT.

This syncline extends north of east from Bokoshe to Spiro. From Spiro eastward and northeastward to Arkansas River the country is sand-covered and the axis of the syncline cannot be definitely located.

MILTON ANTICLINE.

LOCATION AND EXTENT.

Beginning near Lequire, the Milton anticline extends east and northeast, passing through or near Lequire, McCurtain, Milton, and Bokoshe, and to Arkansas River near Redland. Near McCurtain this fold rises in a dome around which the Hartshorne (Panama) coal outcrops. In this dome the rocks are considerably disturbed and there are several local faults which are shown by the displacement of the coal in the mines, but which are seldom noticeable on the surface. For a short distance west of Lequire the Ft. Smith & Western Railway lies practically on the north of the axis, but crosses it again about two miles west of McCurtain. From this place to Milton the railroad is approximately one-half mile south of the axis. At Milton the axis swings somewhat to the north and passes nearly midway between the old and new towns of Bokoshe, and extends northeastward about one-half mile west of Redbank Creek to the confluence of that stream with Cache Creek, and to the Arkansas.

COWLINGTON SYNCLINE.

LOCATION AND EXTENT.

The Cowlington syncline cuts through the extreme northwestern corner of the county, north of Cowlington, entering from Haskell County and extending into Sequoyah County from Leflore County. The features of this syncline are discussed in more detail under the same title under the heading of "Structure" of Haskell County.

STRUCTURE IN THE AREA SOUTH OF THE CHOCTAW FAULT.

GENERAL STATEMENT.

The structure of this area is very complex, more so than any other portion of the State. The strata are very highly tilted, warped, and faulted in a large measure. In many cases the folds have been completely overturned. Detailed work has been done by the United States Geological Survey, but as stated before the results have not been published, so that the locations of the folds and faults are not available at this time.

DEVELOPMENT.

GENERAL STATEMENT.

The only area that has received much development is the Poteau field. However, in a few other areas sufficient showings of gas have been encountered to indicate that more development in these areas will follow. In addition to some miscellaneous drillings, 4 or 5 wells near Spiro are gas producers.

POTEAU FIELD.

LOCATION AND EXTENT.

The Poteau gas field is located about 4 miles east of Poteau in Leflore County. The field so far developed includes an area of about 4 square miles.

GEOLOGY, STRUCTURE, AND DEVELOPMENT.

The surface rocks are the McAlester shale, which varies in thickness throughout the area on account of erosion having removed some of the upper part of the formation. All of the gas wells in the Poteau field are located on or near the axis of the Poteau anticline, which extends in a northeast-southwest direction from just east of Howe for a distance of 12 miles across the Arkansas line.

The first well in this region was drilled in July, 1910. To date of going to press more than 15 wells have been drilled, most of which are the property of the Leflore County Gas & Electric Company. During 1914, 4 wells were completed in this field. The initial capacity varies from 250,000 to 18,000,000 cubic feet of gas per day with an average rock pressure of about 400 pounds. The production comes from about the upper 200 feet of Hartshorne sandstone or from the lower sands of the McAlester shale. The producing sand usually measures 200 to 220 feet in thickness. In the well near Cameron only 55 feet of sand were found.

In Massard Prairie, 5 miles southeast of Ft. Smith, Ark., the gas wells range in depth from 1,312 to 2,845 feet. In the deepest well 17 sands were encountered in 2,845 feet, but not all were productive. The most productive sands are between 1,000 and 2,100 feet. The wells vary in capacity from 140,000 to 4,250,000 cubic feet of gas, and show rock pressure from 145 to 280 pounds to the square inch. All of the wells start in or near the Hartshorne sandstone, and the gas is obtained from the Atoka formation. The following logs of wells in this area, one east of Poteau from which a production of 12,000,000 cubic feet of gas per day was reported, and the other, a well located near Cameron, are representative of these two areas.

Log of gas well 3½ miles east of Poteau.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Conductor	6	6	Lime	7	1,077
Hard shell	18	24	Black shale	553	1,630
Shale—water	136	160	Black sandy shell	25	1,655
Shell	30	190	Black shale	42	1,697
Black slate	80	270	Coal (gas)	3	1,700
Hard shell	5	275	Hard shell	2	1,702
Black slate	60	335	Black shale	94	1,796
Shell	20	355	Black hard shell	4	1,800
Black slate—water	290	645	Black sand shell	20	1,820
Sandy shale	60	705	Gray sand	15	1,835
Black slate	145	845	Black and gray sand	33	1,868
Sandy shale	15	860	Gray sand, gas	32	1,900
Black shale	210	1,070			

Log of well in Massard Prairie, 5 miles southeast of Fort Smith, Ark.

Character of Rock.	Thickness.	Depth.	Character of Rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Top and shale	150	150	Sand	30	1,975
Sand	19	169	Shale	45	2,020
Shale	221	390	Sand	185	2,205
Sand	15	405	Shale	47	2,252
Shale	20	425	Sand	28	2,280
Sand	25	450	Shale	90	2,370
Shale	245	605	Sand	15	2,385
Sand	40	735	Shale	150	2,535
Shale	10	745	Sand	25	2,550
Sand	25	770	Shale	5	2,555
Shale	235	1,005	Sand	8	2,563
Sand	15	1,020	Shale	44	2,607
Shale	95	1,115	Sand	30	2,637
Sand	253	1,378	Shale	16	2,653
Shale	122	1,500	Sand	20	2,673
Sand	52	1,552	Shale	172	2,845
Shale	393	1,945			

Summary of drilling in Poteau gas field, Leflore County.

Location.	Capacity.		Depth.	Rock Pres.		Remarks.
	Initial.	Present.		In.	Pr.	
Middle sec. 27, T. 7 N., R. 26 E.	1,800,000	5,500,000	1,466	204	412	Sand 220 ft.
East side sec. 21, T. 7. N., R. 26 E.	1,800,000		1,803	355		Lost in 1912 in attempting to pull casing.
NW. ¼ sec. 3, T. 7 N., R. 26 E.	Unknown	500,000	1,303	300	350	Sand 55 ft. thick. Cameron.
NW. ¼ sec. 3, T. 7 N., R. 26 E.	500,000	500,000		250	250	
NE. ¼ sec. 23, T. 7 N., R. 26 E.	1,000,000	500,000	1,575		402	Tubing and packer lost. Caved-plugged.
Center sec. 34, T .7 N., R. 26 E.	2,000,000		1,600	350	412	
NE. ¼ sec. 34, T. 7 N., R. 26 E.		5,000,000	1,535		412	
SW. ¼ sec. 35, T. 7 N., R. 26 E.	250,000		1,950			Caved badly. Plugged.
SE. ¼ sec. 27, T. 7 N., R. 26 E.	10,000,000	18,000,000	1,490	412	412	
SE. ¼ sec. 27, T. 7 N., R. 26 E.	200,000		2,600			Caved badly. Plugged.
SE. ¼ sec. 27, T. 7 N., R. 26 E.	5,000,000	5,000,000	1,513	412	412	
NE. ¼ sec. 21, T. 7 N., R. 26 E.		2,000,000	1,912		412	
Sec. 36, T. 7 N., R. 26 E.		500,000	1,450		220	
NE. ¼ sec. 5, T. 7 N., R. 27 E.						1913. Dry. Showing of oil. Abandoned.
Sec. 5, T. 7 N., R. 26 E.						1914. Showing of oil. Abandoned.

The production of the wells in this field is reported to be about 12,000,000 cubic feet per day, with a gas pressure averaging about 400 pounds to the square inch. Gas from these wells has been piped to the town of Poteau for domestic consumption. Several industries have located at Poteau on account of the fuel facilities of the gas field, and several others, especially glass plants are considering locating here.

In case of future drilling it would seem best to keep fairly close to the axis of the anticline, since all of the big wells so far drilled hold this position. It is true, however, that because of tightening and thinning of the sand that big production may not always be found. All other things being equal, however, the most favorable location seems to be at or near the highest point of the structure if the largest gas production is desired. It is impossible, however, to draw even a proximate conclusion as to possibilities for oil from the dip. In case any wells are drilled for oil, it will be necessary in order to reach the proper depth to drill deeper, since the rocks dip away from the axis of the anticline 260 to 300 feet to the mile. It will probably be best under such circumstances to drill just a short distance down the dip from the farthermost producing gas well, as it is easily possible where rocks have such a high angle of dip, to begin too near the syncline.

MISCELLANEOUS DRILLING.

A well near Bokoshe, in sec. 5, T. 8 N., R. 24 E., showed some gas but no oil. The capacity of the well is unknown. This well is a little more than one-half mile south of the axis of the Milton anticline. Probably the most promising place on the structure is the doming which occurs near McCurtain. The rocks as a whole are rather steeply tilted and considerably faulted, locally.

Near Panama a well has been drilled which showed some gas. This well probably was intended to be placed on the Backbone fault and anticline which passes northeast a mile or so north of the town. The anticline is faulted over a large part of the region, and the beds to the south are thrust over the younger beds to the north. The Atoka formation outcrops along the axis. Rock dips range from 12° to 20°, or even more.

In the region of Spiro, in northern Leflore County, 4 or 5 wells located on the anticline passing through Spiro are gas producers reported at 750,000 to 3,000,000 cubic feet per day.

SUMMARY.

The northern half of Leflore County, the area north of the Choctaw fault, is considered probable territory for oil and gas. The production so far has been gas, and only a few showings of oil have been reported from the wells drilled in this county. It is thought that many locations along the Heavener, Howe, Poteau, Hartford, Milton, and Backbone anticlines might be productive of gas. However, the Backbone anticline has been faulted in part making prospecting precarious, because the fracturing of the strata may have furnished a means of escape, and thus preventing accumulation of gas in large quantities.

In the region to the south of the Choctaw fault, little is known concerning the prospects for the occurrence of oil and gas in commercial quantities. From the available data at hand the area does not appear to be favorable, for the reason that the folding and faulting were so severe that the oil and gas if present in the rocks would have an easy means of escape. The presence of known asphalt deposits in the area indicate that some of the petroleum has escaped. Whether or not it is all gone is a question which we are unable to answer.

LINCOLN COUNTY.

LOCATION.

Lincoln County lies slightly north and east of the center of the State. It extends from T. 12 N. to T. 17 N. inclusive, and from R. 2 E. to R. 6 E. inclusive. It includes 25 whole townships and parts of 5 others. The total area is approximately 990 square miles. It is regular in shape, being a rectangle 33 miles long and 30 miles wide.

TOPOGRAPHY.

Lincoln County lies within the Sandstone Hills region. The topography is usually that of a rolling or hilly surface; the eastern part being timbered and the western part mostly prairie. In the eastern part of the county the streams have dissected the surface, giving rise to a rough topography. The Neva limestone forms an escarpment, capping the tops of the hills in the vicinity of Avery and west of Kendrick. The surface varies in elevation from about 760 feet to 1,080 feet, the lowest being where Deep Fork of Canadian River flows out of the county, and the highest at the town of Carney.

Deep Fork of Canadian River and its tributaries drain the whole county with the exception of a small area along the northern boundary, which is drained by tributaries of Cimarron River.

GEOLOGY.

The surface rocks in Lincoln County consist of Permian Redbeds, red-Pennsylvanian, and light-colored Pennsylvanian. Beede* has mapped the approximate boundary between the Permian and Pennsylvanian as an irregular north-south line extending through the center of the county, the Permian rocks occupying the western part of the county and the Pennsylvanian the eastern part.

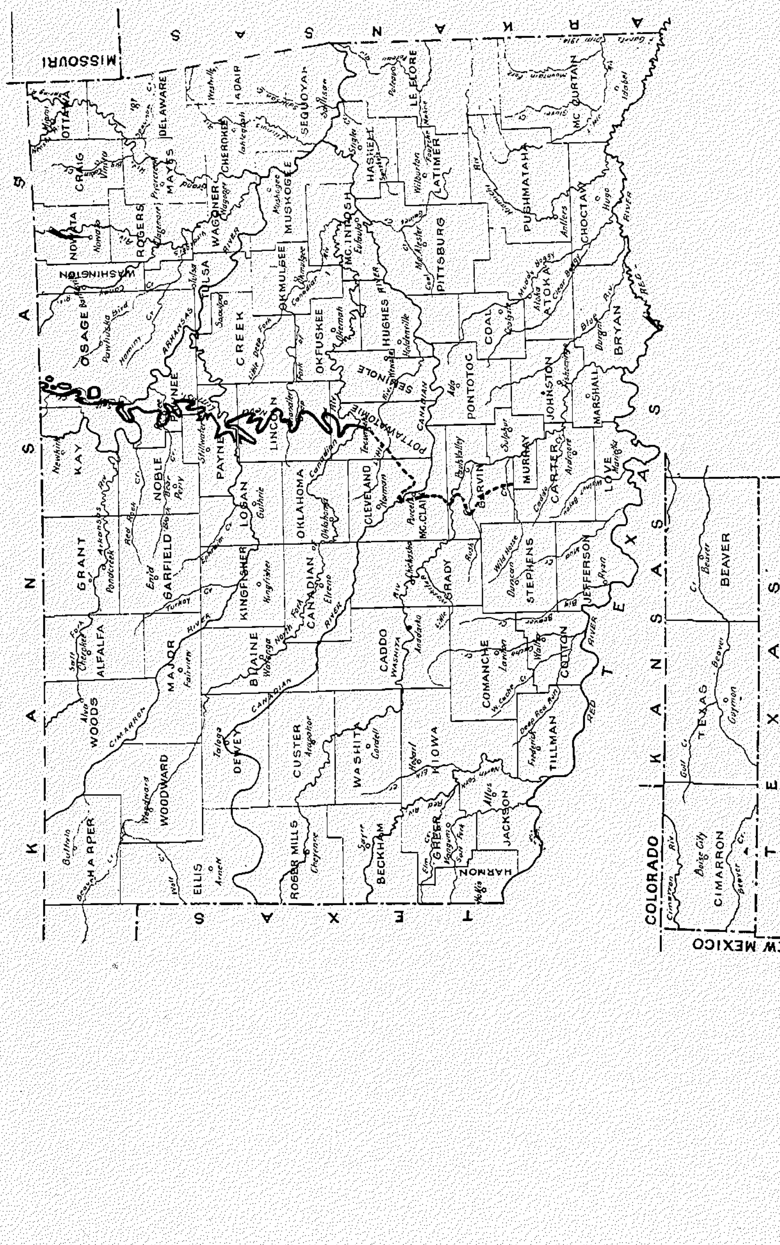
The map on page 299 shows the generalized outcrop of the Neva limestone, and the sandstones which replace it south of the Cimarron River. The base of the Permian is below the Neva as represented by the line, but the contact of the Permian and Pennsylvanian is so closely associated that the line may be regarded as the eastern edge of the Permian rocks in this section of Oklahoma.

*See figure 7 on page 299.

The Permian and red-Pennsylvanian rocks consist of red sandstones and shales, forming prominent sandstone escarpments. The latter series of rocks in addition includes some thin, irony and sandy limestones. The principal feature of the red-Pennsylvanian is a thin-bedded limestone which appears on the margin of the highest lands to the north and west of Kendrick. The same outcrop can be traced north to Payne County line. It appears that this limestone is probably the horizon of the Neva limestone. To the east of this outcrop the formations are sandstones of all kinds, shales, and siliceous, white to red, massive limestones. The formations usually encountered in drilling are shown by the following well log:

Chandler deep well, in sec. 4, T. 14 N., R. 4 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Red clay	30	30	Lime	4	1,394
Red sand	30	60	Blue mud	10	1,404
Water, sand	5	65	Lime	2	1,406
Water, sand	70	135	Red mud	20	1,426
Red shale	30	165	Red shale	50	1,476
White shale	70	235	Sand	24	1,500
Red shale	10	245	Blue mud	50	1,550
White shale	15	260	Red mud	40	1,590
Red shale	30	290	Sand	30	1,620
White shale	30	320	Blue mud	30	1,650
Blue shale	30	350	Red rock	40	1,690
Red shale	200	550	Sand	30	1,720
Water, sand	10	560	Red mud	40	1,760
Blue shale	40	600	Blue mud	20	1,780
Red shale	40	640	Water, sand	20	1,800
Lime	5	645	Lime	10	1,810
Blue shale	10	655	Blue mud	40	1,850
Water, sand	15	670	Water, sand	50	1,900
Blue shale	20	690	Blue mud	75	1,975
Lime	6	696	Water, sand	25	2,000
Blue shale	10	706	Blue mud	20	2,020
Water, sand	40	746	Sand	60	2,080
Blue shale	50	796	Blue mud	10	2,090
Red shale	30	826	Sand	50	2,140
Yellow clay	15	841	Blue mud	10	2,150
Blue shale	20	861	Water, sand	50	2,200
Red shale	4	865	Blue mud	20	2,220
Sand	8	873	Sand	20	2,240
Blue shale	6	879	Blue shale	60	2,300
Water, sand	30	909	Sand shale	4	2,304
Blue shale	50	959	Blue shale	76	2,380
Red shale	31	990	Water, sand	10	2,390
Lime	8	998	White slate	5	2,395
Yellow clay	20	1,018	Brown slate	13	2,408
Red shale	182	1,200	Lime and sand	20	2,428
Water, sand	80	1,280	Blue shale	7	2,435
Blue shale	20	1,300	Sand and lime	40	2,475
Lime	20	1,320	Blue shale	5	2,480
Blue mud	70	1,390	Sand	45	2,525



MAP SHOWING APPROXIMATE EASTERN LIMIT OF PERMIAN ROCKS.

Figure 7.

STRUCTURE.

The general structure of the county is that of a gentle westward-dipping monocline, the dip ranging from 20 to 100 feet per mile, except where interrupted by a reversal dip to the east.

Only preliminary reconnaissance work has been done over the northeastern part of the county in the vicinity of Kendrick and Avery. In this area no definite structure could be worked out. However, there may be such, but the formations in certain parts of the area are too uncertain to make correlations for the determination of folding.

Two miles due west of Avery there appears to be an irregularity in the normal west dip. Detailed work might reveal the presence of some kind of structure in this locality.

In the SE. ¼ of sec. 31, T. 17 N., R. 5 E., there appears to be a slight northeast dip, and also a southwest dip, which if true indicates an anticline or dome. The structure, if any, could not be traced from the above locality on account of poor exposures.

DEVELOPMENT.

There is much activity in Lincoln County, especially in the northeastern part. Snowden and Leschen drilled one of the deepest tests in the State in the NW. corner of NW. ¼ sec. 16, T. 16 N., R. 5 E., to a depth of 3,915 feet. Showings of oil were reported at depths of 2,748, 3,375, 3,419 feet respectively, and gas at 3,425 feet. In correlating the sands encountered with those in the Cushing field the 25-foot sand at a depth of 2,310 feet is probably equivalent to the Layton, the 210-foot sand at 2,940 feet equivalent to the Wheeler, and the 48-foot sand at 3,427 feet equivalent to the Bartlesville. The complete correlation of the formations encountered in this well is given in the correlation table of Oklahoma oil sands included in this report. The following log is that of the above mentioned well:

Leschen & Snowden well, in NW. cor. NW. ¼ sec. 16, T. 16 N., R. 9 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	18	18	Blue rock	20	385
Brown shale	12	30	Red rock	40	425
Red rock	30	60	Sand	10	435
Brown rock	30	90	Red rock	55	490
Red rock	45	135	Sand	25	515
Sand rock	20	155	Red rock	55	570
Red rock	30	185	Lime	15	585
Sand and water	20	205	Red rock	10	595
Red rock	27	232	Lime	35	630
Sand	16	248	Sand	10	640
Shale	62	310	Lime	12	652
Red rock	15	325	Blue mud	38	690
Sand	8	333	Sand	30	720
Red rock	17	350	Lime	8	728
Lime	8	358	Sand	47	775
Red rock	7	365	Blue slate	13	788

Leschen & Snowden well, in NW. cor. NW. ¼ sec. 16, T. 16 N., R. 9 E.
(Continued.)

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Shell	5	793	Dark slate	90	2,425
Pencil cave	32	825	Lime sand	15	2,440
Shell	15	840	Black slate	75	2,515
Red and blue rock	70	910	Lime	5	2,520
Blue shell	8	918	Black slate	50	2,570
Blue shale	7	925	Shell	5	2,575
Red rock and caving	35	960	Black slate	157	2,732
Pinch cave	22	982	Lime	6	2,738
Sand	58	1,040	Black slate	10	2,748
Slate	20	1,060	Sand (show oil)	4	2,752
Sand	10	1,070	Water	23	2,775
Slate	36	1,106	Sand	15	2,790
Lime	12	1,118	Slate break	5	2,795
Slate	22	1,140	Sandy shale	95	2,890
Shell	8	1,148	White slate	40	2,930
Slate	47	1,195	Black slate	10	2,940
Sand, water	85	1,280	Gray sand	210	3,150
Red rock	20	1,300	Sandy shale	95	3,245
Sand	32	1,332	Slate	10	3,255
Slate	73	1,405	Shell	65	3,320
Red rock	15	1,420	Slate	5	3,325
Sandy slate	45	1,465	Shell	15	3,340
Sand, water	20	1,485	Limy sand	60	3,400
Slate	25	1,510	Black shale	27	3,427
Shell	6	1,516	Lime and sand	1	3,428
Slate	4	1,550	Brown sand	7	3,435
Shell	5	1,555	White sand	25	3,460
Slate	5	1,660	Dark sand	15	3,475
Shell	6	1,666	Black shale	10	3,485
Slate	34	1,700	Lime and sand	3	3,488
Sand	24	1,724	Very dark sand	12	3,500
Slate	26	1,750	Black shale	60	3,560
Sand	200	1,950	Black slate	130	3,645
Sandy slate	20	1,970	Lime	6	3,651
Black slate	10	1,980	White slate	9	3,660
Blue slate	48	2,028	Red rock	5	3,665
Lime slate	2	2,030	Blue slate	40	3,705
Slate	45	2,075	Light gray sand	10	3,715
Sand	5	2,080	Black slate	80	3,795
Hard lime	5	2,085	Sand	45	3,840
Lime sand	25	2,110	Blue shale	40	3,880
Blue slate	200	2,310	Black shale	35	3,915
Layton sand	25	2,335	Total depth		3,915

A well has been reported to have been drilled in the NE. ¼ of sec. 2, T. 16 N., R. 5 E., northeast of Avery and abandoned. Another well reported to have been abandoned at a depth of over 2,000 feet, was drilled by T. B. Slick in sec. 13, of the same township and range. A deep well was drilled at Chandler in sec. 4, T. 14 N., R. 4 E. to a depth of 2,525 feet and abandoned. A well was drilled near Fallis to a depth of more than 2,500 feet and then abandoned as a failure without having had a showing of either oil or gas. The Meeker Oil and Gas Company abandoned their test in sec. 4, T. 14 N., R. 4 E. near Meeker, as a failure at a depth of 3,150 feet without encountering a showing of oil or gas. Luther and others are drilling a test in sec. 34, T. 14 N., R. 2 E., near Wellston. The Universal Oil Company has made a location for a test in the NE. 1/4 sec. 30, T. 17 N., R. 3 E., south of Vinco. The Monitor Oil & Gas Company encountered 10,000,000 cubic feet of gas in their test in sec. 6, T. 15 N., R. 17 W., in Creek County just across the Lincoln County line, at a depth of 1,250 feet.

The Roxana Petroleum Company in their test in sec. 30, T. 17 N., R. 3 E., encountered a volume of gas estimated at about 30,000,000 cubic feet from a sand at a depth of 1,485 feet. The gas was mudded in and drilling was continued.

SUMMARY.

All of Lincoln County may be considered as probable territory for the occurrence of oil and gas. The Permian rocks are not thick and can usually be easily passed through. The petroliferous horizons of other fields in the northeastern part of the State are supposed to pass beneath this area. Formations in the Cushing field would probably be encountered in the eastern part of Lincoln County at approximately 700 feet greater depth. Westward the formations will be encountered still deeper. A test should not be abandoned at a depth less than 3,500 feet. The eastern part of the county in proximity to the Shamrock field will probably receive the first development, but the north and central parts will receive more attention than heretofore given and this may result in discovering new fields.

LOGAN COUNTY.

LOCATION.

Logan County is located a little north of the center of the State. It extends from T. 15 N. to T. 19 N. inclusive, and from R. 4 W. to R. 1 E. It includes 19 entire townships and parts of 3 others. The total area is approximately 742 square miles.

TOPOGRAPHY.

Logan County is entirely within the Redbeds Plains region. The topography is that of a rolling prairie plain. The surface is much broken and eroded in the southern and eastern portions. Farther north, however, flat areas are not uncommon. The surface varies in elevation from 860 feet to 1,280 feet, the highest point being in the N. 1/2 of sec. 17, T. 15 N., R. 1 W., about 2 miles southwest of Beulah, and the lowest in the east-central part of the county on Cimarron River.

The principal stream is Cimarron River, which drains almost the whole area with the exception of the southeastern part of the county. Tributaries of Deep Fork drain the latter area. The most important tributaries of the Cimarron are Beaver, Ephriam, and Spring creeks.

GEOLOGY.

The surface rocks in Logan County are in the Enid formation of the Permian Redbeds. They consist of soft red shales, clays, and sandstones. The latter vary in color from red to white, and in character from massive to soft and friable, and are usually cross-bedded. In some localities the sandstones are conglomeratic. In exposures the shales and hard sandstones alternate, giving rise to sandstone escarpments, where the shale or soft sandstone has weathered out from beneath the hard and more resistant layers of sandstone. Outcrops of this nature were noted along the south bank of Cimarron River, and in the Mulhall and Orlando areas. From well records it seems that the thickness of the red-Permian and red-Pennsylvanian is about 1,500 feet.

The following logs of wells drilled in Logan County give an idea of the formations encountered.

Well at Mulhall in NE. ¼ sec. 4, T. 18 N., R. 2 W.

Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*
Surface soil	47	47
Red shale	225	272
Lime	3	275
Red shale	21	296
Sand	6	302
Gray shale	5	307
Lime	28	335
Red shale	103	438
Lime	12	450
Red shale	135	585
Lime	17	602
Gray shale	13	615
Lime	28	643
Gray shale	32	675
Red shale	5	680
Lime	55	735
Gray shale	45	780
Gray shale	128	908
Lime	9	917
Gray shale	8	925
Lime	3	928
Gray shale	12	940
Sand	18	958
Gray shale	57	1,015
Red shale	30	1,045
Brown shale	25	1,070
Lime	4	1,074
Blue shale	41	1,115
Lime	22	1,137
Sandy shale	28	1,165
Sand	30	1,195
Blue shale	17	1,212
Lime	19	1,231
Gray shale	29	1,260
Lime	6	1,266
Red rock	5	1,271
Blue shale	43	1,314
Lime and shale	6	1,320
Sand and water	12	1,332
Red rock	2	1,334
Sand	21	1,355
Shale	14	1,369
Lime	8	1,377
Brown shale	23	1,400
Sand shale	13	1,413
Brown shale	17	1,430
Blue shale	7	1,437
Lime	8	1,445
Blue shale	38	1,483
Lime	20	1,503
Blue shale	17	1,520
Brown shale	5	1,525
Sand (showing)	15	1,540
Sand and shale	10	1,550
Blue shale	10	1,560
Loose sand	10	1,572
Fine sand	4	1,576
Red shale	4	1,580
Salt water sand	30	1,610
Red shale	5	1,615
Salt water sand	20	1,635
Red shale	5	1,640
Blue shale	15	1,655
Lime	5	1,660
Red shale	15	1,675
Sand and water	15	1,690
Blue shale	10	1,700
Sand	5	1,705
Blue shale	35	1,740
Shale and lime	10	1,750
Brown sand	10	1,760
Blue shale	10	1,770
Brown shale	5	1,775
Blue shale	15	1,790
Sand shale	5	1,795
Blue shale	10	1,805
Red shale	20	1,825
Lime and sand	5	1,830
Blue shale	10	1,840
Blue sandy shale	10	1,850
Blue shale	10	1,860
Brown shale	10	1,870
Red shale	10	1,880
Abandoned in lime formation.		

Meridian well, in NW. ¼ sec. 30, T. 16 N., R. 1 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface	45	45	White sand (gas)	20	2,080
Sand	20	65	Gray sand (salt water)	10	2,090
Red shale	540	605	Lime	50	2,140
Brown shale	235	840	Black shale, hard shell	5	2,145
Red shale	40	880	Gray sand (some gas and salt water)	10	2,155
Red sand (salt water)	15	895	Black shale shell	30	2,185
Red shale	5	900	Red shale shell	15	2,200
White sand (salt water)	20	920	Brown shale shell	12	2,212
Red shale	40	960	Gray shale shell	3	2,215
Brown shale	10	970	Flinty lime	37	2,252
Red shale	45	1,015	Black shale shell	16	2,268
Blue shale	5	1,020	Lime	42	2,310
White sand	10	1,030	Black shale	18	2,328
Brown sand (salt water)	20	1,050	White sand (some gas salt water)	22	2,350
Brown shale	10	1,060	Gray sand, salt water	2	2,352
Dark brown shale	120	1,180	Lime, Miss.	10	2,362
Gray shale	10	1,190	Lime and sand	5	2,367
White shale	50	1,240	Black shale	22	2,389
Blue shale	60	1,300	White lime	5	2,394
Gray shale	35	1,335	Gray bastard rock	9	2,403
Red shale	15	1,350	Brown shale	46	2,449
White shale	30	1,380	Hard shell	1	2,450
Black shale	145	1,525	Mottled red, white and blue shale	44	2,494
Gray shale	80	1,605	Lime	4	2,498
Gray lime	10	1,615	Gray shale	18	2,516
White shale	105	1,720	Hard shell	2	2,518
Blue shale	60	1,780	Light blue shale	10	2,528
White sand (salt water)	5	1,785	Dark blue shale	24	2,552
Brown shale	10	1,795	White sand, dry	26	2,578
Lime	10	1,805	Lime, Miss.	15	2,593
Brown shale and hard shell	70	1,875	Blue shale	44	2,637
Red shale	30	1,905	White sand (salt water)	27	2,664
Gray sand (salt water)	9	1,914	Blue shale	20	2,684
Black shale	55	1,969	Gray lime	12	2,696
Red shale	11	1,980	Blue shale	18	2,714
Lime	8	1,988	Gray lime	5	2,719
Gray and red shale	61	2,049	Dark blue shale	8	2,727
Gray sand (salt water)	11	2,060			

STRUCTURE.

Reconnaissance field work of a preliminary nature has been done over certain parts of the county. The general dip of the rocks throughout the county is to the west about 20 feet per mile. At different places the normal dip varies and in some cases there is a reversal dip to the east.

Four miles south of Mulhall, in the vicinity of the well being drilled by the Big Star Oil Company, in sec. 21, T. 18 N., R. 2 W., there seems to be a variation in the normal dip. Detailed work in this area might show features of probable structure. Northeast of Mulhall in secs. 26 and 27, T. 19 N., R. 2 W., there is another variation in the normal dip, which suggests possible structure.

Other folds are probably present in the county. A preliminary survey has been made over a small portion of the county and later work may reveal favorable structure.

In comparing the logs of the wells drilled at Meridian and Mulhall the sand found at 1,030 feet in the Meridian well appears to be equivalent to that found at 1,165 feet in the Mulhall well, a dip of 95 feet, the difference in surface elevation of the two wells being about 50 feet.

DEVELOPMENT.

The development up to June 1, 1916 is the only available data at this time. A dry hole was drilled in the NE. 1/4 sec. 4, T. 18 N., R. 2 W., by the Mulhall Oil & Development Company. A showing of oil was encountered at a depth of 1,540 feet. At the present time a well is being drilled in the SE. 1/4 sec. 21, T. 18 N., R. 2 W. by the Big Star Oil Company. A showing of oil was reported at a depth of 558 feet. The Cimarron Valley Oil Company is drilling a test well in sec. 28, T. 17 N., R. 1 W., southwest of Coyle, but have shut down at 1,710 feet, May, 1916. The Number One Oil Company is drilling a test in the same section as above. The present depth is about 910 feet. The Big Star Oil Company has been reported to have made a location on the Pritchett farm in sec. 34, T. 18 N., R. 2 W. The Mutual Oil & Gas Company is preparing to drill in the SW. 1/4 sec. 13, T. 17 N., R. 4 W., at Crescent. Other prospective locations have been reported.

SUMMARY.

The chances for the economic occurrence of oil and gas decrease from the east to west part of the county. A fair estimate of the normal westward dip will place the sands which are productive in the fields farther east at depths varying from 2,200 to 4,000 feet below the surface. If taken into consideration this has a tendency to retard the development of the area. If the most favorable locations are given thorough testing they may encounter either oil or gas in commercial quantities. Up to May, 1916, only one well had been drilled which would be considered a fair test. A thorough test in this area should not be abandoned at a depth less than 3,500 feet.

LOVE COUNTY.

LOCATION.

Love County is located in the extreme south-central part of the State. It extends from T 6 S. to T. 9 S. inclusive, and from R. 3 E. to R. 3 W. inclusive. It contains 9 whole townships and parts of 10 others. The total area is approximately 523 square miles.

TOPOGRAPHY.

The greater portion of Love County lies in the Coastal Plains region. In general the surface is rolling. The main feature of the region is the escarpment formed by the Goodland limestone, and is very prominent from near Eastman south to Red River, then southeastward. A peculiar feature of the topography is the large loop taken by Red River about 5 miles southwest of Marietta, where it turns and flows in a general south direction for a distance of about 12 miles, then curves around to the north and flows in that direction roughly paralleling the southern route for about 10 miles. Several miles east of Bomar it turns abruptly to the east and flows for several miles in that direction, thence north again. It is not known from the data at hand as to the cause for the large loop or meander of Red River, whether it is due to structural or other causes. In connection with the deflection at Horseshoe Bend, about 2 miles east of Bomar, an anticline has been located at that place and the axis extends about N. 30° W. It is possible that this deflection here noted is due at least in part to this anticline.

Red River and its tributaries drain the entire area. The principal tributaries are Hickory Creek which drains the northeastern part of the county; and Simon Creek, Walnut Bayou, and Mud Creek, which drain the central and western parts. Most of the drainage is to the southeast, which conforms to the general dip of the Cretaceous (surface) formations. The Red River valley may be characterized as being a broad, flat area having rounded sand dunes and sand flats in many cases, and in others excellent alluvium soil.

The range in elevation is from 1,000 feet above sea level, several miles southwest of Marsden, to 593 feet on Red River, where it flows out of the county.

GEOLOGY.

GENERAL STATEMENT.

The surface rocks exposed in Love County are Pennsylvanian and Cretaceous, with the exception of a small area of lower Paleozoic rocks older than the Pennsylvanian, in the Criner Hills near Overbrook.

PALEOZOIC ROCKS.

In the Criner Hills the lower Paleozoic rocks have been faulted into contact with the Glenn formation of Pennsylvanian age. The history and stratigraphy are similar to that of the Arbuckle Mountains. These formations extend from Carter into Love County near Overbrook, and constitute only a very small area in the latter county. The reader is referred to "Carter County" for a more detailed description of this area.

The Glenn formation, which consists of shales, sandstones, and thin limestone conglomerate, outcrops in a V-shape area in the northeastern part of Love County. The outcrop covers an area of approximately 20 square miles. The line of contact between the Glenn formation of Pennsylvanian age and the Trinity sand of Cretaceous age has been mapped from Hoxbar, where it enters Love County in a general southern direction, to the NE. cor. sec. 26, T. 6 S., R. 2 E. Several small outliers of the Glenn have been mapped southeast of this point and also a large outlier in secs. 18, 19, and 20, T. 6 S., R. 3 E., where Pumpkin Creek has eroded through the Trinity sand, exposing the highly tilted strata of the Glenn formation. The southeasternmost outlier is exposed along the same creek in the NW. 1/4 sec. 32, T. 6 S., R. 3 E.

From sec. 26, T. 6 S., R. 2 E., the contact turns at right angles and returns northwestward along Hickory Creek to Marsden, and extends into Carter County.

Throughout the area where the Glenn formation is exposed the strata of this formation are highly tilted. The general dip seems to be to the northeast from 50° to 90°. Under such conditions any oil or gas in the rocks would have an easy means of escape, so that there would be no reservoir suitable for an accumulation of oil and gas. It is not known how much territory is included in the highly tilted folding of the Glenn formation, other than that exposed. The Cretaceous formations, the basal part of which is the Trinity sand, being unconformable on the Glenn conceals the structure of the latter. However, the area in the near vicinity of the exposed Glenn may be safely placed in this class. It is thought from a study of the outliers as found in the SE. cor. T. 6 S. R. 3 E. that this zone of highly tilted folding extends farther southeast beneath the Cretaceous for an unknown distance.

The fact that a few oil seepages and asphalt deposits have been found in this area does not mean that oil and gas will be found in commercial quantities, but is indicative that these substances have been and are still escaping and are not accumulating in a reservoir. However, if there should be structure in the Cretaceous overlying the highly tilted strata some accumulation might be expected in the Trinity sand, but not in the Glenn formation.

CRETACEOUS ROCKS.

GENERAL STATEMENT.

The Cretaceous formations are unconformable on the older Paleozoic sediments. After the latter had been deposited there was an upheaval, the strata being intensely folded. After a period of erosion this area was probably submerged again in Permian times, and again in Cretaceous times. The Cretaceous sediments are not folded and faulted as are the Pennsylvanian and pre-Pennsylvanian formations. They have remained in their original flat position with a slight dip of about 35 feet per mile to the southeast.

The Cretaceous formations exposed in Love County from oldest to youngest are: Trinity sand, Goodland limestone, Kiamichi formation, Caddo limestone, Bokchito formation, and possibly a few outliers of the Bennington limestone. The characteristics of these are essentially the same as described under "Bryan County," hence repetition is unnecessary.

TRINITY SAND.

The Trinity sand, basal Cretaceous, outcrops over a large part of the county. The line of contact between it and the Glenn formation has already been described above. The Trinity is exposed over all of the western part of the county.

To the south of the Healdton oil field, nearer Red River, the Permian Redbeds material seems to pass under still younger rocks. These sediments consist chiefly of white or light-colored pack-sands and clays, with an occasional conglomeratic layer made up of quartz pebbles. These beds are supposedly Cretaceous, and probably belong to the Trinity sand horizon. Fossils are few, with the exception of silicified wood which is very abundant, but a fairly careful correlation of the formations in Oklahoma with those in north Texas, which are known to be Cretaceous, lends added strength to this contention. The occurrence of a number of remnants of this formation in the neighborhood of the oil field points to a more widespread deposit than was first thought.

Until about two years ago the western limit of the Trinity sands in Oklahoma was mapped as extending only a short distance to the west of Walnut Creek Bayou in central Love County, and extending north to the township line running about midway between Ardmore and Marietta. In the fall of 1913 field work was begun in the region about Healdton and to the south, on the assumption that all the surface rocks were Permian. It was found that many of these rocks differed greatly in lithologic character, position, and structural conditions from those of known Permian age. After a careful examination of the rocks and field correlations with those of Cretaceous age, it was decided that much of the surface rock in the area under consideration is Cretaceous. In order to make a more definite comparison, a study was made of the Cretaceous rocks on the Texas side of Red River, directly south of the Healdton field. About 4½ miles southwest of the town of Leon, Okla., is a crossing on Red River known as Rock Bluff Ferry. On the Oklahoma side the area in the big bend of the river consists of a sand-covered, flat plain, and terraces sloping gently to the river. On the Texas side the bluff rises abruptly to a height of 100 feet above the low-water level. The section is well exposed and was examined for a distance of about 4 miles. The rocks exposed show from approximately the base of the Trinity sand series up into the formation, a distance of 100 feet at the immediate bluff, and in going back from the river a short distance the Goodland limestone is found overlying the Trinity formation.

The section at Rock Bluff Ferry is a fair average of the Trinity formation in the area under consideration, yet it cannot be taken as a typical section, since the degree of variation from place to place is great.

At the crossing the low-water line is about 710 feet above sea level, and the top of the highest part of the bluff from 100 to 110 feet higher. Beginning at the base, the following section is exposed: At the base 16 feet of cross-bedded, fine to coarse sands with interbedded chert and quartz pebbles. The mass of the material varies in color from light yellow to saffron. The pebbles range from a few, irregularly distributed, to a solid mass varying in size from that of a pea to 3 inches in diameter. The mass of sand is loosely cemented and disintegrates readily into loose sand and gravel. The pebbles are chiefly light-colored, but all colors may be found. Locally the sand contains streaks of red, sandy clay, and in places the sand is blackish on the outside, often showing hardened masses with blackened surfaces.

Above this gravelly conglomerate are about 32 feet of loose pack-sand white to yellow in color, containing many spherical forms of bright yellow, unconsolidated sand. A little farther to the northwest, at about the same horizon, are found numerous marble-like hard sand-balls consisting of white, rounded grains of sand in more or less concretionary form, and yellow or black on the outside. Sometimes several of these are cemented in one mass.

At this particular location is a lenticular band of red to chocolate-colored sandy shale 3 inches to 12 inches thick. About 5 or 6 feet higher in the pack-sand there is a little clay, in which the color grades from yellow to purple. These 5 or 6 feet of clay, with the sand, make up to a total thickness of about 43 feet. In places the sand becomes gray, green, and brown, while at about 43 feet from the base the sand and clay contain a large amount of limy streaks and irregular concretions. A material of similar nature continues upward for a distance of 25 feet or more to the base of a hard capping conglomerate-pebble bed. Near the top of the sand are some thin layers of gypsum. Hard concretions are also found in the upper part of this series. The bluff is capped with a ledge of conglomerate about 3 feet thick, consisting of fine to coarse, oolitic-like grains and pebbles of varying size. The conglomerate is hard, massive, in part cross-bedded, and cemented together with a white, chalky-appearing cement. In general, the mass is given a mottled appearance.

This is due to the presence of pebbles, colored pink, red, yellow, purple, greenish, brown, white, clear, and blue, with all variations in shade. Some of the pebbles are rounded, others subangular and irregular, but always with smooth surfaces.

Going to the southward a considerable thickness of sand and local conglomerates is found between the main conglomerate bed and the Goodland limestone.

The following description of a section just west of the Rubottom store, in the W. ½, sec. 13, T. 7 S., R. 3 W., along the east side of the small stream, gives a fair idea of the condition to the north of the above location. In the cut along the stream, sandstone of supposed Cretaceous age rests on a considerable thickness of red shale, which may replace a part of the sand and conglomerate in the section to the south, or it may be the top of the Permian series.

Section along stream west of Rubottom store.

	Feet.
Underlying red shale	30
White to greenish sandstone, with massive, round and kidney-shaped concretions	10-20
Quartzite conglomerate	2
Shaly interval	5
Calcareous quartzite	2
Shaly interval	8
Soft, sandy limestone	2
Sand and gravel	20
Quartzite bed	3

Beginning a few rods north of the above location with the conglomerate bed in the bottom of stream the following section occurs to the top of the hill:

Section 20 rods north of above section.

	Feet.
Sandy gravel conglomerate (1 pebble found 3 inches in diameter)	½
Basal part of sandstone, with fine conglomerate cemented with lime. Sandstone weathers out into rough irregular masses	15
White, greenish, shaly sandstone, with many calcareous, irregular sur face concretions	10
Deep red to purple sandy shale	7
Yellow sandstone, with interbedded limestone at top, glassy quartzite associated with oolitic quartz and pebbles	24
Heavy conglomerate, weathered out and lying about in large fragments.	

Sections similar to the upper members of those given above may be made at many localities over the area north of Red River The characteristic rocks over the surface of the area are heavy quartzite conglomerates, chief of which is the one represented at the top of the Rock Bluff section. It is a heavy, massive quartz-conglomerate, with pebbles ranging from a fraction of an inch in diameter to 3 inches or more. The pebbles are all chert and quartz. The basal conglomerates exposed in Rock Bluff do not extend far to the northward. The principal sandstones outcropping, come in between the horizon of the heavy conglomerate, and represent various horizons in the pack-sand. The outcropping sandstones are irregular masses weathered into rough, kidney-shaped bodies, having a characteristic blocking. These sandstones are all dark-colored on the outside, and on the inside vary from gray, mottled, soft sandstones to hard, red, irony sandstones, in some cases becoming almost flinty. There are characteristic grains and cleavage planes in the sandstone which group them all in one series. However, there is little reason to believe that the principal sandstone of the area is a distinct sandstone occupying a definite horizon, but locally there may be one or more layers or masses occurring at any horizon within a favorable distance of 100 feet, or at any level throughout the thickness of the pack-sands shown in the above sections. These sandstones are chiefly much hardened or indurated masses. There is, however, one principal level of the sandstone masses which occurs about 35 feet below the heavy conglomerate. In some places the heavy conglomerate rests directly on the masses of sandstone, the intervening pack-sand and associated materials having been removed chiefly by the action of water. In other places the conglomerate and sandstone rest on heavy red shale beds of Permian age. All the intervening materials have disappeared, and the more resistant parts make up a new succession.

In some instances the heavy conglomerate caps the hills and presents a good section of the series. Half a mile to a mile away the same bed of conglomerate is found apparently in place, but 50 to 100 feet lower, the full section of unconsolidated material having disappeared.

OTHER FORMATIONS.

The Goodland limestone lies above the Trinity. It is about 25 feet thick in this area. The outcrop is a narrow band which enters the county about 10 miles southeast of Ardmore and extends at first south and east for about 5 miles, then almost due west to Eastman, where it swings to the southeast and extends to Red River.

The outcrops of the Kiamichi formation and Caddo limestone parallel that of the Goodland limestone and are found south or southeast of the latter. The Bokchito formation is exposed around Marietta. Typical exposures have been noted southeast of Marietta along Red River, where it caps the top of the cliffs on the Oklahoma side of what is known as Horseshoe Bend. The Caddo is also exposed at this place.

OCCURRENCE OF ASPHALT IN CRETACEOUS ROCKS.

Six miles south and about 2½ miles west of Rock Bluff Ferry. in the north end of Gordon Mountains, near the line between Montague and Cook counties, Texas, about 4 miles east of St. Jo, considerable asphalt is found. It occurs in the northeast bluff on a high ridge, and is chiefly in a layer of sandstone 1 to 2 feet thick, lying about 5 to 10 feet below the Goodland limestone. The sandstone is highly impregnated with asphalt, and in places it oozes from the rocks in a semi-viscous state. The overlying sandstone consists of a loosely cemented gray to brownish sand overlaid by soil and fragments, while farther back on the hill the limestone is in place. The asphalt from this locality has been used on the streets of St. Jo.

The limestone ridges are flat-topped and without timber. The margins of the ridges are timbered. An occasional hackberry or oak grows on top of the limestone. Below the asphaltic horizon is a fossiliferous limestone similar to the upper limestone, except for being more shaly and weathering into rounded knobs and ridges, with much loose debris over the surface. These lower limestone hills are in part covered with timber. On the Oklahoma side numerous occurrences of asphalt have been reported, but upon examination of these very few were found to contain any asphalt, the black color of the rocks being due to the highly oxidized state of the contained iron. In some localities, for example, about the Wheeler oil field and the segregated land in the vicinity of Asphaltum, the surface sandstone which is saturated with asphalt is very similar in appearance to certain parts of the pack-sands in the Trinity series moreover, and it is believed that at least a remnant covering of these sands extends to this distance to the northward. The origin of the asphalt cannot be definitely determined, but it is very likely that the oils giving rise to this deposition have worked up from rocks older than the Cretaceous. There is very little evidence in the Trinity sands of sufficient organic matter to produce any appreciable amounts of bituminous substances.

A cursory examination of the immediate Red River region shows superficial deposits of unconsolidated sands that are probably of recent origin. They are easily distinguished from the older deposits, because of their loose, unconsolidated character. In the broad stream valleys alluvium covers the older rocks so that they are inaccessible.

STRUCTURE.

In general the structure of Love County is of two types—pre-Cretaceous and Cretaceous. The pre-Cretaceous structure as outlined in the discussion of the Glenn formation is exposed only where that formation outcrops. In other places it may be highly tilted, but it cannot be ascertained that such is the case, on account of being concealed by younger formations.

The Cretaceous structure is that of a normal southeast dip about 35 feet per mile. Folding in the Pennsylvanian may or may not be revealed in the Cretaceous strata. Folding in the Pennsylvanian could have occurred prior to the deposition of the Cretaceous sediments, but if any folding occurs in the Cretaceous it is thought that it also extends down into the Pennsylvanian.

Very little structure has been worked out on the Cretaceous in Love County. A preliminary survey of the area in the vicinity of Horseshoe Bend on Red River shows an indication of folding. Northeast and southeast dips were noted, but sufficient data could not be obtained to outline it.

In eastern Love County some structural features are evident. In a general way, as stated above, the principal streams lie in the major synclines, and many of the smaller streams are in minor basins or synclines. While the divides are more or less in the nature of anticlines, it is difficult to determine the highest points on the structure. There are no rocks in the area covered by these Cretaceous sediments which can be taken as a key upon which to contour the structure properly. In many places apparent structure is due to the slumping and weathering conditions of the rocks of the Trinity sand series. While many of the rocks outcropping are apparently in place, the best policy to follow is that they are not in such a condition, for the reason that there are few, if any, of the rocks which have not been moved more or less from their original position. In the mapping of any structure in this area, it should be kept in mind that there is a chance of a vertical drop of as much as

100 feet, due to the giving away of the pack-sands. Some structural features exist and on a large scale, but the degree of accuracy is not such that any line of structure can be drawn for a considerable distance and be expected to prove productive. The structure which will prove productive is only on local doming, if the production is at all dependent upon surface conditions.

The principal production of the Healdton and adjoining pools appears to be in the underlying Pennsylvanian rocks. What the structural conditions of these rocks are cannot be stated in advance of drilling. Some of the production is in the Permian Redbeds, but it is very probable that any oil or gas here encountered has migrated into the rocks from the underlying Pennsylvanian.

DEVELOPMENT.

Several wildcat wells were drilled in this county prior to 1914, but no results were obtained. After the opening of the Healdton field in the latter part of 1913, attention became centered in that field so that development in Love County was temporarily abandoned. Two wells were drilled some years ago, about 100 feet apart, in the southern part of sec. 34, T. 6 S., R. 3 E., where crumpled strata appear along a creek. Oil seepage from the rocks was probably the cause of the excitement, but it is not known when these wells were drilled, by whom, nor to what depth.

In the SW. 1/4 of sec. 26, T. 6 S., R. 3 E. a rotary drill was sunk to a depth of about 400 feet about a year ago, but the parties were unable to go deeper on account of the hardness of the rock. Drill core from this boring taken at a depth of 319 feet contained casts of fossils, among which were several pelecypods of probable Pennsylvanian age. The rock is a hard, fine-grained, gray micaceous sandstone containing besides the fossils, bits of nodular clay, concretionary pyrite, and a few crystals of sphalerite. The rock has a dip of 45° or more and is good proof that the structure in these older rocks is quite different from that of the Cretaceous surface deposits which lie almost horizontal. Drilling was resumed in May, 1916 with a churn drill. In 1915, however, owing to its nearness to the Healdton field, a number of locations were made in different parts of the county. The Waco Petroleum Company is drilling a well on the Cal Stewart farm northeast of Marietta. Several showings of oil were encountered in the Trinity formation and caused some excitement in that area. The Life Stake Petroleum Company is drilling a well in sec. 25, T. 6 S., R. 2 E., northeast of Marietta. The usual showings of oil in the Trinity sand were encountered at a shallow depth. Several deep showings were also reported. C. E. Zahn is drilling a well in sec. 15, T. 8 S., R. 2 E., 2 miles east of Bomar. The Minnesota-Oklahoma Oil Company is drilling a well in sec. 23, T. 7 S., R. 2 E.

Several wells are drilling in the vicinity of Burneyville. In T. 7 S., R. 1 W., Ed Sewell in sec. 33, and the Oklahoma Star Oil Company in sec. 7, are drilling wells. Other drillings in Love County are: Flynn and others in sec. 8, T. 7 S., R. 1 E.; Healdton Pool Oil Company in sec. 34, T. 6 S., R. 1 W.; Oklahoma-Texas Oil Company in sec. 9 T. 7 S., R. 2 W., Pierce-Fordyce Oil Association in sec. 13, T. 7 S., R. 3 W.; Burford and others in sec. 30, T. 6 S., R. 2 W., their well in sec. 12 having been abandoned at a depth of 2,003 feet.

In November, 1916 sixteen wells were drilling and three new locations had been made. The results of all are awaited with interest. Some new fields may be discarded, but so far no important results have been obtained.

SUMMARY.

Almost all of Love County is considered in probable oil and gas territory. The Pennsylvanian, the source of the oil and probable oil and gas horizon in the Healdton field, with the exception, it is thought, of a few shallow sands, probably underlies Love County. The structure, however, in all instances cannot be determined from surface indications because of the unconformity with the Cretaceous. The areas in the near vicinity of the Criner Hills and also where the upturned edges of the Glenn formation are exposed are not considered favorable territory. It is not known what the structural conditions are in all other areas. Any structure found in the Cretaceous is thought to extend down into the Pennsylvanian. In many of the tests drilled showings of oil have been found in the Trinity sand, especially is this true of the wells drilled northeast of Marietta. The oil in this sand has probably migrated from the Pennsylvanian below. However this does not mean that larger accumulation of oil will be found below the Trinity, as the oil could have migrated in the sand from some distant seepage or from the upturned edges of the Pennsylvanian, if such is the structural condition at that place.

It is thought that in Love County some new fields may be opened, up, but in most cases it is strictly "wildcat" drilling.

MAJOR COUNTY.

LOCATION.

Major County lies well toward the northwest corner of the State. It extends from T. 20 N. to T. 24 N., and from R. 16 W. to R. 9 W. It includes 23 whole townships and parts of 8 others. The total area is approximately 990 square miles.

TOPOGRAPHY.

That part of Major County east of a line drawn from a point about 6 miles south of the northwest corner of the county, to a point on the south county line about 5 miles west of the town of Hemstead, is in the Redbeds Plains. This area is a rolling prairie plain. The surface shales and thin-bedded sandstones of this area disintegrate, forming a fertile soil. Many valuable farms and ranches are found here.

Bounding this area on the west are the Gypsum Hills. They occupy a strip about 5 miles in width and extend entirely across the county. These Gypsum Hills have been formed by the east-flowing tributaries of Cimarron River, extending their sources westward into westward-dipping ledges of gypsum.

Just west of the Gypsum Hills zone a large sand plain occupies the remainder of the county. This sand plain has a general slope to the southwest. This general slope is interrupted frequently by sand dunes. The entire area is covered by blackjack oak trees.

The greater part of Major County lies within the Redbeds Plains. The topography of this part of the county is that of a rolling prairie plain broken by the valleys of Cimarron River and North Fork of Canadian River. The southwestern part of the county is rougher, and gypsum escarpments are not uncommon. The county is drained by Cimarron River and North Fork of Canadian Rivers and their tributaries.

GEOLOGY.

The surface rocks are Permian except in the valleys of Cimarron River, North Fork of Canadian River and their tributaries, where Recent sands and gravels are found. The following Permian formations outcrop in Major County: Woodward, Blaine, and Enid. The Enid formation consists chiefly of brick-red clay shales, with some interbedded layers of red and white sandstones. Some of the upper strata are highly gypsiferous and some salt springs are found. The Blaine formation consists of gypsum, and thin dolomite beds. The main features of the Blaine formation are two large gypsum members and a sand gypsum member with a few thin dolomite beds, all of which are interstratified with red and sometimes blue shales.

Above the Blaine formation is approximately 300 feet of rocks, consisting chiefly of shales, sandstones, and dolomites, distinguished from the formation above and below by the prominence of dolomites and the absence of gypsum. This is the Woodward formation. As a matter of fact most of the Woodward formation in Major County is covered by dune sand which has drifted from the North Fork of Canadian River. In a good many cases this sand extends up to and over parts of the Gypsum Hills.

STRUCTURE.

The general attitude of the strata in Major County is that of a gentle southwestward-dipping monocline. There may be local variations in this general dip. In the area of the Enid formation very few outcrops can be found and variations are hard to recognize. In the southwestern part of the county in the Woodward formation area the surface rocks are so covered with dune sand that the structure is not apparent at the surface. The gypsum ledges in the area of the Blaine formation are well exposed and have considerable horizontal extent. A detailed examination of these ledges may find indications of structure favorable for the accumulation of oil or gas.

SUMMARY.

Strata which may contain oil or gas probably underlie Major County, though so deep as to make exploration too expensive at the present time. The workable area for structure, indications of which are found at the surface, is limited to the outcroppings of the Blaine formation. How severe the folding must be in order to insure influence at the great depth at which the producing sands would probably be found is not known, though it would be safe to figure on rather severe folding. Oil or gas may be found where there are no surface indications, but drillings in these areas are very uncertain.

MARSHALL COUNTY.

LOCATION.

Marshall County lies in the south-central part of the State between Love and Carter counties on the west, and Bryan County on the east; and is bounded on the north by Johnston County, and on the south by Red River. It includes the land from T. 5 S. to T. 8 S., and from R. 4 E. to R. 7 E. approximately, and embraces an area of about 442 square miles.

TOPOGRAPHY.

For a description of the topography of this county reference may be made to the subject of "Topography" under "Bryan County." The surface features of both of these counties are essentially the same, being the result of weathering of the same formations.

GEOLOGY.

The surface geology of Marshall County is very simple, consisting of Cretaceous sands, clays, and limestones lying one upon the other in their normal relationship. The Trinity sands at the base of the Cretaceous system outcrop over the northwestern and western portions of the county; the Goodland and Kiamichi limestones occupy small areas overlapping the Trinity in the west-central parts of the county and occur as outliers capping the hills within the area of the Trinity sands; the Caddo limestone covers two large areas on either side of Glasses Creek, in the east-central portion of the area under discussion; and the Bokchito formation, consisting largely of sandy clay shale, and red friable sandstone, occupies a small area of about 18 square miles around Cumberland in the eastern and southeastern parts of the county. Quaternary sands and silts cover considerable areas on either side of Washita and Red rivers, where flood plains are developed, and locally, north and northwest of Linn, terrace gravels of Tertiary age have been reported. Nowhere in the county do Paleozoic or any pre-Cretaceous rocks appear at the surface, so far as is known. From studies carried out in other regions it is reasonable to assume that the Trinity formation represents shore sands which were deposited unconformably upon the eroded and tilted edges of older strata as the sea advanced northward over the land. The limestones and shales deposited upon the sands are later and deeper sea deposits.

STRUCTURE.

Structurally, the Cretaceous system lies almost as deposited. It has been lifted out of the sea on an average, in Marshall County, of more than 800 feet, resulting in a general dip of the rocks to the south of about 40 feet per mile, but no marked folding nor any faulting has resulted from this disturbance. Locally a minor crumpling of the beds is clearly discernible with dips of 10° to 15° but whether such structures have resulted from lateral pressure or from a slumping of the pack sands is a problem for future study. Low-lying anticlines have been reported by geologists in the employment of oil companies, and the gas and oil wells east and southeast of Madill testify to structures of this kind. The survey staff is not at present in possession of the detailed data required to detect all the anticlinal and synclinal features of the county, but this lack of information regarding the surface geology should not discourage the search for anticlines nor retard the consequent development of this oil field.

Logs of some of the newer wells (those drilled in 1916) give some information regarding the deep-lying formations.

The Lebanon well located in the NW. ¼ sec. 5, T. 7 S., R. 4 E. is about 16 miles south of the Carboniferous outcrops directly north of Lebanon. The bottom of the Trinity sand, which dips south 40 feet per mile, should then be found 540 feet below the surface at Lebanon, a correction being made for a difference in elevation of 100 feet between the two places. The deepest "lime shell" recorded in the log of this well as given below, occurs 609 feet below the surface, and may mark the lower limit of the Trinity at this locality. On the other hand, the "red rock" recorded so frequently and abundantly in the log speaks for Permian or Pennsylvanian strata, and presumably Pennsylvanian because the eastward extension of the Permian Redbeds in Carter County is west of Ardmore, 20 miles west of the Lebanon well, and Pennsylvanian rocks outcrop 6 miles southeast of Overbrook, only a few miles from Lebanon. From these considerations therefore the "red rock" found between 325 and 340 feet of this well probably represents the contact between the Cretaceous and the Pennsylvanian system. The cutting of "lime shell" have not been examined by the writer and it is possible that Pennsylvanian limestones crowded with shells may have been meant when the record was made by the driller. In Love County, just across the county line, in sec. 26, T. 6 S., R. 3 E., the sandstone core taken from a boring said to have been drilled to a depth of 319 feet was examined. It contains what appear to be Pennsylvanian pelecypods, together with pyrite and sphalerite crystals. This drilling was done about 5 miles northwest of Lebanon. It seems, therefore, that the rocks which were drilled through in the Lebanon well and below the "red rock," recorded at 325 to 340 feet, are Pennsylvanian, and that the rocks above this level are Cretaceous.

The following log is of the Lebanon well.

Log of well in NW. 1/4 sec. 5, T. 7 S., R. 4 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface soil	40	40	Sand (show of oil)	5	508
Quick sand (water)	20	60	Blue shale	12	520
Pack sand mixed with lime	80	140	Sand (water)	30	550
Quick sand	10	150	Blue slate	57	607
Lime shell	20	170	Lime shell (water)	2	609
Sand (water)	20	190	Brown shale	126	735
Limy and sandy	70	260	Red rock	20	755
Lime shell	5	265	Yellow shale	25	780
Sand and water	20	285	Sand water	25	805
Blue mud	15	300	Red rock	15	820
Lime shell	25	325	Water sand	40	860
Red rock	15	340	Blue mud	30	890
Sand shell	10	350	Red mud	16	906
Yellow rock	20	370	Blue mud	9	915
Lime shell	20	390	Water sand	25	940
Blue mud	5	395	Brown shale	25	965
Red rock	5	400	Red and yellow shale	60	1,020
Sand	5	405	Water sand	40	1,060
Red rock	15	420	Red rock	15	1,075
Sand hard	30	450	Blue shale	25	1,100
Blue shale	53	503	Shale	15	1,115
			Red rock	45	1,160

The log of the well drilled in the center of the SW. 1/4 sec. 9, T. 6 S., R. 6 E., southeast of Madill, gives "red rocks" at 350 to 360 feet below the surface. This layer is encountered in all the wells recently (Dec. 1916) drilled in this general region and is pronounced by the oil companies operating here as the Permian or the Pennsylvanian, with the oil bearing Arbuckle sand occurring below, in Pennsylvanian strata. The red rock is said to color the water a deep blood-red color and is apparently a shale, quite different from anything occurring in the Cretaceous. It is not at all beyond reason that further exploitation will show the Arbuckle sand to be, in fact, of Pennsylvanian age. In a previous report of the Madill oil pool it is stated* that "the porous conglomerate and the sand at the base of the Trinity form the receptacle which holds the oil that is being exploited at Madill."

*Taff, J. A., and Reed, W. J., The Madill oil pool, Oklahoma: Bull. U. S. Geol. Survey No. 381-D; 1908, p. 35.

Following is the log of the well in the SW. 1/4 sec. 9, T. 6 S., R. 6 E.

Well near center of SW. 1/4 sec. 9, T. 6 S., R. 6 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Lime	20	142	White sand	3	385
Shale	9	151	Lime	18	403
Lime	6	157	Blue clay	4	407
Gray sand	78	235	White sand	15	422
Slate and sand	65	300	Blue sand	3	425
White sand	43	343	White sand	55	480
Break	2	345	Pink sand	15	495
Lime	5	350	Gray sand	3	498
Red rock	10	360	Blue clay	106	604
Blue clay	5	365	Arbuckle sand	21	625
Gray sand	7	372	Yellow clay	30	655

MADILL OIL AND GAS FIELD.

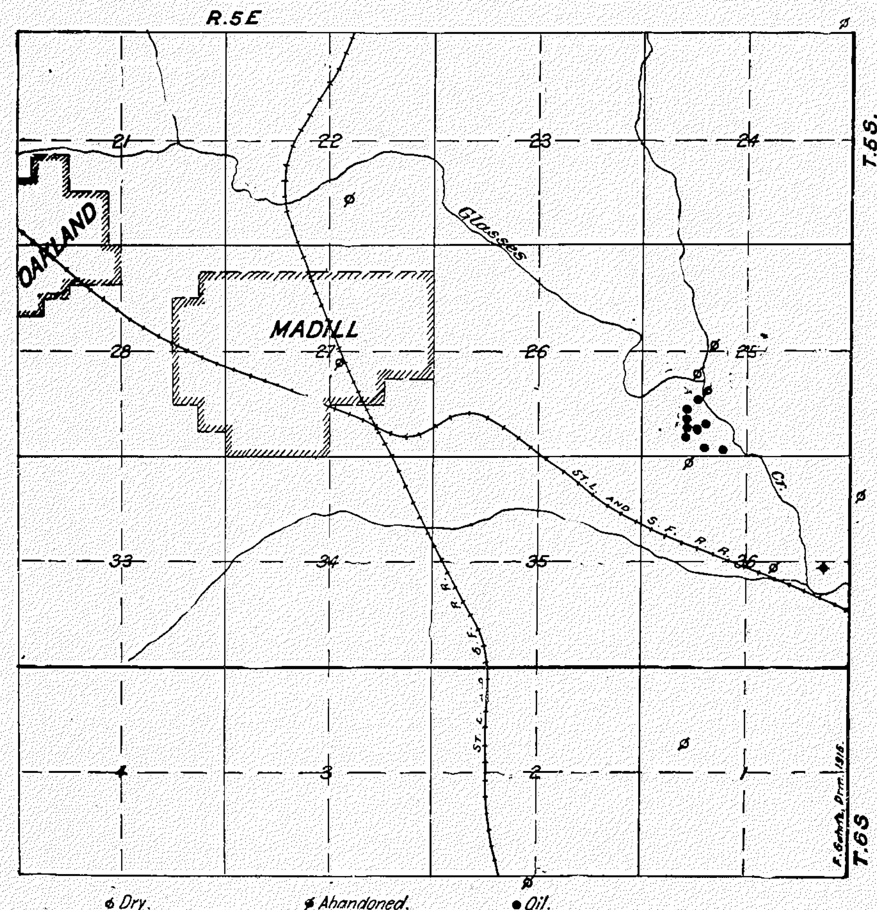


Figure 8.

DEVELOPMENT.

MADILL POOL.

The Madill pool is located on the Arbuckle farm in the SW. ¼ sec 25 T. 5 S., R. 5 E., about a mile east of Madill. This pool was discovered in 1906. Considerable drilling was done but the limits of the pool were never extended farther than the area mentioned above.

In 1909 the number of productive wells was five, which together have produced since that time scarcely two tank cars per month and which are now practically sealed by paraffine which has accumulated in the wells. Attempts have been made to reopen these older wells by pumping steam into them as is done successfully in Pennsylvania when the wells become choked with paraffine, but all attempts have thus far failed at Madill. The largest of these older wells was completed in March, 1909, and its production has been variously estimated at from 400 to 1,000 barrels per day. However, at the present writing (May 30, 1916) no pumping whatever is being done in the field 2 miles east of Madill. Since April, 1909, 8 other wells have been completed in the Madill field close to the former producers, four of which proved dry and four of which yielded a small amount of oil for a time. In the NE. ¼ sec. 25, T. 5 S., R. 5 E. are two wells, one yielding 5 or 10 barrels per day and the other barren. In the SE. ¼ sec. 36 of the same township are two other wells, one a small gas well and the other dry and abandoned. In the NW. ¼ sec. 31, T. 5 S., R. 6 E. is a dry well, and in the NW. ¼ sec. 19 of the same township are two other wells, one barren, the other with a showing of oil but abandoned.

Just across the line from the last mentioned well, in the extreme SE. cor. sec. 13, T. 5 S., R. 5 E., is an abandoned well which yielded only a showing of oil. A derrick has been erected in the NW. ¼ near the center of sec. 30, T. 5 S., R. 6 E. to further test out this region, but no drilling has been done as yet May 30, 1916.

In the SE. ¼ sec. 22 in the town of Madill are three or four dry holes, and there is another in the NW. ¼ sec. 1, T. 6 S., R. 5 E.

The Arbuckle Petroleum Company has a dry hole in the SW. cor. sec. 30, T. 5 S., R. 5 E. 500 feet deep. Near the center of sec. 19 of the same township is another dry hole 800 feet deep. Near the center of sec. 17, T. 5 S., R. 5 E. are two wells, one 1,742 feet deep, in the bottom of which the tools were lost; the other is now drilling.

In the same section, one-half mile northeast, the Cromwell Oil & Gas Company of Muskogee have an abandoned gas well 500 feet deep.

The Madill pool produces the lightest grade of petroleum so far found in Oklahoma. It has a specific gravity of 47.5° Baume, about 7° higher than the light crude oil of the Muskogee pool, and 13° higher than the average Mid-Continent crude oil. On distillation the Madill crude yields about 60 per cent of light oil (gasoline and kerosene), about 7 per cent of paraffin, and little or no asphalt.

MISCELLANEOUS DEVELOPMENT.

In the SW. ¼ sec. 19, T. 7 S., R. 7 E., a showing of oil was found at 1,000 feet but the well was abandoned.

In the center of the SW. ¼ sec. 9, T. 6 S., R. 6 E., the 1916 Oil and Gas Company is drilling a well with the intention of going to a depth of 2,000 feet.

In the SE. ¼ sec. 35, T. 7 S., R. 5 E. two gas wells have been completed 500 feet apart and 700 feet deep. A half mile southeast in sec. 2, T. 8 S., R. 5 E., a third gas well 700 feet deep has been drilled. The first of these three wells, the easternmost location in sec. 35, produces 5,000,000 cubic feet of gas per day, and the other two are reported as being as strong.

In sec. 25, T. 5 S., R. 3 E. is a dry, abandoned hole 300 feet deep.

The Lebanon well in the center of sec. 5, T. 7 S., R. 4 E., whose log is given above to its present depth of 1,160 feet, will be drilled to a depth of 3,000 feet if no difficulties are encountered.

SUMMARY.

Although there has been considerable prospecting for oil and gas in Marshall County, the only production so far obtained has been some oil in the Madill pool and several good gas wells 4 miles north of Lark. Prospects for oil in any greater quantity appear, in the face of this array of dry holes, very bad, but when we consider that many of the locations were selected in a very unscientific manner and with no regard whatever to the structure of the region or any consideration of geological principles, the hope of finding oil in paying quantities is magnified many times. It is a difficult field to prospect because of the almost flat-lying Cretaceous rocks in the first place, where structure is hard to locate, and in the second place, because the folding of the older Paleozoic rocks lies concealed beneath the Cretaceous cap of sands and limestone and it is not necessarily coincident with the folding, if there be any, in the Cretaceous. It should be remembered, however, that the platting of the logs of the wells already drilled, if accurately and intelligently recorded, will be of great assistance in solving these problems.

MAYES COUNTY.

LOCATION.

Mayes County is located in the northeastern part of the State. It extends from T. 19 N. to T. 23 N. inclusive, and from R. 18 E. to R. 21 E. inclusive. It includes 19 whole townships. The total area is 684 square miles.

TOPOGRAPHY.

Mayes County lies in two physiographic provinces. The eastern and central parts of the county are in the Ozark Plateau, while the western part is in the Sandstone Hills region. The surface in the eastern townships is rough and broken, and covered with timber, while in the central part it is largely a flat prairie. Sandstone hills covered with scattered growths of timber extend across the western region. The range in elevation is from 1,250 feet in the SE. cor. T. 20 N., R. 21 E. to 550 feet where Grand River flows out of the county in T. 19 N., R. 19 E.

Grand River flows south across the county, draining all of the county. The principal tributaries to Grand River in this area are Cabin, Spring, Choteau, Pryor, Salina, and Spavinaw creeks.

GEOLOGY.

GENERAL STATEMENT.

The surface rocks in Mayes County are Devonian, Mississippian, and Pennsylvanian, with the exception of Recent sand and alluvium.

DEVONIAN ROCKS.

The *Chattanooga shale* of Devonian age outcrops along Clear Creek in the southeastern part of the county, where 40 feet of the formation have been uncovered, and also along Spavinaw Creek near the town of Spavinaw, where it has a thickness of about 100 feet. This formation consists of hard, fissile, carbonaceous, and bituminous black shale.

MISSISSIPPIAN ROCKS.

The Mississippian rocks are divided into the Boone formation and the Chester group.

The *Boone formation*, which is at the base of the Mississippian, consists of chert and limestone, and outcrops over the eastern part of the county. This formation is on the average about 200 feet thick and lies unconformably on the Chattanooga shale.

The *Chester Group*, which lies unconformably on the Boone formation, outcrops as a narrow belt. It is subdivided into the Mayes limestone, Fayetteville shale, and Pitkin limestone. The *Mayes limestone*, basal part of the Chester, is predominantly limestone in this area. The thickness varies but does not exceed 100 feet. The *Fayetteville formation*, which lies conformably on the Mayes limestone, consists of black shale and limestone. Near Yonkers the formation varies from 70 to 90 feet in thickness, the lower shale from 10 to 20 feet, the limestone 10 to 15 feet, and the upper shale from 30 to 50 feet. Southwest of Locust Grove the entire formation has a thickness of about 100 feet. The *Pitkin limestone* consists of granular and slightly oolitic, massive strata of limestone. It extends only a few miles from Wagoner County into Mayes County. From a thickness of 60 feet just south of the Mayes County line it dwindles to about 10 feet in the vicinity of Yonkers, and has not been observed north of the line between T. 18 and T. 19 N. The unconformity between the Pitkin and Pennsylvanian formations above may be responsible for the thinning and disappearance of the Pitkin to the north.

PENNSYLVANIAN ROCKS.

The Pennsylvanian formations, which consist of the Morrow and Winslow formations, outcrop in the western part of the county.

The *Morrow formation*, which lies unconformably on the Mississippian, consists of limestone with subordinate amounts of shale and sandstone. To the north of Wagoner County the Morrow thins rapidly and the lower part changes in character from almost pure limestone into a coarse-grained sandstone near Locust Grove. The upper part is separated from the lower by a distinct unconformity. In the Seneca fault, which extends from the SW. cor. T. 21 N., R. 19 E., in a northeast direction to sec. 7, T. 23 N., R. 22 E., limestone thought to be the Morrow is exposed in the small creek 1½ miles east and 1½ miles south of Pryor, and again in the SE. ¼ sec. 20, T. 22 N., R. 20 E. The last mentioned exposure is the northernmost occurrence of the Morrow.

The *Winslow formation*, which is correlated with the Cherokee formation farther south, consists for the most part of shales and sandstone. Near the southern boundary of Mayes County the Winslow lies unconformably on the Morrow formation, but in the northern part of the county, owing to the disappearance of the Morrow and Pitkin formation, it lies unconformably on the Fayetteville shale. The Winslow or Cherokee formation is one of the oil and gas horizons in the northeastern oil and gas fields.

STRUCTURE.

GENERAL STATEMENT.

Mayes County lies on the southwestern flank of the Ozark uplift. In general the rocks dip away from the uplift and in this county the dip is to the west. This general dip is interrupted in many places by folding and faulting trending northeast-southwest. The folding and faulting probably occurred in late Pennsylvanian times. To the west of the Pennsylvanian-Mississippian contact these folds and faults merge into the gentle westerly dip of the Prairie Plains monocline. As a rule oil or gas is not found in commercial quantities in the Mississippian, hence these folds which occur in this series probably would not be productive.

LOCUST FAULT.

This fault extends southward from the vicinity of Locust Grove southward into Cherokee County. The downthrow side is to the west and brings the Chester formations below the level of the top of the Boone hills on the east side of the fault. The vertical displacement of the fault is not more than 200 feet.

SENECA FAULT.

The Seneca fault extends from a point a few miles south of Pryor northeastward to the vicinity of Spurgeon, Missouri. This fault, which is a simple block fault, varies from one-eighth mile to more than one-half mile wide. Included in the block are the Morrow and the lower part of the Winslow formations which are brought into contact with the Chester formations on either side. It appears that the fault is due to the dropping of a block on the crest of a strong anticline. The vertical displacement is not more than 300 feet.

MINOR FAULTS.

Two small faults have been found, one in sec. 16, T. 19 N., R. 19 E., and the other in sec. 6 of the same township.

FOLDS.

Most of the folding in Mayes County is gentle. The dips rarely exceed 5° and in most cases are less. All the major tributaries of Grand River from the east flow near or on the axes of anticlines. Some of these anticlinal streams are Spavinaw, Salina, Spring, and Clear creeks. These folds extend across Grand River but a short distance farther west die out and merge into the gentle westward-dipping Prairie Plains monocline.

DEVELOPMENT.

No production of any consequence has been found in Mayes County. The Chelsea field in Rogers County lies about 5 miles from the northwest corner of the county. The east Claremore field is a short distance west of Mayes County.

A number of wells have been drilled in Mayes County but information is available on only a few of those reported. About a year ago a test was started on the Atkins farm in sec. 28, T. 20 N., R. 18 E., but the outcome is not known. O. W. Killam is reported to have drilled a well in sec. 13, T. 20 N., R. 19 E., and encountered 500,000 cubic feet of gas in a shallow sand.

SUMMARY.

The surface rocks in the eastern part of the county are Mississippian, and it is thought that even with favorable structure in these rocks, production in commercial quantities will not be found. In the western part of the county the Pennsylvanian rocks are thin and overlie the Mississippian. Even though the Pennsylvanian is the oil and gas horizon farther west, this thin mantle in this area probably does not afford a reservoir for oil and gas in commercial quantities. However, the extreme western and northwestern parts of the county offer the best possibilities. Wells drilled in the eastern part of the county have encountered strong flows of salt water. Drilling should be confined to the Pennsylvanian.

McCLAIN COUNTY.

LOCATION.

McClain County is located in the south-central part of the State. It extends from T. 5 N to T. 10 N., inclusive, and from R. 4 W. to R.

3 W. inclusive. It includes 11 entire townships and parts of 10 others. The entire area is approximately 599 square miles.

TOPOGRAPHY.

The topography is that of a rolling prairie plain into which the Canadian has cut a broad, rather shallow valley, and into which smaller streams have cut narrow canyons and gulleys.

The surface ranges in elevation from 900 feet in T. 5 N., R. 3 E. to 1,350 feet in T. 9 N., R. 4 W. The central and northern parts of the county are drained by Canadian River and streams tributary to it, while the southern part is drained by streams tributary to Washita River.

GEOLOGY.

The rocks at the surface in McClain County are Permian and Pennsylvanian. The exact location of the contact between these rocks is not known. The fact that the upper Pennsylvanian as well as the lower Permian in this area consists of red shales and sandstones makes the tracing of the contact rather difficult. J. W. Beede* has drawn the line of contact between the Permian and Pennsylvanian from the Kansas-Oklahoma line as far south as Tecumseh in Pottawatomie County. He has indicated its probable position as far south as the Arbuckle Mountains. In McClain County it runs due south from Purcell.

STRUCTURE.

The general dip of the strata in McClain County is to the southwest. It is hard to find local variations in this general dip because the greater parts of the outcrops are crossbedded lenticular sandstones and clay shales.

DEVELOPMENT.

The Home Oil Company is drilling a well in the NE. 1/4 of the NW. 1/4 of sec. 20, T. 8 N., R. 4 W. Latest reports were that they were at a depth of 1,400 feet. The B. & R. Oil Company is drilling in the SW. 1/4 of the NW. 1/4 sec. 29, T. 8 N., R. 4 W., at a depth of 1,500 feet, at last reports.

SUMMARY.

McClain County is in probable oil and gas territory. It lies for the most part north of the synclinal trough caused by the influence of the Arbuckle Mountain uplift on normally southwest dipping strata, and is in territory where some accumulation would be expected, though the lack of reliable strata on which to determine local folding makes the problem of finding favorable locations for drilling difficult.

*Beede, J. W., Bulletin Okla. Geological Survey No. 21, 1914.

McCURTAIN COUNTY.

LOCATION.

McCurtain County, one of the largest in the State, extends from T. 1 S. to T. 10 S. inclusive, and from R. 21 E. to R. 27 E. inclusive, and embraces an area of approximately 1,932 square miles. It is bounded on the north by Leflore and Pushmataha counties; on the east and south by the states of Arkansas and Texas respectively; and on the west by Pushmataha and Choctaw counties. The county seat is Idabel, situated in a southerly location on the St. Louis & San Francisco Railroad.

TOPOGRAPHY.

The topography of McCurtain County may be divided into two distinct divisions separated one from the other by an east-west line drawn through the center of the county through the center of T. 5 S. The northern half lies within the Ouachita Mountain region and the southern half within the Gulf Coastal Plain province or its subdivision, the Red River Plain. For a discussion of the topographic features characteristic of the northern mountainous region, reference may be made to Pushmataha County under which heading a general account is given; and for a statement concerning the topographic forms prevailing in the southern portion of the county, the description of the topography of Bryan County is sufficient.

GEOLOGY.

Likewise, the geology of McCurtain County may be discussed under two separate heads: (1) That of the mountainous region to the north, corresponding to the Ouachita Mountain topographic province; and (2), that of the Coastal Plain strata, corresponding to the physiographic province by the same name.

The strata involved in the folded mountainous region are chiefly of Carboniferous age whose history may be found briefly discussed under the geology of Pushmataha County.

The Cretaceous sediments of the southern half of the county overlap the older folded and eroded rocks to the north, and slope with a gentle dip toward the Gulf of Mexico. The structure and relative position of each individual formation are the same as that in Bryan County and the other counties along Red River. The exact boundary of each separate formation has never been drawn upon a map but a general description is given in connection with the geology of Bryan County.

DEVELOPMENT.

With the exception of a single well now being drilled near Garvin on Little River there is no prospecting for oil in this county. This well is being drilled by the Louisiana Petroleum Company who is making use of the rotary equipment. The location is in sec. 1, T. 7 S., R. 22 E. The log of this well has been in part preserved and is given below:

Log of well in sec. 1, *T.* 7 *S., R.* 22 *E., McCurtain County, Oklahoma, from* 487 *feet to* 1,151 *feet.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
White sand	20	507	Light sand	7	677
Dark chocolate shale	2	509	Rock formation composed of lime, lime rock, slate, pyrites of iron, shells, sand, some shale, slate color, hard	128	805
Soft lime rock	6	515	Gray shale and thin rocks	8	813
Shale	2	517	Rock sand, close grain	2	815
Rock	6	523	Shale, gray and hard	3	818
Shale	2	525	Sand rock, close grain	3	821
Rock	10	535	Shale and hard rock	5	826
Shale	3	538	About the same	6	832
Rock	22	560	Shale, reddish layers hard	8	840
Shale	2	562	Rock, hard	6	846
Reddish rock	10	572	Dark shale	4	850
Shale	2	574	Rock	5	855
Rock	18	592	Rock with layers of shale, bluish gray	11	906
Shale with flakes of rock	2	594	Hard and rough	17	923
Rock, very hard, some gas	5	599	Rock hard, shale cong.	89	1,012
Shale	2	601	Red shale with thin rock	33	1,045
Shale with flakes of rock	4	618	Chocolate conglom.	103	1,148
Rock with some gas	15	633	Sand rock, pyrites of iron	3	1,151
Lime rock	14	647			
Shale	4	651			
Lime rock	1	652			
Brown shale	7	659			
Lime rock	3	662			
Brown shale	4	666			
Sand rock	4	670			

The indications are that the first three items of the well record represent the base of the Trinity sand and that the remainder of the record from 515 feet to the bottom of the well represents an alternating series of Carboniferous sandstones and shales. (The term "rock" does not mean very much).

SUMMARY.

The Paleozoic area, occupying the northern half of the county, is at the present time, little known. It is a region, for the most part, of intensely folded and faulted strata and for these reasons may be regarded as a field unlikely to yield petroleum or natural gas in economic quantities.

The southern or Cretaceous area is likewise little known, and is a hazardous field in which to prospect for oil because of the unknown structure which lies unconformably beneath the Cretaceous surface formations. Oil may be encountered in the southern half of McCurtain County. There is a greater possibility of finding it here than to the north, chiefly for the reason that the Paleozoic strata would not here be likely to be so sharply folded as in localities nearer or within the main mountain mass.

McINTOSH COUNTY.

LOCATION.

McIntosh County is located in the east-central part of the State. It extends from T. 8 N. to T. 12 N. inclusive, and from R. 13 E. to R. 18 E. inclusive. It includes 16 whole townships and parts of 8 others. The total area is approximately 742 square miles.

TOPOGRAPHY.

McIntosh County is within the Sandstone Hills region. The topography consists essentially of roughly parallel sandstone hill zones, between which are shale valleys. The entire county is wooded with the exception of some of the high divides. The surface elevations range from approximately 500 feet to approximately 1,000 feet, a difference of 500 feet. The lowest point is found in the southeastern part of the county where the east county line intersects Canadian River in sec. 36, T. 10 N., R. 18 E. The highest point is near the center of sec. 8, T. 11 N., R. 15 E.

The county is drained for the most part by the Canadian River and streams tributary to it, the largest of which is North Fork joining the main stream in McIntosh County near the center of sec. 9, T. 9 N., R. 17 E. Deep Fork of Canadian River is a large tributary to North Fork, and joins it in sec. 3 T. 10 N., R. 16 E. The extreme northeastern part of the county is drained by tributaries to Arkansas River.

GEOLOGY.

The surface rocks in McIntosh County are for the most part Pennsylvanian, though along the larger stream valleys are found Recent sands and gravels. The Pennsylvanian strata consist of massive, light brown to gray sandstones and shales. The sandstones are found capping the hills and the shales occupying the valleys.

STRUCTURE.

The Pennsylvanian strata are a part of a rather flatly northwest-dipping monocline. There are local variations in this general northwest dip. Snider* has mapped Warner anticline as extending from Muskogee County southwest into McIntosh County. In McIntosh County it extends from the northeast corner of sec. 36, T. 12 N., R. 18 E. northwest to the center of the SE. 1/4 of sec. 5, T. 11 N., R. 18 E., a distance of 5 miles. The Warner syncline is mapped as extending from Muskogee County into McIntosh County and crossing diagonally sec. 1, T. 10 N., R. 18 E. There may be other variations in the monoclinal fold in McIntosh County but no detailed search has been made for them.

*Snider, L. C., Geology of east-central Oklahoma: Okla. Geol. Survey Bull. No. 17.

DEVELOPMENT.

The development in McIntosh County will be discussed by townships beginning with the townships farthest northwest.

T. 12 N., R. 14 E. has seen in the past few years considerable drilling. The most encouraging results to date have been in secs. 9 and 10. In sec. 9 Rebold and Newman had a well with an initial production of 20 barrels, and the Madeline Oil Company a well which made 5 barrels of oil daily, initial production. Gas has been found in secs. 4 and 6. Jordon and Young encountered 12,000,000 cubic feet of gas at a depth of 1,640 feet in their well in sec. 4. Hunter and Ranger had 15,000,000 cubic feet of gas at a depth of 1,450 feet in their well in sec. 6. In the same section Kingwood Oil Company encountered 6,000,000 cubic feet of gas. A dry hole was completed in sec. 15 by Newman. Drilling is being done at several locations within this township.

There is considerable drilling in T. 12 N., R.15 E. at the present time. No encouraging results have as yet been reported. Keaton and Company have a dry well in sec. 4.

Gas has been reported as being found at a depth of 1,830 feet in sec. 12, T. 12 N., R. 16 E. A dry hole has been reported from sec. 4, T. 12 N., R. 16 E.

In T. 12 N., R. 17 E., McMann Oil Company has a show of oil at a depth of 2,300 feet in sec. 12. This is the only encouraging report for this township. Several other wells are being drilled.

Encouraging results have been obtained in T. 11 N.. R. 14 E. The Gundich Oil Company brought in a 400 barrel well in sec. 6. In another well in the same section both gas and oil were found. In sec. 5, Gundich Oil Company encountered 15,000,000 cubic feet of gas. Recently the interests of the Gundich Oil Company were purchased by the Oklahoma Oil Company. In sec. 8, the Kingwood Oil Company encountered 5,000,000 cubic feet of gas. In the same section the Oklahoma Oil Company has a 200 barrel well.

In T. 11 N., R. 16 E., several drills have been working. Broken Hill Oil Company encountered 2,000,000 cubic feet of gas at a depth of 1,550 feet in sec. 36.

In T. 11 N., R. 17 E. considerable gas has been found. The Gladys Belle Oil Company has 35,000,000 cubic feet of gas in one well in sec. 32, and 12,000,000 cubic feet in another. The same company had 15,000,000 cubic feet of gas in their well in sec. 29. Several wells are drilling near the gas wells in the hope of encountering oil.

SUMMARY.

McIntosh County is within proved oil and gas territory. The production to date has been mostly gas.

MURRAY COUNTY.

LOCATION.

Murray County is located in the south-central part of the State. It extends from T. 2 S. to T. 2 N. inclusive, and from R. 1 W. to R. 4 E. inclusive. It consists of 8 entire townships and parts of 9 others. The total area is approximately 424 square miles.

TOPOGRAPHY.

The topography of Murray County is of two distinct types—plains and mountains. The plains are found in the extreme southern and the extreme northern parts of the county. The Arbuckle Mountains run through the central part and occupy the eastern part of the county. These mountains consist of ridges. On a small scale they are very rough.

GEOLOGY.

Rocks belonging to the following series outcrop in Murray County: Quaternary, Permian, Pennsylvanian, Devonian, Cambro-Ordovician, Cambrian, and pre-Cambrian.

The pre-Cambrian occupies a small area in the NE. corner of T. 2 S., R. 1 E.

The Cambrian is represented by the Reagan sandstone and occupies a narrow belt in contact with and to the southwest of the pre-Cambrian outcrop mentioned above.

The Cambro-Ordovician is represented by the Arbuckle limestone. It occupies the surface in two general areas. That in the northeastern part of the county covers a continuous area of approximately 50 square miles. That in the eastern part consists of three disconnected areas whose total area is approximately 35 square miles.

The Ordovician rocks consist of the Viola limestone and Simpson formation. These rocks occupy a narrow belt to the south and west, respectively, of the Cambro-Ordovician areas mentioned above.

The Silurian consists of Hunton limestone and Sylvan shale. These rocks occupy a narrow belt south and west of the Ordovician mentioned above.

The Devonian consists of the Woodford chert. These rocks occupy a narrow belt to the south and west of the Silurian mentioned above.

The Pennsylvanian consists of limestones, conglomerate limestones, sandstones, and shales. These rocks are at the surface in two areas in Murray County. One in the northeastern part of the county covers about 50 square miles. The other in the south and southeastern parts of the county covers an area of about 50 square miles.

The Permian consists of red sandstones and shales. These rocks are at the surface in the extreme southwestern part of the county. They cover an area of approximately 18 square miles.

The Quaternary consists of sand, alluvium, and gravel. These rocks are found in the narrow valley of Washita River, which runs through the center and diagonally in a northwest-southeast direction across the county.

For a detailed description of the above rocks see "Johnston County."

STRUCTURE.

The position of all the rocks in Murray County has been influenced by the Arbuckle Mountain uplift. In general the position of the rocks is that of an anticline very much modified by faults and cross folds. The rocks older than the Pennsylvanian have been folded and faulted very severely. The Pennsylvanian and Permian dip at low angles away from the axis of the Arbuckle Mountains.

DEVELOPMENT.

W. J. Scott and others drilled a well in sec. 3, T. 2 S., R. 3 E., to a depth of 2,600 feet. An oil sand was encountered at 2,140 feet. The hole was plugged back to this depth and shot. The well produced after the shot at the rate of 5 barrels daily.

SUMMARY.

No large production of oil or gas is expected in Murray County. The severe folding and faulting is incompatible with the possibility of finding large unbroken structure, favorable for the accumulation of oil or gas in large pools. The finding of small production and showings is not surprising, as minor folds, fault zones, and strata sealed with asphalt may hold minor accumulations.

MUSKOGEE COUNTY.

LOCATION.

Muskogee County is located in the east-central part of the State. It extends from T. 9 N. to T. 16 N. inclusive, and from R. 15 E. to R. 21 E. inclusive. It includes 17 entire townships and parts of 13 others. The total area is approximately 876 square miles.

TOPOGRAPHY.

Almost the entire county lies within the Sandstone Hills. The extreme northeastern corner is in the Ozark Plateau region. The topography consists essentially of sandstone-capped hills and shale valleys. There is a close relation between the topography and the structure. The hills occupy the synclines and the valleys the anticlines. The tops of the hills are usually broad and flat. The streams are broad and sluggish.

The surface in Muskogee County ranges in elevation from 430 feet to 1,000 feet, a distance of 570 feet. The lowest point is at the confluence of the Canadian and Arkansas rivers, in the NW. 1/4 of sec. 2, T. 11 N., R. 21 E. The highest point is in the SE. 1/4 of sec. 16, T. 10 N., R. 19 E., about 1½ miles west and one-half mile south of Porum. Muskogee County is drained by Arkansas and Canadian rivers and streams tributary to them.

GEOLOGY.

The rocks at the surface in Muskogee County are: Mississippian, Pennsylvanian, and Quaternary. These series are briefly described in order from the oldest to youngest.

MISSISSIPPIAN ROCKS.

The Mississippian rocks outcrop in the northeastern part of the county. The following Mississippian formations are present: Pitkin limestone, Fayetteville formation, and Boone formation.

The *Boone formation* consists of the oldest rocks in Muskogee County. They occupy an area of less than one-half a square mile in the northeastern part of the county. They lie for the most part in the N. ½ of sec. 13, T. 15 N., R. 20 E. Only the upper part of the Boone formation is exposed in this county. It consists of interstratified chert and cherty limestone.

The *Fayetteville formation* occupies a little more than one-half of a square mile of the surface in this county. The outcrops are confined to two isolated areas, one in secs. 6 and 7, T. 15 N., R. 20 E. and the other in sec. 36, T. 14 N., R. 20 E. Only the upper part of this formation outcrops in Muskogee County. The formation consists of dark blue to black fissile shale, with usually thin limestone beds.

The *Pitkin limestone* occupies an area of about 5 square miles. They outcrop along the streams in the central part of T. 15 N., R. 20 E., in the southeastern part of T. 14 N., R. 20 E., in the eastern part of T. 13 N., R. 20 E., and in the NE. cor. of T. 12 N., R. 20 E. This limestone consists of light blue to brown, granular, earth strata interbedded with fine-textured massive layers. The thickness of the Pitkin limestone is about 50 feet.

PENNSYLVANIAN ROCKS.

The Pennsylvanian rocks in Muskogee County are grouped in the following formations: Possible Senora formation, Stuart shale, and Thurman sandstone, Boggy shale, Savanna sandstone, Winslow formation, and Morrow formation.

The *Morrow formation* occupies an area of about 13 square miles in the northeastern part of the county. It outcrops in the central part of T. 15 N., R. 20 E.; the SE. part of T. 14 N., R. 20 E.; the eastern part of T. 13 N., R. 20 E.; and the NE. cor. of T. 12 N., R. 20 E. It consists of limestone and shale with local beds of sandstone, the limestone predominating. Some of the limestones are variable in thickness and consist of rather hard, blue, fine-textured rock. Some of the limestone layers are fossiliferous. The shales are blue and black with thin beds of limestone and sandstone locally developed. A good many of the shales in this formation are rich in carbonaceous material.

The *Winslow formation* occupies an area of approximately 478 square miles. It occupies a belt about 15 miles wide which runs in a northwest-southeast direction through the center of the county. Its contact with older rocks to the northeast is very irregular in outline. The Winslow formation consists of bluish and blackish clay shale, sandy shale, brown sandstone, and thin beds of coal.

The *Savanna sandstone* occupies an area of about 17 square miles in the southwestern part of the county in T. 11 N., R. 19 E. and T. 10 N., R. 11 E. Three prominent sandstone members separated by shales make up this sandstone. The total thickness is from 1,200 to 1,500 feet. The sandstones are gray or brown on weathered surfaces, and their texture is fine and compact, with occasional inclusions of chert.

The *Boggy shale* outcrops over an area of about 150 square miles in the southwestern part of the county. It consists of a great thickness of shale and irregularly distributed thin-bedded sandstones. The entire thickness is 2,000 to 3,000 feet.

The *Senora formation, Stuart shale,* and *Thurman sandstone* occupy an area of about 73 square miles in the western part of the county. The contact lines between these formations have not been mapped. The Thurman sandstone consists of coarse white chert and quartz. Some shale and impure limestone is found. The Stuart shale consists of shales interbedded with thin-bedded shaly sandstones. The Senora formation consists of sandstones and shales interstratified.

QUATERNARY ROCKS.

The *Quaternary* consists of terrace sands and river alluvium. It occupies an area of about 139 square miles along the valley of Arkansas, Canadian, and Neosho rivers.

STRUCTURE.

Structurally Muskogee County can be divided into two parts, that part east of Arkansas and Neosho rivers belonging to the Ozark uplift and that part west of these rivers belonging to the Prairie Plains monocline. In a general way the rocks dip southwestward at the rate of less than 20 feet to the mile in the Ozark uplift area and more than 100 feet to the mile in the Prairie Plains area. There are numerous variations in this general dip of the strata.

A fault enters Muskogee County near the NE. cor. of sec. 6, T. 15 N., R. 20 E., and extends in a southwest direction across the township to a point near the W. cor. of sec. 19. This fault has brought the Winslow formation in contact with the Pitkin limestone and the Fayetteville formation. The Winslow formation is on the northwest side of the fault line. The Pitkin limestone and the Fayetteville formation are on the southeast side.

An anticlinal fold enters the county near the E. cor. of sec. 25, T. 14 N., R. 20 E., and extends in a southwest direction almost to

Arkansas River. There are other variations of the general attitude of the rocks in Muskogee County which will be discussed in connection with the various oil and gas pools.

DEVELOPMENT.

GENERAL STATEMENT.

In the county the following fields have been more or less developed: Beland, Boynton, Briartown, Cole, Fern Mountain, Haskell, Muskogee, and Muskogee South (Chicken Farm), Porum, Warner, Webber Falls, and Yarhola. The county, prior to 1914, held the foremost place among light oil producers of the State. At the present time, however, the Cushing pool is the greatest light oil producer in Oklahoma, if not in the world. Prior to the discovery of the Cushing field, the Madill pool was producing the highest grade of oil, but in too small quantities to receive much consideration. The best Cushing crude is as a rule about the same in specific gravity as the best Muskogee oil, and both are heavier than the Madill oil.

BOYNTON POOL.

The Boynton pool which created a great deal of excitement during the latter months of 1914 is located in T. 14 N., R. 16 E., in the southwestern part of Muskogee County. The pool was discovered in the early part of the year, and the first well drilled was completed in May in sec. 21. A few days later H. H. Galbreath completed a gas well in sec. 19 at a depth of 1,800 feet, which was reported to have produced between 5,000,000 and 10,000,000 cubic feet of gas per day. The most recent completion in the area is the gas well of 5,000,000 cubic feet capacity in sec. 1.

Development has continued slowly so that at the present time about 20 wells are producing oil, 7 gas, and 6 or 8 have recently proved to be dry. The wells produced from 12 to 150 barrels per day. The present productive area is limited to secs. 5, 9, 10, 11, 12, 14, 15, 16, 17, 21, 22, 23, 25, 28, 29, and 35. Dry holes which have been completed are in the west ½ SW. ¼ sec. 21, center NE. ¼ sec. 8, sec. 7, sec. 9, etc., and the NW. ¼ SW. ¼ NW. ¼ sec. 23. Two gas wells have been completed west of the main pool, and several rigs are being prepared for further exploitation in that region.

Good gas-producing sands are reported from about 825 feet, 1,100 feet, and 1,400 feet. At least four lower sands have been reported as producing oil. These are found at or near the following depths: 1,550 feet, 1,650 feet, 1,750 feet, and 1,880 feet. The 1,550 foot sand, which is known as the Boynton sand, is by far the most important in the region.

The production of oil for the year up to December, 1914, amounted to more than 10,000 barrels, and of this production all was stored because of lack of pipe-line facilities. The Prairie 2-inch line was connected up in the latter part of the year 1915, so that at the present time most of the oil is sold.

COLE POOL.

Within the last three months of 1914 a pool was opened in T. 14 N., R. 15 E. This new field lies 6 miles west of Boynton. At the present time between 10 and 20 wells have been completed to the 1,610 foot sand. Fully one-third of these wells have been dry.

The best wells have been drilled in sec. 11. Three have a capacity of more than 150 barrels. In sec. 10, to the west, 2 wells have lately been completed which produced 100 and 60 barrels respectively. The latter is located in the northwest quarter of the section, and was completed at a depth of 1,467 feet in a sand which is said to differ widely from that in the other wells.

The oil is for the most part high grade and light green in color.

FERN MOUNTAIN POOL.

The Fern Mountain pool, which is a recent discovery, will probably go down in the history of Oklahoma oil and gas development as a field with a promising beginning, but a great disappointment to investors. This will certainly be true unless some new development occurs in a short time. Fern Mountain oil field is located in T. 15 N., Rs. 17 and 18 E. The discovery well was drilled on the Jane Jackson allotment in sec. 13, T. 15 N., R. 17 E., and came in as a 400 barrel producer. The second well in sec. 18, T. 15 N., R. 18 E., is a small pumper estimated at about 10 barrels. Two other wells in sec. 23, T. 15 N., R. 17 E., and sec. 19, T. 19 N., R. 18 E. each produced about 10 barrels when placed on the pump. In addition to these wells, 26 others have been drilled which have failed to give a fair showing of either oil or gas.

The sand, which is rather thin, occurs at about 1,600 feet. Only 12 feet of pay sand was found in the well in sec. 23, T. 15 N., R. 17 E. Recently a dry hole has been completed in sec. 19, T. 15 N., R. 18 E., within one-fourth mile of the McLain well in sec. 18 of the same township and range. It is generally conceded that future drilling will be very limited unless the test well in sec. 3, T. 15 N., R. 18 E. proves good, although failure at this point should not wholly condemn the area.

HASKELL POOL.

The Haskell, Bald Hill, and Pine Hill pools are so closely connected that it is rather difficult to separate them. Pine Hill pool, in secs. 26 and 27, T. 13 N., R. 13 E., and the Haskell pool, in T. 16 N., R. 15 E., may in a way be considered as part of the present Bald Hill pool. In the Haskell pool apparently 4 sands have given production. Wells from the 1,900-foot sand with 300 to 700 barrels production per day are not uncommon. From the 1,360-foot sand, gas is the chief product and oil wells though not uncommon are generally small producers. Wells of from 50 to 100 barrels initial capacity are the average. The most important well during the early months of 1915 was the 25,000,000 foot gas well of the Caney River Gas Company in the NE. 1/4 of NE. 1/4 sec. 17, T. 15 N., R. 15 E. The production is from the 800-foot sand. Other gas wells in the same general area usually make from 3,000,000 to 10,000,000 cubic feet per day.

During 1913, the Haskell pool produced a total of about 26,200 barrels. This gives the field an average output of 2,190 barrels per month. The producing wells have an average daily capacity ranging from 52 to 88 barrels. It is easily concluded from these figures that the wells must decline rapidly.

The following table shows the drilling record of this field for 1909, 1910, and 1911. For 1912 and 1913, the figures are combined with Glenn pool and others.

Drilling record and initial production, both total and average per well, in the Haskell oil and gas field.

Year.	Wells completed.				Initial production.	
	Total.	Oil.	Dry.	Gas.	Total.	Average per well.
1909	10	5	5	0	460	92.0
1910	12	7	5	0	405	57.9
1911	3	1	1	1	300	300.0
1913	----	----	----	----	------	71.7

MUSKOGEE POOL.

GENERAL STATEMENT.

The Muskogee pool extends southwest from the city for a distance of 6 miles and includes what is known as the Chicken Farm district. All of the wells begin at or near the top of the Fort Scott (Oswego) formation. The field, then, is one of the oldest, if not the oldest, geologically, in the State. The wells in most cases must extend beyond the lower limit of the Pennsylvanian rocks if the thicknesses given by Taff in the Muskogee folio are accepted. The logs of wells show the rocks to be sandstones and shales in the lower part of the well. It would seem, then, that the Morrow and Winslow formations thicken faster to the south than was first thought, and that it is possible for this production to be from Pennsylvanian sediments. A few wells undoubtedly are light producers from below the Pennsylvanian.

The following log is representative.

Stevens No. 1, in sec. 9, T. 14 N., R. 18 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Unrecorded (water)		160	Sand, black	20	1,250
Slate		450	Slate	50	1,300
Sand	20	470	Sand	15	1,315
Slate, black	155	625	Slate	60	1,375
Lime	10	635	Lime	15	1,390
Slate	265	900	Sand	30	1,420
Sand	30	930	Slate	45	1,465
Slate	75	1,005	Lime	15	1,480
Lime shells	10	1,015	Slate	10	1,490
Lime, hard	20	1,140	Lime	15	1,505
Slate	70	1,210	Sand (water)	65	1,570
Lime	20	1,230	Slate	20	1,590

Stevens No. 1, in sec. 9, T. 14 N., R. 18 E.—Continued.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Lime, white	80	1,670	Slate	42	2,090
Slate, black	20	1,690	Sand	80	2,170
Lime shells	125	1,815	Slate	10	2,180
Shale, brown	85	1,900	Sand, green	40	2,220
Sand, black	65	1,965	Red rock	55	2,275
Slate, sandy	35	2,000	Slate	25	2,300
Slate, black	36	2,036	Lime	40	2,340
Sand	12	2,048	Lime, sandy	45	2,385

The following table gives a summary of drilling during the years 1909 to 1914 inclusive.

Drilling record and initial production of wells completed in the Muskogee oil and gas field. 1909-1914.

Year.	Wells completed.				Initial production.	
	Total.	Oil.	Dry.	Gas.	Total.	Average per well.
1909	129	79	41	9	3,245	104.4
1910	171	123	43	5	16,640	135.3
1911	117	81	34	2	6,965	86.0
1912	38	12	24	2	293	24.4
1913	100	60	31	9	1,569	26.1
1914*	338	182	123	33	5,307	15.7
Total.	893	537	296	60	34,019	65.3

*The 1914 figures include Muskogee, Haskell, Broken Arrow, Coweta, and Wagoner pools.

DEVELOPMENT.

The first development on the townsite was begun as early as 1894 by a company drilling for the Cudahy Oil Company. A small production of light oil resulted but the discovery was not followed up until 1904 because of the difficulty of securing lawful titles. During that year between 30 and 40 wells were drilled in the southern part of the present townsite, near the Missouri, Kansas & Texas Railroad track. The wells were all light producers of high grade, light-colored oil. By 1905 the pool had been fairly well tested out, and operations began to slacken. At the end of the next 5 years only a few of the original wells were pumping to the Muskogee refineries.

About 1906 extensions to the southwest began to be developed. Since that time drilling has been fairly continuous in spite of the spottedness of production. Practically one-third of all wells drilled are gas producers. For the most part they are irregularly distributed over the field.

The main production comes from secs. 10, 11, 12, and 13, T. 14 N., R. 17 E., secs. 3, 4, 5, 6, 7, 8, 9, 15, 16, and 17, T. 14 N., R 18 E., and secs. 26, 27, 32, 33, and 34, T. 15 N., R. 18 E. This district includes what is known as the Chicken Farm pool.

During 1913 the Muskogee region produced about 421,750 barrels of crude oil. All pools are combined so that individual productions for the months varied from 1,010 to 1,244 barrels. One notable feature of this pool was that in January the output was greater than during any other part of the year. Few of the Oklahoma pools failed to show an increased production for the latter months.

During 1914 development was much curtailed and such wells as were drilled showed only light production. It is thought that the average initial capacity was not more than 15 or 16 barrels. Early average initial productions were more than 100 barrels. With such figures it is not difficult to see that the drain of seven years is beginning to tell in production.

SANDS.

In the old townsite pool the 1,000-foot sand is the only real productive horizon. In the district to the northwest of the pools under discussion the 400-foot sand is reported to be productive, but in Tps. 14 and 15, dry holes are more frequent from this horizon. In sec. 15, T. 14 N., R. 17 E., a small pumper is reported from a "stray sand." The chief production is from sands ranging from 1,400 to 1,700 feet below the surface.

None of the details of structure have been worked out. As to whether the production comes from lenticular masses of sand or from structural anticlines has not been satisfactorily determined in all cases. It is probable that if all the facts were known each method of accumulation would be found to be instrumental in different cases and possibly both conditions may be found in the same case.

YARHOLA POOL.

The Yarhola pool is located in T. 15 N., R. 16 E., about 15 miles west of Muskogee. In this region dry holes have been so frequent as to scare away most operators. The chief development has occurred in secs. 21, 28, and 33. In sec. 28 a considerable number of small gas wells have been completed. Most of the oil wells are of small capacity. No. 3 of the Gladys Belle Oil Company, in sec. 28, is reported to have produced 74 barrels in the first 24 hours. The largest well so far reported produced 125 barrels. Others nearby produced 35 barrels or less when placed under the pump. Two different sands have been reported from between 850 and 1,575 feet. The first sand is correlated with the Booch, although it is not certain that this is absolutely accurate. Both are productive, the former of gas, the latter of oil.

MISCELLANEOUS DRILLING.

South of Beland in sec. 30, T. 14 N., R. 7 E., on the Brooks farm, the Surety Producing Company is drilling a well and has reached a depth of 1,800 feet. No showing of either oil or gas has been reported.

In November of the past year Sigfreid *et al.* began a test in sec. 21, T. 15 N., R. 16 E. Drilling has progressed so slowly that nothing definite can be said concerning this test at this time.

During the past year drilling was renewed near Wainwright in sec. 16, T. 13 N., R. 16 E. Well No. 3, like the two earlier attempts, was abandoned as a failure at 1,940 feet. Other attempts in the same area have proved nonproductive. At the first of December, 1914, Talbot *et al.* were drilling in sec. 16, T. 17 N., R. 13 E., at about 2,200 feet. To that date no showings of either oil or gas had been noted.

In sec. 30, T. 10 N., R. 10 E., 1¼ miles northeast of Briartown, in western Muskogee County, a "duster" was drilled some distance off the anticline which passes near Vian.

A few miles farther northeast, near Webber Falls, in sec. 1, T. 11 N., R. 20 E., J. V. Snell has completed a 10-inch hole to a depth of over 2,000 feet. A 25-foot sand was passed through from 900 to 925 feet. In the same section a second well has been drilled to a depth of 2,260 feet without a showing of either oil or gas. Both have been abandoned as dry.

Two miles north and 4 miles west of Porum, in sec. 31, T. 30 N., R. 19 E., in the southwestern portion of Muskogee County, a well has been completed. The drilling resulted in a gas well of small capacity which has since been abandoned. It is supposed to be located on the southern extension of the Warner anticline.

SUMMARY.

There seems to be much irregularity in the horizon of producing sands in Muskogee County. Some of them seem to be deeper than the possible Pennsylvanian sands, and it is thought by a number of geologists that the deep production is from sands within the Mississippian. It is possible, however, that the faulting and folding evident to the northeast of Muskogee County, and which trends in a southwest direction into the county and disappears near Arkansas River, may extend farther in this direction than was at first supposed. It has been supposed that the severity of these faults and folds gradually lessens in a southwestern direction, and that they disappear for this reason. It may be, however, that this faulting occurred before the surface sediments to the south of Arkansas River were laid down. In this case the attitude of the surface rocks in this area would not indicate the presence of such faulting and folding. It is a problem which must be solved from well log data. It is an important problem, because if production really comes from Mississippian sands it opens up considerable more territory in the State for exploration. If, however, the production comes from Pennsylvanian it would seem advisable to explore in these rocks for oil-producing sands.

NOBLE COUNTY.

LOCATION.

Noble County lies in the north-central part of the State. It extends from T. 20 N. to T. 24 N. inclusive, and from R. 2 W. to R. 4 E. inclusive. It includes 20 entire townships and a part of 2 others. The total area is approximately 764 square miles.

TOPOGRAPHY.

Noble County is entirely within the Redbeds region. Its topography is that of a rolling prairie plain, varied with sandstone and limestone escarpments. The county is drained by Arkansas River and streams tributary to it.

GEOLOGY.

The rocks at the surface in Noble County are Permian. They consist of shales, sandstones, and argillaceous limestones. The shales predominate. The following log of the Mid-Continent Petroleum Company's well in the N. 1/2 of the SW. 1/4 sec. 22, T. 23 N., R. 2 W. will give a general idea of the underground formations:

Log of Mid-Co. Petroleum Co.'s No. 1 well in the N. ½ SW. ¼ sec. 22, T. 23 N., R. 2 W., near Billings, Okla.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Earth	6	6	Red rock	56	696
Lime	24	30	Hard slate	19	715
Sand	4	34	Red rock	25	740
Slate	16	50	Gas sand	15	755
Red rock	10	60	Slate	10	765
Blue slate	37	97	Soft gray lime	42	807
White shale	13	110	Red rock	23	830
Red rock	5	115	Gas sand	12	842
Slate	20	135	Red rock	18	860
Red rock	105	240	Hard sand and gas	10	870
White slate	10	250	Red rock	14	884
Red rock	15	265	Hard, gritty lime, gas	21	905
Lime	4	269	Hard slate	10	915
Red rock	46	315	Red rock	112	1,027
Slate	10	325	Gas sand	20	1,047
Red rock	5	330	Blue slate	2	1,049
White slate	8	338	Sand and lime	17	1,066
Red rock	17	355	Red rock	64	1,130
Soft slate	10	365	Lime	6	1,136
Soft red rock	15	380	Red rock	14	1,150
Lime	8	388	First water sand; water salty	20	1,170
Sand rock	7	395	Slate	25	1,195
White slate	25	420	Lime	23	1,218
Hard lime	15	435	Red rock	52	1,270
Soft lime	15	450	Lime	30	1,300
White slate	42	492	Brown slate	15	1,315
Red rock	28	520	Lime	75	1,390
Gray lime	15	535	Blue slate	5	1,395
Red rock	25	560	Lime	5	1,400
Hard slate	10	570	Lime and slate	76	1,476
Gas sand	12	582	Gas sand	69	1,545
Red rock	38	620	Slate	25	1,570
Blue lime	5	625			
Hard sand	15	640			

STRUCTURE.

The general attitude of the rock formation is that of a southwest-dipping monocline. There are local variations in this monocline. In the vicinity of sec. 22, T. 23 N., R. 2 W., there is an elongated dome which is located on the southwestern end of a northeast-southwest trending anticline. On account of no outcrops it is impossible to trace the northeastern extent of this anticline. Fath* has mapped this anticline as having a length of at least 7 miles and a maximum width of 5 miles. His discussion of the structure in the region is given below.

GENERAL FEATURES.

The rock beds of northeastern and north-central Oklahoma generally dip to the west or the northwest, and in north-central Oklahoma the average dip at different places ranges from 25 to 50 feet to the mile. Wherever the dip to the west is typically developed the place is unfavorable for finding oil and gas. Oil and gas are more likely to be found at places where the rocks have been warped or folded and the beds either lie flat or dip to the east. The size and value of the more productive oil fields of Oklahoma depend almost directly on the areal extent of the folds and the amount of this dip to the east, and if these are here the controlling features, the anticlinal fold herein described, which resembles that of the developed oil fields in Oklahoma, should be favorable to the accumulation of oil and gas in this region.

The anticlinal fold in this area trends in general northeastward and occupies parts of at least Tps. 23 and 24 N., Rs. 1 and 2 W. As there are few outcrops its exact magnitude and extent can not be fully determined, but sufficient data are at hand to indicate its general shape and size. The scattered rock outcrops show that the anticlinal fold has at least two parts, an elongated dome to the southwest and a broad anticline to the northeast.

THE DOME.

Near the center of T. 23 N., R. 2 W., the anticlinal fold is narrower and its sides are steeper than elsewhere, as is shown by the rock beds, which are excellently exposed here. This local feature is oval and may be called a short anticline or, preferably, an elongated dome.

Unlike many other anticlines and domes in Oklahoma, whose forms can be determined only by painstaking work or by doubtful correlation of beds, this dome is so well exposed that it can be readily seen even by the layman. The structure can be observed to the best advantage by looking south and west from the northeastern part of sec. 15, T. 23 N., R. 2 W.; and by looking west, north and east from the top of the escarpment near the center of the northern part of sec. 22 of the same township. From the first point of observation the crest of the fold may be seen near the north quarter corner of sec. 22, where the beds in the escarpment are practically flat. The dip to the east may be seen in the escarpment east of this crest and can be followed into the west side of sec. 14. From the second point of observation the thin limestone beds

*Fath, A. E., An anticlinal fold near Billings, Okla. U. S. Geol. Survey Bull. 641-E, pp. 125-128, 1916.

can readily be seen descending both to the east and the west from the crest of the dome.

The highest part of the dome is in the south-central part of sec. 15. As before mentioned, the dome is oval and appears to extend southwestward into the SE. ¼ sec. 21 and northeastward into the SE. ¼ sec. 10. The southeast dip on the dome persists for at least a mile, and in this distance the beds descend in elevation more than 130 feet. Exactly how far this dip to the southeast persists is not known, for the rock outcrops are insufficient to permit its determination farther.

On the northwest side of the dome the beds dip away steeply for a mile or more before they resume the normally gentle westward dip of the region.

The southwestern termination of the dome appears to be in the NE. ¼ sec. 28, although this assumption could not be definitely proved. It seems probable that the sandstone which crops out in the road about a quarter of a mile east of the southwest corner of sec. 22 is the lowest sandstone bed. The sandstone exposed a few hundred feet north of the south quarter corner of sec. 22 is almost certainly the highest sandstone bed of the section. Less certainly, but probably, the sandstone exposed in the center of the SW. ¼ NW. ¼ sec. 27 and the residual sandstone near the center of the NE. ¼ sec. 28 are from the same bed. Whether or not the slope of the surface in the SW. ¼ sec. 22 and the SE. ¼ sec. 21 represents roughly the position in which the under ground rock beds lie (dip slopes) can not be certainly determined, but the position of the scattered outcrops just mentioned seems to lend some basis for this assumption.

The dip of the beds in the NW. ¼ sec. 15 is almost north and indicates that the dome is lower in the northern part of this section than farther south. The structure here could not be exactly determined for lack of outcrops, but it is probable that a "low" or "saddle" in the anticlinal axis in this locality marks the northeastern termination of the dome.

THE ANTICLINE.

The northern and apparently the larger part of the Billings anticlinal fold can not be so fully nor so readily distinguished because of insufficient rock outcrops. It is a broad fold at least 5 miles wide and can be traced with certainty northeastward for about 7 miles. It narrows abruptly at its southern extremity, where it is connected with the dome to the southwest by a "low" or "saddle." Its sides are poorly outlined by two belts of scattered outcrops—an eastern belt, in which the beds dip to the southeast and which extends from SW. ¼ sec. 23, T. 24 N., R. 1 W., to the NW. ¼ sec. 16, T. 23 N., R. 1 W., and a western belt, in which the beds dip to the west and which extends from the SW. ¼ sec. 31, T. 25 N., R. 2 W., to the NW. ¼ sec. 3, T. 23 N., R. 2 W. The eastern limit of the eastward-dipping beds was determined at but one place—in the SE. ¼ sec. 22, T. 24 N., R. 1 W. On the northeast there are no outcrops that indicate the character and location of that end of the anticline. The axis of the fold is indistinctly indicated at one place; it appears to cross secs. 30 and 31, T. 24 N., R. I W., in a northeastern direction.

In the belts of outcrops mentioned above, the beds exposed are the same as those in the dome to the southwest, and they can be recognized with comparative ease. The almost complete absence of rock outcrops in the northern part of T. 24 N., R. I W., leaves the attitude of the northeast end of the anticline a matter of conjecture only. Whether the beds north of the secs. 22 and 23, T. 24 N., rise rapidly and resume the normal westward dip, thereby terminating the anticline within this township or whether they continue to strike northeastward and thereby extend the anticline to the township and county to the north can not be determined. The presence of the broad silt-covered valley of Salt Fork River would appear to preclude any possibility of finding the northeast end of the anticline in the township on the north, as even the upland on the south contains practically no outcrops.

In the area embraced by the two belts of outcrops that outline the southeastern and northwestern flanks of the anticline there are a few scattered outcrops that expose beds of shale and thin beds of sandstone. These were not traced from place to place, and their exact position with reference to the beds of the measured section is not known, but they lie below the limestone-bearing series shown in the section. The strike and dip at several of these outcrops are more or less apparent, and the writer's observations are shown on the map by strike and dip symbols. An accurate determination of the strike and dip was made instrumentally in the SE. ¼ sec 31 T. 24 N., R. 1 W., and these are shown on the map by a few short contours. A dip of 18 feet in 500 feet, or at an angle of about 2°, was measured by hand level and pacing in a "wash" in the SW. ¼ sec. 32, T. 24, N., R .1 W. The direction of this dip was measured on a line trending N. 72° E. The exact strike of the beds was not determined. These observations, together with the attitude of the beds in the southeastern belt of outcrops mentioned above, indicate a dip to the southeast in a zone that averages more than three-quarters of a mile in width. This southeastward dip doubtless extends in both directions, but how far can not be determined. The amount of the dip to the southeast by different geologists would probably differ considerably. To the writer, 100 feet would be a low estimate; he would rather consider it equal or even greater than that of the east dip on the dome, which, measured at one place, was about 130 feet.

The strong dip to the southeast was observed in the SW. ¼ sec. 32, the dip to the south measured in sec. 31 and the probable dip to the west observed in the east-central part of sec. 36 and the NE. ¼ sec. 25, T. 24 N., R. 2 W. indicate that the crest of the anticline probably crosses secs. 30 and 31.

The eastern limit of the easterly dip was determined at one place, in the southeastern part of sec. 22, T. 24, N., R. 1 W., for in sec. 23 of the same township the dip is to the west. The axis of the syncline thus formed by the convergence of eastward and westward dipping beds can probably be followed southward, but the poor outcrops in this locality would necessarily make the work slow and uncertain.

A study of the structure contours shows that the anticline pitches to the southwest. The rise of the anticline to the northeast may produce either a broadening or a flattening of the structure in this direction. If it flattens, the northern extension of the dip to the east may terminate in T. 24 N., R. 1 W., and the beds may there resume their normal dip to the west. If the anticline does not flatten but continues northeastward, it probably extends northward to T. 25 N., R. I W. The drill will no doubt at some time furnish much of the information which is now lacking because of the absence of rock exposures.

DEVELOPMENT.

The business men of Perry raised $20,000 for drilling in the vicinity of Perry. Drilling was begun in 1910 and three holes were put down. The first hole was located about one mile south of the city and drilled to a depth of 400 feet; the second hole was located one mile north of the city and drilled to a depth of 1,200 feet; and the third was located in the eastern limits of the city and drilled to a depth of 1,000 feet. The reports show that none of these holes went entirely through the Redbeds. No production was found.

The Glenrose Oil Company is reported to have had a show of gas at a depth of 500 feet in their well in sec. 17, T. 24 N., R. 1 W. This company is drilling two holes in sec. 20, T. 24 N., R. 1 W. All these wells are located on the Billings anticline.

The Mid-Continent Petroleum Company has encountered in their hole in the N. 1/2 of the SW. 1/4 of sec. 22, T. 23 N., R. 2 W. the following:

Sand at 570 feet— 2,000,000 cu. ft. of gas.
Sand at 700 feet— 2,000,000 cu. ft. of gas.
Sand at 920 feet— 5,000,000 cu. ft. of gas.
Sand at 1,027 feet—10,000,000 cu. ft. of gas.
Sand at 1,340 feet— 2,000,000 cu. ft. of gas.
Sand at 2,033 feet (drilled to depth of 16 feet making about 25 barrels of oil.)
Sand at 2,219 feet (drilled in 6 feet estimated production 500 lbs. daily.)
Total volume of gas—21,000,000 cu. ft. of gas.

T. 23 N., R. 3 E. has two holes. One in sec. 31 has been drilled to a depth of 2,250 feet and no gas or oil encountered; the other in the NE. cor. of sec. 33, had salt water at a depth of 2,055. In sec. 25, T. 22 N., R. 4 W., the Chanute Refining Company is drilling. In sec. 36, T. 21 N., R. 1 E., Von Tackey and others had a show of oil and gas at a depth of 2,100 feet. In NE. cor. of sec. 7, T. 21 N., R. 3 E., is a reported hole having a show of gas at a depth of 2,447 feet.

The Roxana Petroleum Company had a slight showing of oil and gas in their well in the NW. 1/4 of sec. 9, T. 20 N., R. 2 W.

SUMMARY.

Noble County may be regarded as being within proved territory for both gas and oil. Though the well in sec. 22 T. 23 N., R. 2 W. did not encounter much oil as was hoped for, yet the showing in the 2,033 foot sand was decidedly favorable and the hole was continued to a depth of 2,129 feet, where, at 6 feet in the sand a considerable flow of oil was encountered. The production has been estimated to be 500 bbls. daily. Further drilling on the Billings anticline will, no doubt, prove up a valuable field.

NOWATA COUNTY.

LOCATION.

Nowata County is located in the northeastern part of Oklahoma in the northern tier of counties bordering Kansas. It extends from T. 24 N. to T. 26 N. inclusive, and from R. 14 E. to R. 18 E. inclusive. It includes 13 whole townships and a part of 7 others. The total area is approximately 588 square miles.

TOPOGRAPHY.

The topography is in general a plain in which the streams have eroded wide valleys. The surface ranges in elevation from 600 to 926 feet. The lowest point is in the southern part of the county along Verdigris River. The highest point is in sec. 25, T. 26 N., R. 18. E.

The entire county is drained by Verdigris River and its tributaries.

GEOLOGY.

GENERAL STATEMENT.

The surface rocks in this county are Pennsylvanian in age. They consist chiefly of shales, sandstones, and limestones. The subdivisions exposed in this area are: Cherokee and Fort Scott formations, Labette shales, Oolagah formation, Nowata shale, Lenapah limestone, Curl, and Wann formations.

CHEROKEE AND FORT SCOTT FORMATIONS.

The *Cherokee formation*, the oldest exposed in this county, outcrops in the extreme southeastern corner of the county. The *Fort Scott* succeeds and lies to the north, northwest and west of the Cherokee. It extends west as far as the Verdigris and from Alluwe in a general northeast direction.

LABETTE SHALE.

The Labette shale is stratigraphically above the Fort Scott formation. It outcrops in a narrow band along the west bank of Verdigris River as far north as Alluwe, then extends irregularly in a general northeast direction from that point.

OOLAGAH FORMATION.

The Oolagah formation, which consists of the Pawnee limestone, Bandera shale, and Altamont limestone, succeeds and outcrops in the same general direction as the preceding formation.

All of the formations mentioned above are described in more detail under the heading of "Geology" of Craig and Rogers counties.

NOWATA SHALES.

The Nowata shales, which lie above the Oolagah formation, consist of a series of shales with a few interstratified sandstones and at least one bed of coal, which is a persistent horizon throughout the extent of the Nowata shales. These shales occupy a greater surface exposure than most Pennsylvanian formations. The outcrop increases in width from a narrow band at the Kansas line to 2 miles at Nowata, and in thickness from 50 feet at the State line to 130 feet at Nowata, and continues to thicken farther southwest. In lithologic character the formation is essentially clay, but arenaceous layers are not infrequent.

LENAPAH LIMESTONE.

The Lenapah limestone lying between the Nowata shales and the Coffeyville formation is named from the town of Lenapah in Nowata County. Here the bed of limestone is typically exposed. The Lenapah outcrops for the most part on the hills. Over the northern area of its outcrop it extends over a large surface area, because it occupies a dip slope. South of Nowata the outcrop is narrow but continues as far south as Buck Creek.

CURL FORMATION.

The Curl (Coffeyville) formation, which lies above the Lenapah limestone generally consists of shale, but near the top sandstones are prominent. Following the general rule, it thickens from the Kansas line southward, the average thickness being 370 feet. This formation has been correlated with the Coffeyville formation of Kansas.

WANN FORMATION.

The Wann formation* is composed of three members, the *Hogshooter limestone member*, *Copan member*, and *Stanton limestone member*. The *Hogshooter limestone* enters Oklahoma 2 miles west of Coffeyville and continues southward across the northeastern corner of Nowata County, and is about 10 feet thick. The *Copan member* lies between the Hogshooter and the Stanton limestones. It consists of a succession of shales, heavily bedded sandstones, and limestone lentils. The outcrop of this formation is about 12 miles wide near the Kansas line and continues southward in a manner similar to the Hogshooter. The *Dewey limestone lentil*, a prominent stratigraphic feature of the Copan member, extends from a point a few miles east of Wann in a southwest direction into Washington County. The *Avant lentil* of the Copan and the Stanton linestone members do not outcrop in Nowata County.

STRUCTURE.

The structure of Nowata County is in general that of a westward-dipping monocline. In some places the normal dip is interrupted by a

*Ohern, D. W., Research Bull. Univ. of Oklahoma, No. 4, 1910, p. 28.

flattening or reversal dip to the east. An example of anticlinal folding is the Coody's Bluff-Alluwe-Chelsea field.

DEVELOPMENT.

GENERAL STATEMENT.

In 1904, after the Secretary of the Interior had confirmed leases in the Cherokee, drilling was prosecuted with great activity in this section of the State. In Nowata County drilling was centered around Alluwe and Lenapah. In 1905 the shallow field development was extended north to Coody's Bluff (a proven territory 15 to 18 miles in length). During the next few years activity continued in the Coody's Bluff field. In 1908 the principal development was in the Delaware-Childers and Nowata or Claggett fields. The Adair field west of Nowata was opened up in 1912.

From 1912 there was a decrease in the production and by 1914 most of the fields were exhausted. In 1915 no development of any consequence was done, most of the area having been developed prior to this time. In 1916, however, there has been an increase in development over that of 1915, on account of the shallow drilling and increase in the price of petroleum.

Nowata County includes several important oil and gas fields, namely, Adair, California Creek, Coody's Bluff-Alluwe-Chelsea, Nowata or Claggett, and South Coffeyville all of which will be taken up in the order named

The following table shows the development and initial production of all fields in the county.

Drilling record and initial production of wells in the Cherokee shallow sand pools 1908-1916.

Year.	Wells completed.				Initial production.	
	Total.	Oil.	Dry.	Gas.	Total.	Average per well.
1908	1,281	1,180	94	7	80,923	68.6
1909	1,563	1,383	161	19	85,799	62.0
1910	1,638	1,477	149	12	79,074	53.5
1911	1,237	1,091	93	52	62,663	57.4
1912	881	761	87	33	10,930	14.4
1913	1,231	1,071	139	21	17,672	16.5
1914	1,636	1,539	86	11	16,476	10.7
1915	596	516	53	27	10,535	20.4
1916	1,217	1,001	94	22	16,423	16.4
Total	11,280	10,019	957	204	380,495	35.5

ADAIR POOL.

LOCATION AND DEVELOPMENT.

The Adair pool lies principally in T. 26 N., R. 15 E., about 6 miles west of Nowata. It is related geologically to the Hogshooter and Bartlesville fields, and with respect to locality, to the Nowata district. The pool was discovered in 1911 and has been the most recent important development in that county. Later development showed an extension to the south towards Purgatory Creek. The chief development has been in secs. 32, 33, and 34. The most recent development in this vicinity has been in secs. 20, 21, 24, 25, 26, 28, 29, 33, and 36. Most of the wells have been small pumpers ranging in production from a few barrels to as high as 150 barrels, according to newspaper reports, averaging about 20 barrels initial production per well.

SANDS.

The wells start near the top of the Curl (Coffeyville) formation and encounter the Fort Scott formation and Bartlesville sand at 625 and 1,025 feet respectively. The thickness of the Bartlesville is approximately 50 feet.

CALIFORNIA CREEK POOL.

LOCATION AND DEVELOPMENT.

The California Creek pool is located chiefly in T. 27 N., R. 15 E., about 5 miles south of Coffeyville, Kansas, along both sides of California Creek. Development of this field began in the early part of 1911 and has continued more or less intermittently to the present time (August, 1916). The oil production is limited to 2 square miles. The pool is of more importance as a gas field than for oil. Late in 1912, 25 gas wells had been brought in with an average estimated daily capacity of 3,400,000 cubic feet and with a total capacity of about 85,000,000 cubic feet per day, the pressure averaging about 373 pounds to the square inch. Most of the gas is piped out by the Kansas Natural Gas Company into southern Kansas.

SANDS.

The geological conditions are very similar to those of the Delaware-Childers pool. Productive horizons are reported from near depths of 220, 515, 1,020, and 1,145 feet. It seems, however, that the Bartlesville, which is generally productive over this region, is not present, or is dry and not reported in most cases.

COODY'S BLUFF-ALLUWE-CHELEA FIELD.

LOCATION AND EXTENT.

The Coody's Bluff-Alluwe-Chelsea field extends along the east side of Verdigris River from Spencer Creek, west of Chelsea on the south to the north line of T. 26 N., R. 17 E. This line may seem more or less arbitrary becaue of the fact that the Coody's Bluff-Alluwe-Chelsea field and Delaware-Childers pools are practically continuous. The total length of the field is about 18 miles, with the greatest width in the vicintiy of Alluwe post office. At this point the lateral extent is approximately 5 miles, while the minimum width, 2 miles or less, occurs near Coody's Bluff post-office. The total area is about 75 square miles.

GEOLOGY.

The wells in the southern part of the pool begin at about the upper level of the Fort Scott formation, while those farther north probably a little below the base of the Altamont limestone, about 300 feet higher geologically. In general the wells at the south end of the pool are from 200 to 350 feet in depth, while those in the Coody's Bluff region are drilled 500 to 750 feet.

STRUCTURE.

Hutchison makes the following statements concerning the structure of this field:

Structurally the Coody's Bluff-Chelsea field is anticlinal. The fold plunges toward the north and disappears near the north end of the development, while southward the rocks level up and have assumed their normal westerly dip by the time the big Cherokee Lease is reached at the southern end of the field.

DEVELOPMENT.

This field was opened up in 1904. The following year was a period of great activity but was surpassed in 1906 when a total of 1,490 wells were drilled. Almost all were producing oil wells. In 1909 development decreased at least 50 per cent and continued to decline from that date. The maximum daily production of over 53,000 barrels was reached in 1906 from 1,267 producing oil wells. The development is fairly solid over the entire area. When the price of oil advanced in the latter part of 1915 and early part of 1916 renewed activity was manifested in the Chelsea portion of the field. Some small wells were completed in secs. 21, 22, 27, and 28, T. 24 N., R. 17 E.

The following table gives the well record and the total and average initial production from 1905 to 1912.

Drilling record and initial production of wells in the Coody's Bluff-Alluwe-Chelsea pool.

Year.	Wells completed.				Initial production.	
	Total.	Oil.	Dry.	Gas.	Total.	Average per well.
1905	689	640	32	17	16,235	25.8
1906	1,390	1,267	97	26	43,422	33.
1909	580	515	65		16,166	29.4
1910	614	561	38	5	14,010	24.8
1911	292	271	17	4	4,537	16.9
1912	594	544	47	3	7,460	13.7

SANDS.

Two productive sands are encountered in this field. The Bartlesville is the upper sand, and is encountered in the lower portion of the field at a depth of approximately 400 feet, and in the upper portion at about 600 feet. This sand is the main producing horizon. The Burgess, or lower sand, occurs about 65 feet below the Bartlesville, in the southern portion of the field, and 200 feet below it in the northern portion. The average thickness of the Bartlesville is about 20 feet. and that of the Burgess about 15 feet.

CHARACTER OF OIL.

The oil in this field is usually green to greenish-black in color, and has an average specific gravity of 35° Baume. The base is both paraffin and asphalt, the former about 8 per cent and the latter about 1 per cent.

NOWATA OR CLAGGETT POOL.

LOCATION AND EXTENT.

The Nowata or Claggett pool is located in T. 26 N., R. 16 E., and the chief production is secured from secs. 8, 9, 16, 17, and 18. This pool is the western extension of the Coody's Bluff pool and is sometimes described under that heading.

GEOLOGY AND SANDS.

The wells in the eastern part of the field begin at the top of the Oologah formation, or Big Lime, while in the western part they begin near the top of the Lenapah limestone. The wells vary in depth from 500 feet near Verdigris River to 750 feet at the western extremity of the pool. The productive sand, which is the Bartlesville, is encountered from 390 to 410 feet below the top of the Fort Scott or Oswego limestone. The thickness of the sand averages about 18 feet.

DEVELOPMENT.

Dry holes completely define the limits of practically all the productive area, and are scattered over the surrounding territory. All were not dry in the strictest sense of the word, and it is likely that large numbers were of too small production to be economically handled, and were abandoned.

Drilling record and initial production of wells in the Nowata or Claggett pool, 1909-1912*, *by years.*

Year.	Wells completed.				Initial production.	
	Total.	Oil.	Dry.	Gas.	Total.	Average per well.
1909	232	213	15	4	5,620	26.4
1910	109	103	4	2	2,150	20.9
1911	149	88	25	36	1,202	13.7
1912	51	8	19	24	115	14.4
Total	541	412	63	66	9,087	18.6

DELAWARE-CHILDERS POOL.

LOCATION AND EXTENT.

The Delaware-Childers pool lies principally in T. 27 N., Rs. 15 and 16 E. It extends from Delaware to Childers. The chief productive area is limited to a narrow strip which merges into the Coody's Bluff-Alluwe pool south of Childers, and extends west 26° north, almost to the NE. cor. T. 27 N., R. 14 E., a distance of about 14 miles. At its widest point it is less than 3 miles wide, while at the narrowest point in sec. 22, T. 27 N., R. 15 E. it is less than one-fourth of a mile wide. It may be said to be the westward extension of the Coody's Bluff-Alluwe pool, and is similar in practically every way.

GEOLOGY.

The surface rocks as a whole are composed of shales and limestones with a few sandstones in layers. Toward the west end of the pool drilling starts in the Nowata shale, while at the east end the Pawnee limestone is the surface formation.

*Years of 1913, 1914, 1915, and 1916 included with the Cherokee shallow sand pools.

DEVELOPMENT.

The first active development in this field was in 1908. The initial production of the wells was high, some of the wells having an initial production of 150 barrels per day. In 1909 over 475 oil wells were completed, having an average initial daily production of 120 barrels per well. The pool was developed rapidly and the production declined in the same manner. At the present time, August, 1916, the pool is almost exhausted, the producing wells being pumped and many of the wells having been abandoned. In character the oil is very similar to that of Coody's Bluff pool. The following table gives well record and initial production 1909-1912.

Drilling record and initial production of wells in the Delaware-Childers Pool, 1909-1912*

Year.	Wells completed.				Initial production.	
	Total.	Oil.	Dry.	Gas.	Total.	Average per well.
1909	546	475	65	6	57,320	120.7
1910	757	673	80	4	59,185	88.0
1911	650	597	43	10	54,266	90.9
1912	236	209	21	6	3,355	16.1
Total	2,189	1,954	209	26	174,126	78.9

SANDS.

The wells which generally range from 670 to 900 feet in depth obtain their best production from the Bartlesville sand. This sand is found at a depth of 750 feet and is 50 feet thick. The Oswego limestone occurs at approximately 300 feet, and the Big Lime, or Oolagah formation, at 125 to 200 feet.

SOUTH COFFEYVILLE POOL.

GENERAL STATEMENT.

During 1915 and 1916 some development has been carried on in the vicinity of South Coffeyville. In T. 29 N., R. 15 E., several producing wells were completed. The Stamm Oil Company completed two 25 barrel wells in sec. 26. Breene and associates completed a 40 barrel well in sec. 23 and 2,000,000 cubic feet of gas in sec. 26. The sand is encountered at about 850 feet.

SUMMARY.

All of Nowata County is in probable oil and gas territory. Production began as early as 1904 and although it has declined greatly the different fields are still producing some oil. Up to the present time a large number of the wells have been abandoned and the fields have become almost exhausted. The whole county has been tested to a great extent, so that no new fields of any importance are likely to be found, but an increase in production may be obtained from the more complete drilling of all the fields of the county.

*Following years are included with the Cherokee shallow sand pools.

OKFUSKEE COUNTY.

LOCATION.

Okfuskee County lies in the east-central part of the State. It extends from T. 10 N. to T. 13 N. inclusive, and from R. 7 E. to R. 12 E. inclusive. It includes 16 entire townships and parts of 3 others. The total area is 617 square miles.

TOPOGRAPHY.

Okfuskee County lies within the Sandstone Hills. The sandstone-capped hills lie in more or less parallel zones, separated by broad shale valleys. The drainage of the greater part of the county is south into the Canadian River. The northern one-third of the county drains into Deep Fork of the Canadian.

GEOLOGY.

Most of the surface rocks in Okfuskee County are Pennsylvanian and consist of shales, sandstones, limestones, and an occasional dolomite. Along the stream valleys are Recent sands and gravels. Shales predominate. Economically the sandstones are important, as they have been used for building stone. The following Pennsylvanian formations are known to outcrop in Okfuskee County:

(1) *Senora formation.*—The sediments in this formation are sandstones and shales interstratified. The sandstones often occur in lentils. The shales are bluish clay shales and brownish sandy shales, while the sandstones are generally fine-grained and gray or reddish brown in color. (2) *Calvin sandstone.*—The upper part of this formation consists of thin-bedded sandstones with some shales. The lower part is made up of soft, rather massive sandstones. (3) *Wetumka shale.*—This formation is composed almost entirely of friable laminated clay shales. (4) *Wewoka formation.*—This formation consists of massive, brown, friable sandstones interstratified with soft blue shales and an occasional limestone.

STRUCTURE.

The Pennsylvanian strata are a part of the Prairie Plains monocline, which in Okfuskee County has a low dip to the west. There are local variations in this general west dip caused by folding and some faulting.

The only area in this county in which the structure has been worked in detail is that in the vicinity of Paden. The work was done through a co-operative agreement of the United States Geological Survey with the Oklahoma Geological Survey. The structure was surveyed by A. E. Fath and K. C. Heald by means of a plane table using a telescopic alidade and stadia rod. The report as submitted is given in the following pages.

FAULTED STRUCTURE IN THE VICINITY OF THE RECENT OIL AND GAS DEVELOPMENT NEAR PADEN.

BY A. E. FATH. ASSISTED BY K. C. HEALD.

INTRODUCTION.

The finding of considerable gas and a small amount of oil in a wildcat well near the town of Paden, Okfuskee County, Oklahoma, on November 10, 1914, caused much excitement in that vicinity for several weeks following the discovery. Leasing became very active, and acreage, some of which was several miles from the well, was reported as selling at $100 to $150 per acre.

Gas with some oil was struck when the drill had penetrated the sand but a few inches, and the well was shut in immediately. Up to the date of writing, March, 1915, no further attempt has been made to prove the productivity of the pay sand. The depressed condition of the petroleum industry is reported as the cause for the delayed development.

To determine the geological conditions which may have caused this occurrence of oil and gas a hasty examination, covering a few days, was made in the vicinity of the well. The finding of faulted structure east of the discovery well at the very beginning of the examination seemed to warrant the making of as detailed a survey of the faulted area as was possible in the time still available for this work. The results thus obtained seemed to justify the publication of a map showing the rock outcrops surveyed, together with a brief description of the geology and a discussion of the possible relations of the structure to the occurrence of the oil and gas encountered in the well.

Although the work was confined to the comparatively small area mentioned above, the data here presented may have a very important bearing on the occurrence of oil and gas which was encountered in the well, as faulting is known in some instances to be the governing factor in oil and gas accumulation. It is possible, however, that other structural features favorable to the accumulation of oil may be present outside of the area studied.

GEOGRAPHY AND TOPOGRAPHY.

The well in which the oil and gas were encountered lies in the southeast corner of the SW. 1/4 sec. 8, T. 12 N., R. 7 E. The area embraced by the accompanying map includes sections 4, 5, 8, 9, 16, 17, 20, and 21, of this same township.

Paden, a thriving small town lying two miles from the well in sections 16, 21, and 22, on the Fort Smith & Western Railroad, has received an impetus to its growth through the possibilities of a nearby oil field. Prague, another and larger town on the Fort Smith & Western Railroad, lies seven miles to the west and south of the well.

The surface of the region is rolling, interrupted here and there by low escarpments caused by rock ledges. The timber which at one time covered most of this region has been partly cleared away and farming is now the general occupation of the people.

GEOLOGY.

STRATIGRAPHY.

The area lies east of the basal Permian as mapped by J. W. Beede.[1] (See fig. 7). The general westward monoclinal dip present throughout northeast and east-central Oklahoma, prevails in this region also, and appears to place the rocks here exposed below the Permian; hence they may be classed with the red portion of the Pennsylvanian series.

Dolomite beds.—Two closely associated dolomite beds, whose easily recognizable character permitted rapid work in determining the faults described in this report, are the only strata which will receive special description. The best exposure of these dolomite beds seen by the writers is located in the creek bed 800 feet directly east of the west quarter corner of sec. 9, T. 12 N., R. 7 E. No fossils were found in them except fragments of crinoid stems.

The upper of these two dolomite beds is approximately 2 to 4 feet thick and gray to pinkish gray in color, except the upper few inches which are brilliant brick red. At some exposures distinct bedding is present, but this is not a general characteristic. The upper thin brick-red surface is usually highly jointed and at many places has the appearance of a pavement made of blocks 2 to 6 inches in parallelogram dimensions.

Three to 4 feet of reddish shale separate this upper dolomite bed from the lower one.

The lower dolomite bed varies in thickness from 3 or 4 inches to about 18 inches. Its principal character is its two weathering colors, a light brown or chocolate above and a brilliant brick red below. The red is identical with that at the top of the upper dolomite and can readily be mistaken for it. This two-fold color, resembling in appearance a layer cake, is very marked, inasmuch as the two layers are welded together so that they are but a single bed. The thicknesses of the two-color layers vary from place to place, and it is reported that locally the brown layer is missing, although this was not observed in the area studied. This lower bed is more persistent in its outcrop and more easily recognizable because of its striking combination of color than the upper bed, for which reason it is used as a key horizon to which all the elevations on the accompanying map refer. In the record of the well printed on page 26, there are recorded two "shells" lying between the depths of 85 and 90 feet, and between 95 and 100 feet. It cannot be stated positively that these "shells" are the representatives of the two dolomite beds, but it seems probable that they are so if the record is reliable.

Rocks above the dolomite beds.—The rocks immediately overlying the upper dolomite were in no place found to be well exposed. Sand-

[1]Beede, J. W., Okla. Geol. Survey Bull. No. 21, p. 22, 1914.

stone is apparently the overlying rock, but whether any intervening shale is present was not determined. This overlying sandstone is pinkish-gray in color, rather friable, and weathers into rounded forms which at some places contain peculiar pits. Parts of the sandstone are spotted with brilliant red specks and resemble a pox marked surface. The thickness of this sandstone was not determined.

Rocks below the dolomite beds.—Below the lower dolomite there is present a dark red sandstone, but whether any shale lies between these beds was not determined for lack of good exposures. If shale does intervene it must be comparatively thin, not more than a few feet thick. The thickness of the underlying sandstone was not ascertained nor was the succession of strata below it studied in detail, as the rocks are poorly exposed. Beds which probably are stratigraphically lower than the sandstone were observed in the railroad cut on the north side of the town of Paden. The rocks in this cut have a general westward dip. Red shales are the uppermost ones here exposed. Below the red shales and apparently in unconformable relation to it is a reddish conglomeratic sandstone having a thickness of at least 40 feet, and possibly much more. This conglomeratic sandstone varies in character from a fine sandstone to a conglomerate whose pebbles vary from 1/8 of an inch to 2 inches in diameter. Most of the pebbles are a dull white, and appear in the hand specimen to be decomposed chert. These white pebbles are angular or but slightly rounded. Pebbles of a hard dove gray chert are also present and these are better rounded, the corners and edges being worn off in all observed specimens.

The following log is that of the discovery well.

Log of A. C. Rogers well No. 1, drilled by the Prairie Oil & Gas Company, in the SE. cor. of the SW. 1/4 sec. 8, T. 12 N., R. 7 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Sand shell, hard	16	16	Lime	5	625
Red clay	54	70	Red clay	10	635
Water sand	15	85	Sand	15	650
Shell, hard	5	90	Lime	5	655
Red clay	5	95	White clay	25	680
Red shell	5	100	Lime	5	685
Red clay	60	160	Red clay	45	730
Lime	8	168	Lime	5	735
Water sand	12	180	Red clay	25	760
Red clay	50	230	Lime	5	765
Lime	10	240	Red clay	25	790
Red clay	120	360	White clay	24	814
Sand	40	400	Water sand	10	824
Red clay	40	440	White clay	16	840
Water sand	22	462	Red clay	60	900
Red clay	13	475	Shell	17	917
Lime shell	5	480	Slate, clay	68	985
Red clay	45	525	Water sand	30	1,015
Sand	15	540	Slate clay	10	1,025
Red clay	80	620	Red rock	7	1,032

Log of A. C. Rogers well No. 1, drilled by the Prairie Oil & Gas Company, in the SE. cor. of the SW. ¼ sec. 8, *T.* 12 *N., R.* 7 *E.*—Continued.

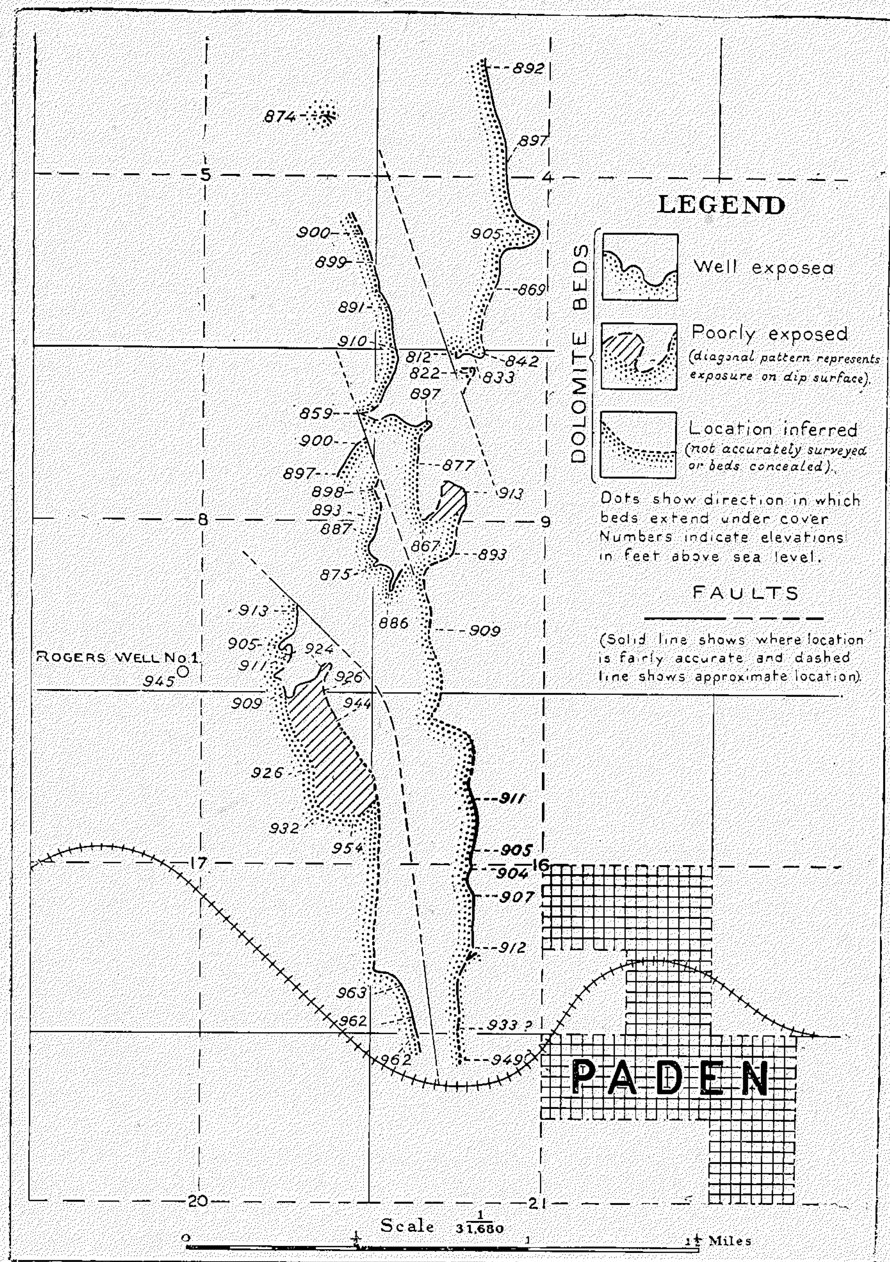
Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*
Water sand	8	1,040
Slate	5	1,045
Lime	5	1,050
Slate clay	25	1,075
Water sand	10	1,085
Slate mud	45	1,130
Red rock	15	1,145
Slate clay	5	1,150
Water sand	75	1,225
Slate	20	1,215
Water sand	75	1,320
Slate	5	1,325
Water sand	65	1,390
Slate	15	1,405
Sand shells	5	1,410
Slate	70	1,480
Sand	15	1,495
Slate	155	1,650
Sand	30	1,680
Slate	15	1,695
Sand	35	1,730
Slate and shells	215	1,945
Lime	10	1,955
Slate	500	2,455
Lime	8	2,463
Red slate	32	2,495
Lime	5	2,500
Shale	40	2,540
Lime	10	2,550
Shale	45	2,595
Lime	25	2,620
Slate	110	2,730
Lime shell	10	2,740
Slate	51	2,791
Sand, oil and gas	2	2,793

STRUCTURE.

The rocks in this locality strike practically north and south, and have a pronounced westward dip which shows not only in the outcrops of the dolomite but also in the rocks exposed in the railroad cut. This westward dip is locally as high as 400 feet to the mile. The only marked irregularities in the north-south strike of the strata are due to faulting, the down-throw sides of the faults forming local synclines.

The most important structural features observed in the area are the faults which lie east of the well. The faulted belt was followed for approximately three miles from the north side of section 21 to sections 4 and 5. It lies in a north-south direction and probably extends beyond the limits mentioned, although the fact was not determined. Within the faulted zone examined, there are at least three principal faults which lie *en echelon* with reference to each other and strike a little west of north. No one of these could be traced for more than 1½ miles. They are probably normal faults as they occur in strata which dip only a few degrees from the horizontal. Small minor faults subsidiary to the main fault are present, but as they do not affect the dolomite beds, they are not easily recognized and therefore were not mapped.

South fault.—Of the three faults shown on the map, the south one is the longest, extending northward from the NW. ¼ NW. ¼ sec. 21, through the west part of section 16, into section 8 near the southeast corner of that section. From this corner the strike of the fault bends to the northwest and the structure is sharply defined in the center of the SE. ¼ sec. 8, where, in the low north-south escarpment, the dolomite ledge ends abruptly and the escarpment to the north is upheld by a sandstone ledge. To the northwest of this point the fault could not



MAP SHOWING FAULTED AREA
IN VICINITY OF OIL AND GAS DEVELOPMENT NEAR PADEN, OKLAHOMA
By A.E.Fath and K.C.Heald
1915.

Figure 9.

be traced in the sandstone beds here present and its prolongation in this direction was not mapped. This structure may not be a single continuous fault for a series of several shorter faults lying parallel or *en echelon* might produce the same relation between the outcrops of the dolomite beds on either side. As no specific evidence was gathered on this point, the simplest explanation, a single fault, has been given to account for the facts obtained.

Middle fault.—The middle one of the three faults was traced but half a mile. It may however extend farther north. This fault has its greatest determinable vertical displacement between the outcrop of the upper dolomite exposed in the creek bed just west of the north-south road at the east boundary of the NE. 1/4 sec. 8, and the outcrop of the lower bed near the top of the south side of this valley. To the south-southeast this fault crosses the east-west quarter line of section 9 somewhere between the west quarter corner and the creek bed to the east. It extends into and ends near the center of the NW. 1/4 SW. 1/4 of this section, where it is represented only by a slight disturbance of the strata.

North fault.—The north fault is best studied along the east-west section line at the north side of the NW. 1/4 sec. 9, where a vertical displacement of 100 feet or more is shown between the exposures of the dolomite beds, one exposure being 300 feet east of the northwest corner of this section and the other in the creek bed a few hundred feet farther east. This is the maximum displacement determined for any of the three faults. Greater vertical displacements may be present, but, if so, were not observed. This north fault was traced but a short distance southward into section 9, as it apparently leaves the dolomite outcrops and enters that of the underlying sandstones in which it can be traced only with great difficulty. To the north it traverses the SW. 1/4 sec. 4, but its exact location within this quarter section was not determined because of poor exposures. Whether it enters section 5 is also a matter of conjecture. Some slight evidence found in surface features would indicate that the fault lies between the outcrop of the dolomite shown in the SE. 1/4 sec. 5, and the exposure shown on the map in the northwest quarter of the same section. If this be true, there is a westward dip of about 40 feet to the mile from the exposure in the NW. 1/4 sec. 4, a remarkably low dip as compared to others in this region. This, however, seems improbable. Another fault lying between these two exposures would explain this discrepancy, but no evidence was collected to prove its existence.

A noteworthy relation exists between the faults and the positions in which the adjoining rocks lie. As already mentioned, the highest dip determined in the region amounts to 400 feet to the mile. This occurs on the east side of the creek along the section line at the north side of the NW. 1/4 sec. 9. The feature to be noted is that this maximum dip lies close to and on the down-throw or east side of a fault. This dip is opposite in direction to that which might be expected were it due to the drag of the beds along the fault plane. It may, however, be due to the drag of a second and reverse movement along the fault plane, which had a vertical displacement less than that of the initial movement, the difference in amount being represented by the present vertical displacement of the fault.

Relation of faulted structure to occurrences of oil and gas.—Conviction seems to be growing among geologists that oil and gas had their source in the carbonaceous matter contained in shales, once deposited as muds. Compression probably is the most important factor in forcing the occluded water and hydrocarbons from the shales into the more porous rocks, where differences in the specific gravity and capillarity of these fluids, their molecular repulsion, and perhaps other forces not known, cause them to separate from each other. The action of these forces for separation is accelerated by various other causes such as migration of these substances through the rocks and the varying porosity of the rocks through which they migrate. After the separation of oil, gas, and water has taken place, these substances must be confined in some manner in order that commercial quantities may accumulate. The confining agent is usually an impervious stratum, commonly a shale bed, or an impervious stratum in conjunction with a buoyant agent as salt water. Cases wherein the first of these agents alone is operative may be found in sandstone lenses entirely surrounded by shale, or faulted blocks of sandstone surrounded in the same way. The two agents are operative when the oil and gas occur at the upper end of a dipping lens of petroliferous sand and in domal or anticlinal structures. Faulting as a controlling condition belongs to this category also, although its importance has not been well demonstrated in any of the oil and gas fields in the United States outside of California. If oil bearing sand is faulted across the direction of oil migration so that its broken edge is sealed by an impervious rock, it will check the migration of oil and gas and cause its accumulation. (See fig. 10a). The effectual sealing of a petroliferous sand by an impervious stratum, however, does not necessarily attend every case of faulting, and herein lies the uncertainty of oil and gas accumulating behind such structures.

In the majority of observed cases, accumulations of oil and gas must be the result of upward migration of these substances. If a fault occurs in such a way that the up-throw side is also on the up-dip side and the vertical displacement is only great enough to partly dislocate the sand, the oil will not be confined, as it may still move upward into the upper limb of the broken sand. (See fig. 10b.) If the vertical movement is in the reverse direction and the sand only partly disrupted, a small accumulation of oil and gas may result, its size depending on the amount of displacement. (See fig. 10c.) Complete disconnection of the sand by faulting furnishes much more favorable conditions for oil accumulation, but here again uncertainty arises, in that even if the fault is great enough to completely disconnect the broken ends of the sand, the lower limb may not be effectively sealed, but may be faulted against another porous stratum, into which the oil and gas may migrate with little or no interference. No accumulation will occur under this condition. Another possibility is that the fault, instead of being a simple plane, may be a zone of broken rock or brecciation into which the oil and gas can migrate and escape either to the surface or to some other porous stratum. It is thus seen how varying are the factors in faulting which may affect petroliferous sands and how uncertain it is that such faulting may cause a commercial accumulation of oil and gas.

CONCLUSIONS AND RECOMMENDATIONS.

The position of the south fault described in this report, which lies up the dip from the discovery well and has its down-throw to the east, leads to the inference that this fault has caused the oil and gas to accumulate to the west of it. The record of the well reports 51 feet of "slate" followed by 10 feet of "lime shell" and 110 feet of "slate" as overlying the gas sand. These strata, in being faulted down across the pay sand, may possibly have acted as a seal and checked the upward migration of the oil and gas, thereby causing the accumulation.

The possibility that the faults are superficial and that they grade into anticlines with depth is a possibility which can be determined only by extensive drilling. If such a condition exists here, the possibilities of a small oil pool would be greater than if the faults extend down to and break the petroliferous sand.

It is possible that other geological features not determined during the present investigation and lying outside of the area described in this report may have had greater influence than the faults in causing the accumulation of oil and gas encountered in the well. The lack of data in regard to such features permits of only generalized recommendations as to the future oil and gas possibilities of this region. It is suggested that before development in this region is undertaken detailed geological surveys should be made of the territory adjoining the area described in this report, particularly to the west of it. It is probable that if the faulting has been a factor in causing the accumulation encountered in the well, the petroleum has migrated in the sandstone bed up the dip from the west and has lodged against the fault on its west side.

DEVELOPMENT.

There has been considerable drilling in Okfuskee County, but no important fields have been opened up. By far the most important well drilled in the county was the well put down by the Prairie Oil and Gas Company in the SE. ¼ SE. ¼ sec. 8, T. 12 N., R. 7 E. This well was drilled to a depth of approximately 2,900 feet. Perhaps the latest reports on this well gave the production as 25 barrels of oil daily and 7,000,000 cubic feet of gas daily. However, there has been no attempt at additional dr.lling.

A well was drilled in sec. 29, T. 10 N., R. 11 E., near Weleetka, to a depth of 3,800 feet. It was reported that gas was found in a deep sand.

SUMMARY.

The fact that faults show at the surface in the vicinity of the Paden development makes exploration in that area difficult. These faults may, of course, grade into anticlines at the depth of the producing sands. This is a problem that only drilling will solve. If the faults penetrate the oil-bearing horizons the chances of finding large accumulations of oil or gas are less, because unless the fault zone be impervious it is probable that the oil and gas have escaped to the atmosphere, or have been disseminated through other porus strata. If the fault zone be impervious, this kind of structure favorable for the accumulation of oil and gas would be small as compared with anticlinal structure.

Okfuskee County is within proved oil and gas territory and no doubt continued exploration will find profitable accumulations of oil and gas.

OKLAHOMA COUNTY.

LOCATION.

Oklahoma County is located in the central part of the State. It extends from T. 11 N. to T. 14 N. inclusive, and from R. 4 W. to R. 1 E. inclusive. It includes 20 entire townships. The total area is approximately 720 square miles.

TOPOGRAPHY.

Oklahoma County lies entirely within the Redbeds Plains. In general the topography is that of a rolling prairie plain. In many places the surface is dissected by streams, giving locally a badland type or topography. This feature is noticeable along practically all of the small tributaries to the larger streams. In the western part of the county the range in elevation is not as great as in the eastern part, so that these parts of the county furnish different types of topography. The western part of the county is almost treeless except along the streams, while the eastern part is covered by a growth of blackjack oak.

Almost the entire county is drained by North Fork of Canadian River and its tributaries. A peculiar feature of this stream is the big loop in its course in the eastern part of the county. From a short distance east of Oklahoma City the stream flows in a general northeast direction to the west central part of T. 13 N., R. 1 W., thence southeast past Harrah for a considerable distance, before it assumes its general eastward course. In some cases streams are diverted from their general course by structure, but sufficient data has not been collected to say that this loop is due to such cause. Another striking feature of the drainage in this area is that of Deep Fork of Canadian River, which, from its head just north of Oklahoma City, parallels the course of North Fork of Canadian River as far north as Arcadia. The large streams just mentioned above have wide, flat, alluvial valleys. Some of the railroads have taken advantage of this type of topography and have followed the course of the streams, thus avoiding the rougher uplands.

The municipal reservoir, which is being constructed for the water supply of Oklahoma City, is located on North Fork of Canadian River about 6 miles west of Oklahoma City. The water supply comes from the above mentioned stream. The reservoir covers a large acreage and the capacity is estimated at 6,800,000,000 gallons. The main dam is constructed at a place where the valley is narrow.

GEOLOGY.

The surface rocks in Oklahoma County are Permian Redbeds, with the exception of Recent stream deposits of sand and alluvium. The Permian rocks in this county are included in the Enid formation, the classified basal formation of the Permian Redbeds. This formation consists of shales and sandstones. The color of the shales is red, while that of the sandstones may be red, white, yellow, or brown. The shales and clays are of such a character that in many cases they are suitable for clay products such as brick and tile. The sandstones are usually cross-bedded, lenticular, and very porous. They often grade into shales within a short distance, so that it is very difficult to follow a sandstone for a long distance. Many sandstone beds outcrop in the eastern part of the county and are of the character mentioned above. Several prominent beds are exposed about a mile north of Oklahoma City, and are more uniform in character than the usual type of sandstone in this county. Another prominent series of sandstones outcrops along the west side of Deep Fork of Canadian River and extends from near Oklahoma City to at least several miles beyond Witcher. These sandstones are perhaps the most persistent of all the rock outcrops.

The Recent deposits occupy an area of at least 100 square miles along North Fork of Canadian River and other streams.

The subsurface formations as indicated by well logs are: Permian Redbeds, consisting principally of red shales and sandstones and perhaps a few strata of gypsum; red Pennsylvanian, consisting of red, blue, and brown shales, and sandstones; and non-red Pennsylvanian, consisting principally of blue shales and limestones. As indicated by well records, the Permian and red Pennsylvanian average about 1,400 feet in thickness in this county.

The following logs show the character and thickness of the above mentioned subsurface formations:

Log of Merchants Oil & Gas Company well No. 1, in the NE. cor. SW. ¼ sec. 5, T. 11 N., R. 2 W.

Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*
Surface soil, sandy loam	23	23
Sand, fresh water	4	27
Red shale and soft red sand rock	12	39
Dark hard gumbo	2	41
Soft red sand rock	219	260
Red clay and gumbo	70	430
Soft sand shell	2	432
Redbeds, kaolin and chalk	76	508
Gypsum	4	512
Red shale and clay streaked with gypsum	68	580
Gypsum	5	585
Red shale with gypsum	20	605
Red clay and shale	45	650
Red clay, shale, boulders	45	695
Sand rock	4	699
Red clay and shale	10	709
White sand, rock, trace gas	11	720
Blue shale	2	722
Red clay, shale, gypsum	78	800
Redbeds—clay, shale, gypsum, boulders	68	868
Hard white rock	11	879
Red shale, clay, and boulders	46	925
White sand rock	5	930
Soft red clay	20	950
White sand rock	10	960
Red shale, broken rock	40	1,000
Red shale, clay and gypsum streaks	50	1,050
White sand rock	5	1,055
Red soft clay	15	1,070
Red shale, broken rock	19	1,089
Red gumbo	21	1,110
Hard sand rock	2	1,112
Red shale, clay, gypsum, boulders	38	1,150
White sand rock	10	1,160
Red shale	40	1,200
Red gumbo	18	1,218
Hard white sand rock	11	1,229
Red shale & broken rock	19	1,248
Red clay	5	1,253
White sand rock	3	1,256
Red clay, gypsum streaks	4	1,260
White sand rock	3	1,263
Red clay, gypsum streaks	20	1,283
Red shale, boulders	7	1,290
Red gumbo	21	1,311
Crystal gypsum	2	1,313
Red clay	7	1,320
White sand rock	3	1,323
Red shale, boulders	5	1,328
White sand rock	14	1,342
Red clay and blue gypsum	8	1,350
Red shale and gypsum	40	1,390
Hard sandy rock	10	1,400
Brown and blue shale	72	1,472
Brown shale	26	1,498
Sandy shale	2	1,500
Brown and blue shale	100	1,600
Soft sand rock	2	1,602
Brown shale	38	1,640
Brown clay and shale	60	1,700
Brown and blue shale	65	1,765
Brown gumbo	32	1,797
Shell rock	1	1,798
Dark gray shale	77	1,875
Hard white lime rock	7	1,882
Sandy shale, boulders	18	1,900
Lime rock	1	1,901
Brown and gray shale	47	1,948
Brown gumbo	24	1,972
Brown and gray shale boulders and gumbo	90	2,062
Brown and gray shale	30	2,092
White lime sandy rock pyrites in bottom	65	2,157
Brown gumbo	4	2,161
Brown shale, trace oil	17	2,178
Brown gumbo	8	2,186
Shell rock	1	2,187
Yellow and brown clay mixed with lime	8	2,195
Lime rock	9	2,204
Brown clay, boulders	7	2,211
Blue shale, boulders	70	2,281
Blue lime rock	7	2,288
Blue shale, boulders	9	2,297
Hard blue lime rock, sandy	7	2,304
Blue shale	8	2,312

Log of Merchants Oil & Gas Company well No. 1, *in the NE. cor. SW.* ¼ *sec.* 5, *T.* 11 *N., R.* 2 *W.*—(Continued.)

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Blue lime rock	2	2,314	Tough blue shale or gumbo	6	2,714
Blue shale	10	2,324	Hard lime rock	4	2,718
Lime rock, blue and sandy	12	2,336	Mixed shale	6	2,724
Blue mixed shale	46	2,382	Lime rock	6	2,730
White and red mixed sand rock	4	2,386	Mixed shale, lime streaks	45	2,775
Blue and brown shale	31	2,417	Hard mixed shale	49	2,824
Sandy lime rock	8	2,425	Hard gray rock, sandy	6	2,830
Blue, brown and yellow shale, lime and sand streaks	75	2,500	Mixed shale	16	2,846
Blue shale, muddy, with traces of lime	85	2,585	Hard gray rock	4	2,850
Sandy lime rock	5	2,590	Mixed shale	32	2,882
Mixed shale, lime	20	2,610	Gray sandy rock	4	2,886
Hard sandy lime	5	2,615	Blue shale	49	2,935
Mixed shale, lime	20	2,635	Gray sandy rock	25	2,960
Soft blue shale	45	2,680	Blue shale	20	2,980
Lime rock	28	2,708	Gray sandy rock	5	2,985
			Blue shale	10	2,995
			Sandy lime rock	6	3,001

Log of well at Spencer, Oklahoma.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Gravel	39	39	Sand	15	885
Red rock	7	46	Red rock	35	920
Sand	214	260	Sand, salt water	10	930
Red rock	40	300	Red rock	10	940
Sand	98	398	Sand, salt water	10	950
Red rock	2	400	Red rock	175	1,125
Sand	160	560	Sand	8	1,133
Red rock	30	590	Red rock	43	1,176
Pink slate	11	601	Sand	10	1,186
Lime shale	3	604	Red rock, much salt water	26	1,212
Black slate	2	606	Gravel	10	1,222
Coal	4	610	Red gravel and hard shells	242	1,484
Muddy slate	2	612	Red sand	51	1,535
Sand	78	690	Lime shells	5	1,540
Red rock	35	725	Pink rock	90	1,630
Sand	16	741	Sand and yellow oil	20	1,650
Red rock	10	751	Pink rock & dark shale	210	1,860
Sand	30	781	Lime shale	5	1,865
Coal blossom	1	782	Brown shale	20	1,885
Red rock	38	820	Brown and gray shale	97	1,982
Sand	10	830	Sand and oil	9	1,991
Red rock	10	840	Hard shale	11	2,002
White sand	20	860			
Red rock	10	870			

STRUCTURE.

Oklahoma County lies in the Prairie Plains monocline, in which the general dip of the rocks is to the west on an average of about 30 feet per mile. There may be variations in the general west dip or reversal dips to the east, forming structure favorable for the accumulation of oil and gas, but the scarcity of reliable rock outcrops from which the underground structure could be determined makes the work of locating favorable structure very difficult and uncertain.

It is possible that the prominent outcrops of sandstone north of Oklahoma City and along the west bank of Deep Fork of Canadian River. as mentioned under "Geology," by carefully detailed work, could be utilized for the determination of structure.

The usual method of exploring areas where there are insufficient surface indications of underground structure has been to drill "wild cat" wells. Oftimes one such well has condemned quite an extensive territory. where, as a matter of fact, productive areas may be within the territory condemned. The most practical method in such an area is to explore for structure with core drills, and then if favorable structure be found a location can be made for a deep test.

DEVELOPMENT.

At least six wells have been drilled in Oklahoma County, all of which were dry. Some years ago a well was drilled northwest of Newalla. It is reported that the well was abandoned at a depth of about 1,000 feet.

A well was drilled near Spencer to a depth of 2,002 feet. The log of this well, as given under "Geology," indicates that the Permian Redbeds and red-Pennsylvanian were over 1,222 feet thick. It is reported that two showings of oil were found—at 1,630 feet in a 20-foot sand and at 1,982 feet in a 9-foot sand, respectively.

The Merchants Oil and Gas Company drilled a well on the G. M. Housh farm in sec. 5, T. 11 N., R. 2 W., about 5 miles southeast of Oklahoma City. Drilling began in October, 1913, and was completed to 3,001 feet in June, 1914. The log of this well, which is given under "Geology," shows that the Permian Redbeds and red-Pennsylvanian have a thickness of about 1,400 feet in this area. A trace of oil was reported at a depth of about 2,161 feet, in a shale.

A well was drilled in the City Park in the NW. ¼ of the NW. ¼ sec. 13, T. 12 N., R. 3 W. Drilling was discontinued at a depth of 2,786 feet. A showing of oil was reported at a depth of 2,400 feet in a 15-foot sand.

The Mutual Oil and Gas Company drilled a well in the NW. ¼ of the NW. ¼ sec. 7, T. 12 N., R 3 W.

The Luther Oil and Gas Company drilled a well near Luther in the northeastern part of the county, in sec. 34 T. 14 N., R. 2 E. At this location there seems to be only a local variation from the normal westward dip, which would hardly be sufficiently pronounced to produce a reservoir for the accumulation of any oil or gas in commercial quantities.

SUMMARY.

Oklahoma County lies in probable oil and gas territory. The Pennsylvanian, which is the productive oil and gas horizon in the northeastern Oklahoma fields, underlies this county. The surface rocks are Permian Redbeds and are, together with the red-Pennsylvanian formations, on the average about 1,400 feet thick. On account of the lenticular nature of the surface sandstones and unconsolidated character of the shales it is very difficult to determine favorable structure by this method. However, in a few places, as previously mentioned, it is possible that prominent sandstones could be utilized to determine the underground structure. When the surface horizons cannot be used to determine structure, certain fossil beds and well logs would help considerably. A few vertebrate fossils are reported to have been found in a clay pit of the American Brick and Tile Company near Oklahoma City. If the same fossils were found in other localities not far distant it would serve as a key horizon to determine the structure. Well logs are of much assistance, in that certain horizons probably can be correlated and used as a key horizon. The most practical method to use where there are no outcrops, and even in areas of outcrops, is core drilling. Detailed information concerning this method can be obtained by writing to this Survey.

Only a few wells have been drilled in this county and these should not be considered as thorough tests, or as condemning the county, because they were located as "wild cat" adventures, irrespective of favorable structure.

A test drilled in this county should not be considered thorough under a depth of at least 3,500 feet.

OKMULGEE COUNTY.

LOCATION.

Okmulgee County is located in the east-central part of the State. It extends from T. 11 N. to T. 16 N. inclusive, and from R. 11 E. to R. 15 E. inclusive. It includes 16 entire townships and parts of 6 others. The total area is approximately 684 square miles.

TOPOGRAPHY.

Okmulgee County is within the Sandstone Hills region. The topography consists of roughly parallel sandstone hill zones between which are rather broad shale valleys. The sandstone hill zones have been dissected by streams, giving a rough topography. The surface ranges in elevation from 600 feet to 1,000 feet. The lowest point is where Deep Fork of Canadian River leaves the county, in sec. 36, T. 12 N., R. 13 E. The highest point is in sec. 19, T. 15 N., R. 13 E.

Most of the county is drained by tributaries to Arkansas River, and the extreme southwest corner by tributaries to North Fork of Canadian River.

GEOLOGY.

The surface rocks in Okmulgee County are Pennsylvanian with the exception of Recent sands and gravels along the stream valleys. The following Pennsylvanian formations are known to outcrop in Okmulgee County: Wewoka formation, Wetumka shale, Calvin sandstone, Senora formation, Stuart shale, Thurman sandstone, and Boggy shale.

These formations are briefly described in the following paragraphs. The reader is referred to "Hughes County" for a more complete discussion of these formations.

Boggy shale.—This formation consists of a great thickness of shale in which are irregularly distributed thin-bedded sandstones. The maximum thickness of the formation is 3,000 feet.

Thurman sandstone.—This formation consists of coarse, white chert and quartz. Small beds of shale are included and sometimes impure fossiliferous limestones are found. The maximum thickness of this formation is 250 feet.

Stuart shale.—This formation is made up of thin-bedded shaly sandstones and shales. Its maximum thickness is 275 feet.

Senora formation.—The sediments in this formation are sandstones and shales interstratified. The sandstones often occur in lentils. The shales are bluish, clay shales and brownish sandy shales, while the sandstones are generally fine-grained and gray or reddish-brown in color.

Calvin sandstone.—The upper part of this formation consists of thin-bedded sandstones with some shales. The lower part is made up of soft, rather massive sandstones.

Wetumka shale.—This formation is composed almost entirely of friable, laminated clay shales.

Wewoka formation.—This formation consists of massive, brown, friable sandstones, interstratified soft blue shales, and an occasional limestone.

STRUCTURE.

The strata in Okmulgee County belong to the Prairie Plains monocline. These strata dip in a general way to the west. There are local variations in the general dip, though no detailed work has been done and specific instances cannot be pointed out.

DEVELOPMENT.

BEGGS POOL.

LOCATION.

The Beggs Pool is located about 2 miles south of the town of Beggs, with the principal part of the development occurring in Tps. 14 and 15 N., R. 11 E., and T. 15 N., R. 12 E., and with some production in T. 13 N., R. 13 E.

DEVELOPMENT.

The deeper sands reached in this location have been at depths of 2,048 and 2,500 feet. In sec. 10, T. 13 N., R. 13 E. in one well 25 feet of sand were encountered at 1,700 feet, the well being good for about 100 barrels daily. The most important test in 1916 in the old Beggs district was a well drilled to a depth of 2,150 feet, which gave an initial flow of 400 barrels when only a short distance in the sand.

The following logs are typical of this area.

Tammany, Wm. Lowe, No. 2, in sec. 12, T. 14 N., R. 12 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	5	5	Sand	25	1,055
Lime	40	45	Slate	335	1,390
Slate	25	70	Sand (water)	183	1,573
Lime	15	85	Slate	75	1,630
Shelly	45	125	Lime	5	1,635
Slate	125	250	Slate	305	1,940
Lime	20	270	Lime	10	1,950
Slate	30	300	Slate	68	2,018
Lime	15	315	Lime	20	2,038
Slate	125	440	Slate	12	2,050
Lime	10	450	Lime	20	2,070
Slate	225	675	Slate	15	2,085
Lime	25	700	Top oil sand	4	2,089
Slate	75	775	Broken sand and shells	70	2,159
Sand	130	905			
Slate	625	1,030			

Jeffie Stake No. 1, in sec. 3, T. 14 N., R. 12 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	8	8	Slate	420	1,480
Slate	47	55	Sand	150	1,630
Sand	25	80	Slate	30	1,660
Slate	75	155	Lime	10	1,670
Sand	30	185	Slate	170	1,840
Slate	545	730	Sand	10	1,850
Lime	25	755	Shale	155	2,005
Slate	115	870	Lime	5	2,010
Sand	30	900	Shelly	60	2,070
Slate	150	1,050	Lime	15	2,085
Sand	10	1,060	Slate	63	2,018

STRUCTURE.

The structural features in the vicinity of Beggs are discussed in the following pages under the heading "Structural Reconnaissance in the Vicinity of Beggs." During 1914 A. E. Fath and Wilson B. Emory. under a cooperative agreement between the Oklahoma Geological Survey and the United States Geological Survey, made an examination of the region about Beggs for the purpose of locating structure favorable to the accumulation of oil. This report has not been published in any previous bulletin and for that reason is given in full in the following pages, with the various subdivisions concerning geography, drainage, history of development, geology, and structure.

A STRUCTURAL RECONNAISSANCE IN THE VICINITY OF BEGGS.

BY A. E. FATH. ASSISTED BY WILSON B. EMERY.

INTRODUCTION.

Under a cooperative agreement with the Oklahoma Geological Survey, the United States Geological Survey undertook in the summer of 1914 an examination of the region about Beggs, Oklahoma, for the purpose of locating structures favorable to the accumulation of oil, if present. The following report gives the results of the examination, the expenses of which were divided equally between the two organizations.

ACKNOWLEDGMENTS.

The writers desire to take this opportunity of acknowledging the many courtesies shown them by the oil men whom they met in the field, and of expressing their thanks to Mr. Nelson K. Moody, vice-president of The Prairie Oil and Gas Company, Mr. W. C. Newman of Okmulgee, The Producers Oil Company, and The Gunsberg and Southwestern Oil Company, for supplying well records which have been most helpful in the preparation of this report.

GEOGRAPHY.

The region described in this paper includes about 36 square miles in Tps. 14 and 15 N., Rs. 11 and 12 E., Indian Meridian, Oklahoma (see map, Plate XXXII.) The only town in the area mapped is Beggs, which has a population of about 1,000 inhabitants. It is situated on the Red River division of the St. Louis & San Francisco Railroad in the southwest part of T. 15 N., R. 12 E. Several small groups of oil and gas wells lie within the Beggs region, the most notable being the so-called northwest extension of the Preston field which lies about two miles south of Beggs. The main part of the Preston oil and gas field adjoins the area on the southeast.

TOPOGRAPHY AND DRAINAGE.

The Beggs area lies in that part of Oklahoma in which the broader features of the topography are in accord with the underlying geologic structure. Alternating shales and sandstones with a few thin limestones form the stratigraphic series which in general dips gently in a northwesterly direction. This monoclinal structure gives rise to a series of eastward-facing escarpments capped by successive, stratigraphically higher sandstones, which are the more resistant rocks of the region. The shales occupy the gently westward-sloping plains between these escarpments.

Deep Fork of Canadian River and its intermittent tributaries drain the area here described. These tributaries commonly flow in broad shallow valleys, but locally, where they cut through sandstone beds, are confined in small narrow gorges.

CULTURE.

Except for the development of its oil and gas resources the area is given over to grazing and to agriculture. The character of the soil and the vegetation which it supports are dependent directly upon the nature of the surface rocks. The sandstone areas support a thick growth of timber, principally oak, and therefore, not being suitable to farming, are used for stock raising; the shale areas are used mainly for agricultural purposes.

The roads, which are fairly good, follow land lines except in the rougher parts of the region.

HISTORY OF OIL AND GAS DEVELOPMENT.

Active development in this region followed the discovery of oil in 1909 in the Preston field, which lies 5 miles southeast of Beggs. During the years 1910 and 1911 about 44 wells, which comprise the so-called northwest extension of the Preston field, lying about two miles south of Beggs, were drilled. Most of the remaining scattered 35 to 40 wells have been drilled at various times since then.

In the northwest extension of the Preston field several of the oil wells had initial capacities of 1,500 barrels or more, but due to the rapid decline in production, most of these are now abandoned. At the time of this investigation, in September, 1914, only 12 to 15 wells in the entire area were being pumped, none of which had a production of more than 20 barrels per day.

METHODS OF FIELD WORK.

The sandstone outcrops shown by hachures on the accompanying map, Plate XXXII, were surveyed by foot traverses tied to land lines. The elevations recorded were determined by aneroid barometers which were checked at frequent intervals each day on a series of temporary bench marks established by running spirit level lines along the principal roads and section lines. This system of levels was based on the U. S. Geological Survey bench marks located at the northwest and northeast corners of T. 14 N., R. 12 E.

GEOLOGY.

The rocks exposed in this region consist of shales, sandstones, and thin limestones belonging to the Pennsylvanian series. These rocks lie between the horizon of the Fort Scott limestone below and the top of the limestone locally called the Checkerboard lime above.

Two outcrops of the Checkerboard lime, a bed which is about two feet thick, were noted by the writers along Flat Rock Creek at the west side of the area described in this report. These exposures are in sec. 22, T. 15 N., R. 11 E.—one in, and north of, the road at the south side of this section and a short distance west of the creek, and the other in the creek bed at the old "Checkerboard Crossing" near the east-west quarter line of the section. At the latter locality a collection of fossils was made, which has been examined by Dr. George H. Girty and the species identified as follows:

Derbya crassa?
Productus semireticulatus.
Marginifera splendens.
Spirifer cameratus.

The Checkerboard lime is separated by an unknown but not great thickness of shale from a lower limestone, the only other limestone observed in the region. This limestone is exposed in the road about 1,800 feet west of the northeast corner of sec. 25, T. 15 N., R. 11 E. From this exposure fossils were collected in the course of field work and have been identified by Dr. Girty as follows:

Productus nebraskensis.
Deltopecten occidentalis.
Myalina perattenuata?
Pleurotomaria sp.

This limestone is underlaid by an interbedded series of shales and sandstones about 350 feet thick. The sandstones support a heavy growth of timber which has allowed a thick residual soil to accumulate, and the tops of the sandstones are therefore not exposed. The contacts also of the sandstones with the underlying shales are generally concealed by debris, so that it is impossible to obtain exact measurements of the thicknesses of the various sandstones. Most of the elevations as given on the map refer to the tops of the exposed ledges rather than to any definite horizons in the sandstone beds. Where it was possible to identify the same horizon in two or more exposures the elevations are referred to this horizon.

Considering in greater detail the 350 feet of strata just described, the limestone at its top is separated by a shale interval of not more than 50 feet, from the low escarpment in the west part of Beggs. This sandstone, A on Plate XXXII, is exposed in the road south of the Beggs high school, where it consists of two beds separated by 11 feet of shale. The lower bed is about 6 feet thick. Of the upper bed only the lower two feet are exposed. The lower bed contains the following fossils, identified by Dr. Girty:

Deltopecton occidentalis?
" *aff. texanus.*
Myalina deltoidea?
" *swallowi.*

It is believed that this sandstone also forms the low, wooded, north-south ridge which extends northward from secs. 1 and 2, T. 14 N., R. 11 E., through secs. 35 and 36, and into secs. 25 and 26 of T. 15 N., R. 11 E.

An interval of about 60 feet of shale separates this sandstone from the one next below. This lower sandstone, B on the map, is more or less lenticular and consequently varies greatly in thickness from place to place. It seemingly is not present north of Beggs and it is believed that its most northern exposure is the one in the small valley near the east side of the NE. 1/4 NW. 1/4 sec. 31, T. 15 N., R. 12 E. From this place it can be traced southward and westward into sec. 1, T. 14 N., R. 11 E., and from there into the south part of sec. 6 and sec. 7, of T. 14 N., R. 12 E., where it forms a prominent escarpment. The sandstone has a thickness of only a few feet at the outcrop in sec. 31, mentioned above, but near the southeast corner of sec. 6, T. 14 N., R. 12 E. it appears to have increased to a thickness of 35 feet or more.

Along the north side of the valley, extending westward across sections 1 and 2, T. 14 N., R. 11 E., one of the ledges of this sandstone is traceable for almost two miles and it was possible to determine the general structure along the outcrop. On the south side of this valley the outcrops are very poor and do not permit of a determination of the structure. A study of the escarpment at the north side of the Deep Fork valley gave but meagre results.

In sec. 8, T. 14 N., R. 11 E., an interval of about 200 feet separates sandstone B from C the one next below. (See map.) This interval is probably occupied for the most part by shale, although some thin sandstones are interbedded with it. Sandstone C has a thickness which apparently increases greatly from southwest to northeast, for in sec. 8 and to the south and west in T. 14 N., R. 12 E., its thickness is not far from 10 feet, while to the north and east it is 45 or more feet thick. This sandstone also forms the escarpment running across secs. 2 and 3 of this township.

Sandstone D capping the low escarpment crossing the NW. 1/4 sec. 10 and the NE. 1/4 sec. 9, T. 14 N., R. 12 E. lies stratigraphically about 120 feet below sandstone C, which forms the extensive cliffs to the north and west.

The Fort Scott limestone is not definitely known to be present in the Beggs region. No bed which could be certainly correlated with it was here observed and hence it is not definitely known whether the beds described in this report extend to or below the horizon of that limestone.

Rocks stratigraphically lower than those here described are exposed in the adjoining regions to the south and east and in the Beggs area are penetrated by the oil and gas wells. To show the character of these rocks, the record of one of the wells is here given. In the record the first ten feet refer to sandstone C of the map.

Log of Andrew Adams well No. 1, drilled by the Prairie Oil & Gas Company, in the SW. ¼ of NE. ¼ sec. 8, T. 14 N., R. 12 E.

Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*
Surface, yellow, soft	10	10
Shale, light, soft	20	90
Shale, white, soft	40	130
Shale, brown, soft	60	190
Shale, white, soft	30	220
Shale, brown	15	235
Shale, white, soft	45	280
Lime, light, hard	20	300
Shale, black, soft	75	375
Shale, white, soft,	125	500
Shale, sandy, light, firm	15	515
Shale, white soft	55	570
Shale, brown, soft	35	605
Lime, brown, hard	5	610
Shale, white, soft	165	795
Shale, brown, soft	25	820
Shale, dark, soft	30	850
Shale, light, soft	25	875
Sand, light, hard	5	880
Slate, light, soft	7	887
Shale, brown, soft	13	900
Lime, brown, hard; 3 bailers salt water per hour	25	925
Slate, dark, soft	50	975
Slate, light, soft	70	1,045
Sand, light, small amount water	8	1,053
Shale, brown, soft	37	1,090
Shale, light	35	1,125
Shale, brown	65	1,190
Shale, black	20	1,210
Lime, dark, hard	4	1,214
Shale, brown, soft	46	1,260
Shale, light, firm	80	1,340
Shale, brown, firm	40	1,380
Shale, light, firm	20	1,400
Shale, brown, firm	90	1,490
Shale, light, firm	40	1,530
Shale, black, soft	28	1,558
Sand, light, hard, small show of gas at top; hole full of water at 1600 feet	177	1,735
Slate, light, soft	8	1,743
Lime, light, firm	2	1,745
Slate and shell	170	1,915
Water sand	120	2,035
Slate, dark	26	2,061
Lime, black	6	2,067
Slate, black	33	2,100
Lime, black	12	2,112
Slate, dark	48	2,160
Sand, white	5	2,165
Slate, brown	16	2,181
Lime, black	5	2,186
Slate, black	3	2,189
Lime shells, gray	3	2,192
Slate, black	23	2,215
Lime shell	2	2,217
Sand, oil	29	2,246

STRUCTURE.

The area is a part of the general westward-dipping monocline of northeastern Oklahoma, and from a study of the elevations of the sandstone outcrops given on the map, it appears that the monoclinal structure in this area is nearly regular. There are no reversed dips forming anticlines or domes.

The inaccuracies which attend elevations determined barometrically and the impossibility of ascertaining the changing intervals between the sandstones outcropping in the region has not made it practicable to represent the structure by contours except in the vicinity of the so-called northwest extension of the Preston field.

Further, the few well records available do not furnish adequate information as to the thicknesses of the deeply buried beds and no attempt has been made to interpret the underground structure of this area, except at one locality, where sufficient data were available.

Structure in the so-called northwest extension of the Preston field.—Through the records furnished by The Prairie Oil and Gas Company and the Producers Oil Company, who are operating the only wells now producing in the so-called northwest extension of the Preston field, it was possible, knowing the elevations of the surface at the wells, to determine the structure of the Preston oil sand which lies about 2,200 feet beneath the surface and is the producing horizon of this pool. It would appear, as shown in Fig. I, that the structure of the oil sand is not in accord with the structure of the surface rocks.

Unconformities in the Pennsylvanian series are not definitely known to extend into this region, but no other explanation seems quite adequate to account for the discordance of structure noted here. The possibility of an unconformable relation between this sand and the overlying rocks is emphasized by the "spottedness" of its production. This "spotted" character is very similar to that of the Booch sand which is productive to the east, but whether or not the Preston and Booch sands which have this one common character are stratigraphically equivalent is not known from the evidence now at hand.

CONCLUSIONS.

The structure of the rocks exposed in the Beggs area would, by its lack of anticlines and domes, seem to preclude the probability of finding large oil or gas pools therein. In view of the conditions in the northwestern extension of the Preston field, it is entirely possible that other small pools may be present in local structures which do not affect the surface beds, or under other favorable conditions—such, for example, as lenticular sands, not related to structure. Such pools as may be found will probably be of small extent.

BALD HILL POOL.

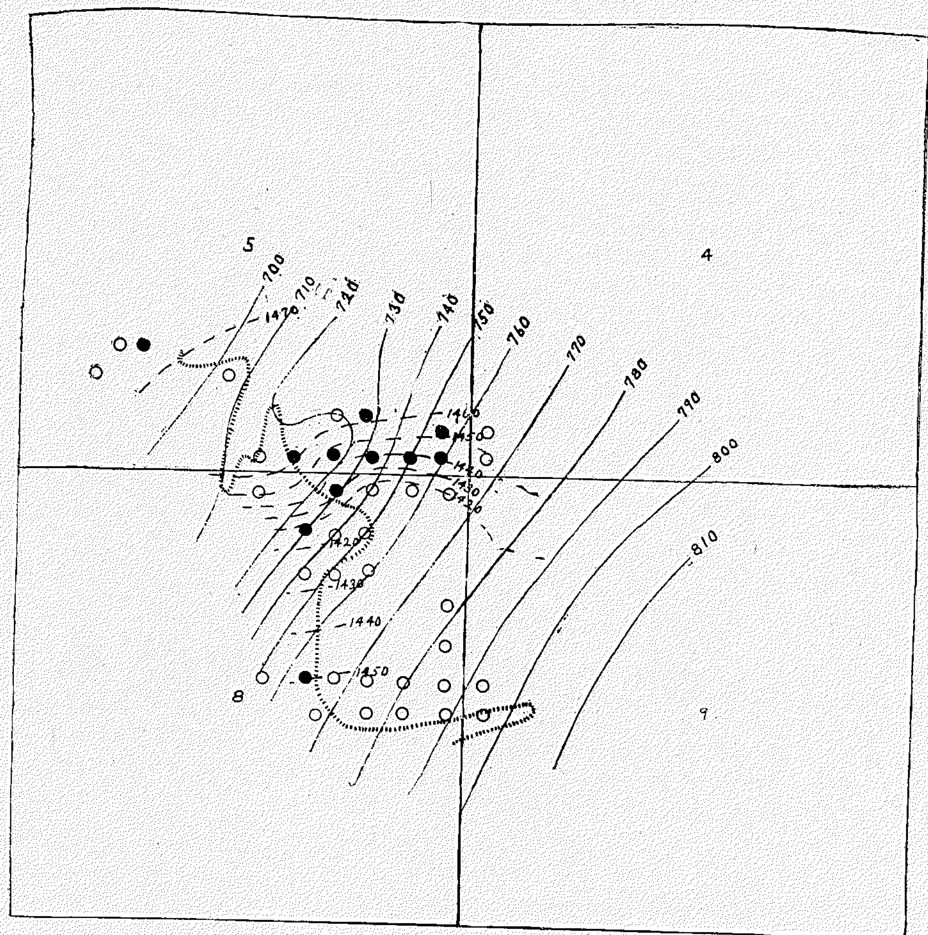
LOCATION.

The Bald Hill pool occupies a part of the following area: T. 14 N., R. 13 E., Tps. 13, 14, 15 N., R. 14 E., and Tps. 14 and 15 N., R. 15 E,. the principal part of the early production being in the southern portion of the last named township.

DEVELOPMENT.

The first well in this field was completed during the winter of 1907-08, in the southwestern part of T. 15 N., R. 15 E. This well was fairly productive and brought about the opening of a pool of considerable importance. During 1913 development was active and the total output reached 1,847,790 barrels. The daily production varied from 2,742 barrels during January, to 7,923 barrels during December. The record for 1913 was surpassed during the year 1914.

Most of the oil wells guage from 20 to 100 barrels, and a few have had initial productions of from 300 to 350 barrels per day. The gas wells, which are few in number, are of small capacity, averaging about 4,000,000 cubic feet daily. During 1915 and 1916 considerable drilling was done in the region, but it appears that at least half of the wells were either dry or abandoned. The producing wells give from 5 barrels to 500 barrels and the new gas yields of importance were on the average about 2,000,000 cubic feet, with some few wells making as high as



Structure Contour Map Showing Discordance in Structure of top of oil sand and surface rocks.

Sandstone ledges.

Structure contours on surface rocks. Based on elevations determined by barometer. Elevations above sea level.

Structure contours on top of oil sand. Based on drill records. Elevations below sea level.

Drill holes. Those whose records were used in determining structure of top of oil sand are shaded.

Figure 11.

10,000,000 cubic feet initial flow. The most of the recent drillings in the scattering areas have found the chief production in the sands at 1,380, 1,610, 1,670, and 1,700 feet.

SANDS AND CHARACTER OF OIL.

In all, 10 sands have produced some oil in this region. The most productive horizons occur at 1,175, 1,450, 1,540, 1,650 (Glenn), and 1,700 feet. Deeper sands are reported in some wells at 2,060 and 2,235 feet. Neither of these deeper sands were of much importance during early development.

The following shows the sands and associated formation.

Jack Summers No. 1, in sec. 17, T. 15 N., R. 14 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Shale	200	200	Sand	186	1,176
Lime	10	210	Slate	224	1,400
Sand	15	225	Sand	175	1,575
Slate	650	875	Slate and lime shells	105	1,680
Sand	30	905	Sand	5	1,685
Slate	85	990	Slate and lime shells	60	1,745

Geological conditions are very similar to those of the Morris field except that the wells probably begin a little higher in the geologic section. The oil, which is dark green in color, tests from 33° to 34° Baume at 60° F., and boils at about 131° F. The paraffin content varies widely, but in practically all cases is greater than the asphalt content, which seldom exceeds one per cent.

BOOCH SAND AREA.

LOCATION.

The Booch sand area is located chiefly in T. 14 N., R. 14 E. Drilling began in secs. 1 and 2, T. 13 N., R. 14 E., and spread from that location until it covers practically all of the first named township.

DEVELOPMENT.

The great development in this region has been carried on by local companies and they have been well repaid for their efforts. It has been determined, however, that the area contains dry streaks, probably due to the lenticular character or the more compact nature of the sands. Recent extensions seem to show that the northern end of the area is the most productive. Some of the wells are of low average, while others are medium. During the month of May, 1914, the production of the region was approximately 22,000 barrels. During the last two years some wells of large capacity ranging from 1,000 to 3,000 barrels, have been drilled but the field is nevertheless on the decline and most of the wells are falling off very rapidly.

The Booch sand, from which the region takes its name, is the chief producing horizon. It is understood, however, that the Booch sand is not limited to this particular locality. In fact, there are two horizons in which production is encountered and the term "Booch sand" is usually applied to the horizon at about 1,200 feet, while that at 1,325 feet is termed the "Second Booch." Each of these sands has a thickness of about 20 feet. These sands produce in various wells from 50 to 1,500 barrels per day initial flow. Four other sands occur below these depths and most of these have been fairly productive. The Morris sand is reached at a depth of 1,560 feet, and the Glenn sand at 1,660 feet.

Some of the best wells were drilled in sec. 13, T. 14 N., R. 14 E., giving from 1,000 to 1,500 barrels initial daily production. A well drilled in sec. 18, T. 14 N., R. 15 E., about half way between the Booch sand area and Boynton is said to have had an initial flow of 15,000 barrels. This well was completed in September, 1915. Forty feet of sand were encountered at the proper depth for the Booch, but the character of the sand was that of the Redfork. There are some small producing wells near this location and several dry holes in the region immediately surrounding. Considerable new work was begun in various parts of the region during the latter part of 1916.

FRENCH POOL.

LOCATION.

In T. 11 N., Rs. 11 and 12 E., about 3 miles west of Henryetta, is a small pool known as the French pool.

DEVELOPMENT.

Five sands are reported in this region at depths between 700 and 1,850 feet. The sands found at 1,050 feet to 1,100 feet are the chief producing horizons. A few wells have been drilled to a depth of 2,500 feet. The wells drilled during the past two years have given an average initial production of from 30 to 50 barrels in the shallower sands. Heavier production is usually found in the upper sands.

SANDS.

The chief oil producing sand is found at about 2,000 feet, although several others are known. This sand is correlated with the Mounds sand, which occurs at a depth of 2,300 feet in that field. The best gas producing horizon in this region is from a 150-foot sand at depth of 1,400 feet. The sands found at 650, 850, 1,000, 1,750, and 2,150 feet are usually either light producers or dry.

The following log is typical of the formations encountered in drilling.

W. B. Pine No. 1, one-half mi. S. of Henryetta, in T. 11 N., R. 12 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	10	10	Sand, white, (heavy paraffin, oil and gas	11	1,027
Slate, white	91	101	Slate, white (lime shells)	865	1,892
Limestone, hard, gray	4	105	Sand, white, dry	15	1,907
Slate, soft, white	100	205	Limestone, hard, gray	101	2,008
Slate, soft, grayish blue	197	402	Slate, soft, white	5	2,013
Sand, white, (water)	32	434	Limestone, hard, gray	7	2,020
Shale, white	76	510	Coal, fine quality	4	2,024
Shale, grayish, blue	355	865	Limestone, hard, gray	252	2,276
Sand, white, (water)	45	910	Slate, soft, gray	30	2,306
Slate, soft, white	50	960	Lime shell, hard, sandy	3	2,309
Slate, hard, gray	56	1,016			

MORRIS POOL.

LOCATION.

The Morris pool in the southeastern portion of Okmulgee County lies in Tps. 12 and 13 N., R. 14 E., southeast of the town of Morris.

DEVELOPMENT.

The first paying well was drilled in sec. 5, T. 13 N., R. 14 E., and proved to be a good producer. Development in the field was rapid. However, the area was soon marked by dry holes in all directions from the initial well. Gas was reported discovered on the Morris townsite. Both oil and gas were found southeast of town. The first well in the latter region was completed during the summer of 1906. Development in this part of the field during the past few years has been very good and this area is now the main portion of the field. The wells begin at about the horizon of the Fort Scott formation and are from 1,500 feet to more than 2,000 feet in depth. The production probably comes from near the base of the Pennsylvanian series. Five sands are known to be productive, yet a large percentage of the wells drilled are dry. The Booch sand occurs at a depth ranging from 1,100 to 1,200 feet. Wells in a deep sand are fair producers, averaging from 200 to 350 barrels per day. The gas wells of this field are reported as yielding from a few hundred thousand to twenty million cubic feet per day. The following logs are typical of the region.

Log of well in SW. ¼ sec. 5, T. 13 N., R. 14 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Unrecorded	105	128	Lime	80	862
Shale	4	22	Sand	100	962
Coal	3	25	Lime	59	991
Shale	100	125	Shale	257	1,248
Sand	12	137	Sand	20	1,268
Shale	45	182	Shale	307	1,575
Sand and shale	30	212	Oil sand	20	1,595
Shale	215	427	Shale	110	1,705
Lime	10	437	Sand and lime	52	1,757
Shale	250	687	Sand, gas	21	1,778
Sand	10	697	Sand	22	1,800
Shale	85	782	Lime, black		2,186

Booch Well in sec. 20, *T.* 13 *N.*, *R.* 14 *E.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Shale	20	20	Lime	80	865
Coal	5	25	Sand	100	965
Unrecorded	103	128	Lime	20	985
Sand	12	140	Sand	263	1,248
Shale	45	185	Bottom	20	1,268
Sandy shale	30	215	Shale	118	1,386
Slate	215	430	Lime	20	1,406
Lime	10	440	Shale	75	1,481
Shale	250	690	Sand	32	1,513
Sand	10	700	Shale	47	1,560
Shale	85	785	Total depth		1,560

PINE POOL.

LOCATION.

The Pine pool is located in T. 14 N., R. 13 E., in the vicinity of the old Bald Hill pool. The chief development is limited to secs. 23, 26, and 27.

DEVELOPMENT.

The test wells produced on the average about 140 barrels per day from a territory that had not been considered favorable. Three sands had been found but only the one at a depth of 1,920 feet is considered of importance. This sand has a thickness of about 30 feet. The large proportion of dry holes has prevented any extensive development in this pool. Some of the earlier wells were reported to have had capacities ranging from 300 to 750 barrels per day from the 1,900-foot sand. More recently one well was drilled with a reported production of 1,400 barrels. Probably one of the best wells in the field is that located in sec. 27. This well is said to have produced 46,000,000 cubic feet of gas and 90 barrels of oil per hour when first drilled.

SALT CREEK POOL.

LOCATION.

The Salt Creek pool, which is frequently considered as an extension of the Tiger Flats pool, is located in T. 13 N., R. 11 E.

DEVELOPMENT.

Development in this region has not been very pronounced at any time, but some fair production has been procured. Seven sands are reported in this area. The Glenn, which is said to have a thickness of 150 feet, is found at a depth of 900 feet. This is the shallowest sand of the field. Three hundred and sixty feet below this sand is the Booch sand or its equivalent, with a thickness of 85 feet. Other sands are reported at 1,525, 1,800 2,080, 2,475, and 2,575 feet. The one remarkable feature of this area seems to be the unusual thickness of the sands which vary from 20 to 200 feet, with an average thickness of about 110 feet.

The following log is typical of this region.

Perryman No. 2, in NW. cor. NW. ¼ sec. 22, T. 13 N., R. 11 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	15	15	Slate	60	1,600
Sand	140	155	Sand	25	1,625
Slate	20	175	Slate	40	1,665
Sand	75	250	Sand	95	1,760
Slate	75	325	Slate	185	1,945
Sand	105	430	Sand	67	2,012
Slate	350	780	Slate	48	2,060
Sand	15	795	Lime	5	2,065
Slate	100	895	Slate	15	2,080
Sand	50	945	Lime	5	2,085
Slate	95	1,040	Slate	70	2,155
Sand	195	1,235	Shelly	50	2,205
Slate	80	1,315	Slate	42	2,247
Sand	25	1,340	Sand	23	2,270
Slate	175	1,515	Sand	13	2,260
Sand	25	1,540			

TIGER FLATS POOL.

LOCATION.

Tiger Flats pool is located west of Okmulgee near the county line, in T. 12 N., R. 12 E.

DEVELOPMENT.

During 1913 a well drilled in sec. 13 of the above township and range was completed at 2,012 feet and produced 200 barrels of oil during the first 24 hours. The 1,500-foot sand in secs. 5 and 6 of the above named township furnished some good wells. In secs. 9 and 10 two sands at depths of 2,150 and 2,300 feet are reported as good producers. Seven sands have been reported from this field lying between 750 feet and 2,400 feet. The 1,500-foot sand is probably the Booch, while the 1,800-foot sand holds about the same stratigraphic position as the Mounds. The 2,300-foot horizon has been correlated with the Fields or Booch sand.

Early in 1916 wells in the SW. 1/4 of sec. 24, T. 12 N., R. 12 E., and in the NW. part of sec. 36, T. 13 N., R. 12 E. produced each, 10,000,000 cubic feet of gas initial yield, at a depth of 2,290 feet. A well in sec. 29, T. 12 N., R. 11 E. was abandoned in April, 1916. at a depth of 2,750 feet after drilling in limestone to a depth of 25 feet. In sec. 29 T. 12 N., R. 12 E., a 30,000,000 cubic feet gas well was found at a depth of 3,390 feet at 10 feet in the sand. Some of the recent wells drilled have produced as high as 600 barrels of oil initial production.

The drilling record of the field for several years is given below. The high average initial production is worthy of note.

HAMILTON SWITCH OR PRESTON POOL.

LOCATION.

The Hamilton Switch or Preston pool consists of the development lying between Preston, which was formerly known as Hamilton Switch, and Henryetta. All of the developed area lies about 5 miles northwest of Okmulgee, in T. 14 N., R. 12 E., centering in sec. 2.

GEOLOGY.

The surface formation consists almost wholly of sandstones and shales, with one or two workable beds of coal included. The rocks are Pennsylvanian in age, but their exact position in the geological section has not been determined. In general, the region resembles that of the Morris area. No detailed structure has been worked out.

DEVELOPMENT.

The Preston pool was developed only in a very limited way prior to the year 1909, although some oil and gas had been found in this region 6 or 8 years before. However, that which had been found was of rather poor quality and in small quantity so that the area failed to attract much attention at that time. This pool was the most important piece of development during 1909. Oil wells of 1,000 barrels initial production, and some gas wells of the capacity of 36,000,000 to 40,000,000 cubic feet of gas were brought in. In a very short time, however, the limits of the field were outlined by dry holes and some of the wells drilled near the wells with the highest initial production were dry. One well drilled during the latter part of 1915 in sec. 12, T. 12 N., R. 13 E. produced 10,000,000 cubic feet of gas from a sand at a depth of 1,820 feet.

Drilling and production table of the Hamilton Switch or Preston Pool.

Year.	Wells completed.			Initial production.	
	Oil.	Dry.	Total	Average per well	Total
1909°	8	0	9	287.5	2,300
1910°	68	22	97	199.1	13,540
1911*	21	15	43	193.6	4,065
1912*	36	27	67	135.0	4,860
1913*	75	51	145	188.8	14,163
1914°	55	31	97	100.0	5,500
Totals	263	155	458	185.66	44,428

*Beggs-Preston together.

°Hamilton Switch alone. Total production estimated.

SANDS.

Producing sands occur at the following depths: 1,100, 1,325 to 1,400, 1,573 to 1,625, 1,725 to 1,800, 2,000, and 2,050 feet. All except the shallowest and the deepest sands are good producers. In sec. 1, T. 11 N., R. 13 E., a 400 barrel well was reported from the 1,750-foot sand.

SCHULTER OR HENRYETTA POOL.

LOCATION.

The Schulter or Henryetta pool lies in T. 15 N., R. 11 E., and

T. 12 N., R. 13 E., and T. 13 N., R. 13 E., the principal part of the producing area being about 6 or 8 miles north of the town of Henryetta. The production begins about one mile southeast of Schulter and extends southeast for a distance of about 6 miles, with an average width of about 1 1-2 miles.

DEVELOPMENT.

The wells vary from 1,200 to 1,500 feet in depth. Production is reported as ranging from 150 to 500 barrels daily. During 1912 a well completed in sec. 35, T. 12 N., R. 13 E. was reported to have produced 1,000 barrels, and in sec. 36 of the same township and range a well of 20,000,000 cubic feet of gas was brought in at a depth of 1,350 feet. This same well is said to have made 100 barrels of oil daily for the first two months. The well was then shot and is reported to have produced 2,070 barrels of oil the first day. Other wells drilled in the field have made from 500 to 1,800 barrels per day initial production. A well in the SE. 1/4 of sec. 3, T. 10 N., R. 12 E., drilled in 1915, gave 6,000,000 cubic feet of gas in a sand at depth of 2,460 feet. Still another well in sec. 5, T. 11 N., R. 14 E. made 12,000,000 cubic feet of gas.

Drilling record and initial production, both total and average per well, in Schulter oil and gas field.

Year.	Wells completed.				Initial production.	
	Total.	Oil.	Dry.	Gas.	Total.	Average per well.
1912	134	90	30	14	12,910	142.4
1913	337	203	105	29	7,912	39.9

MOUNDS AREA.

LOCATION.

The Mounds area is located in T. 16 N., R. 11 E., Tps. 16 and 18, N., R. 12 E., and T. 16 N., R. 13 E.

DEVELOPMENT.

In sec. 28, T. 16 N., R. 12 E., one well is reported to have made 240 barrels of oil per day at a depth of 2,170 feet. A gas sand had formerly been encountered in this region at a depth of 2,070 feet. The wells in this locality have produced in most cases from 5 to 75 barrels of oil, with an occasional one giving higher production, as noted above.

NATURA AREA.

Several wells have been drilled in what is known as the Natura area, which is located in T. 15 N., R. 13 E. Wells have been drilled in secs. 21, 22, 25, 26, 29, 32, 33, and 35. Many of these have been drilled to a depth of 2,000 feet, but they were chiefly dry holes. The Kingwood Oil Company's gas well in sec. 22 was reported to have had an initial volume of 6,000,000 cubic feet. Young, *et al* completed a gas well in sec. 25, and the guage showed 20,000,000 cubic feet on initial flow. A 25 barrel oil well was completed in sec. 29.

ERAM AREA.

The Eram pool, which is an extension of the Booch sand area, is located in T. 13 N., Rs. 14 and 15 E. This field was discovered in the early part of 1914. The best production was obtained in sec. 13, T. 13 N., R. 14 E., on the Lizzie Stake allotment, where some of the wells had an initial production as high as 300 barrels. Several good wells were completed in sec. 7, T. 13 N., R. 15 E. The field is spotted. In some cases offset wells to good producers were dry. The Booch sand is the productive horizon, and is encountered at an average depth of 1,250 feet.

MISCELLANEOUS DEVELOPMENT.

Besides the fields mentioned above, there has been considerable minor development. Almost every section of the county has been tested. Development in the vicinity of Okmulgee has been discussed under the Morris and Pine pools. The Bartlett pool, which is located principally in T. 11 N., R. 14 E., McIntosh County, also extends into Okmulgee County. This pool is discussed under McIntosh County.

SUMMARY.

The fact that the logs of wells in the so-called northwest extension of the Preston field show that the structure of the producing sand in this area does not conform with the structure. As indicated by the surface rocks one of two things is certain; either that the oil bearling sand is lenticular, or else there are structural conditions at depths that do not appear at the surface. The fact that the portion of oil sands in Muskogee County is irregular, and that accumulation of oil and gas in the Paden area in Okfuskee County is associated with faulting indicates that the faulting and folding in Mississippian and older Pennsylvanian rocks in the northeastern part of Muskogee County may extend even as far southwest as Okmulgee County and that these structural conditions are unconformable with the structural conditions in the later Pennsylvanian strata. If this condition be true it makes the problem of locating oil and gas pools in advance of drilling more difficult. The folds apparent in the surface rocks may or may not extend to the depth of the producing sands. There may be favorable folds in the underlying rocks no indications of which can be found at the surface.

OSAGE COUNTY.

LOCATION.

Osage County is located a little east of the north-central part of the State. It extends from T. 20 N. to T. 29 N. inclusive, and from R. 2 E. to R. 12 E. inclusive. It consists of 46 entire townships and parts of 35 others. The entire area is approximately 2,350 square miles.

TOPOGRAPHY.

Broadly speaking, the surface of Osage County is that of a level plain.

A detailed view of portions of it, however, shows both limestone and sandstone escarpments, between any two of which are wide shale valleys. In general the escarpments are east-facing, though local folding has developed some that face west.

The southwestern half of the county is drained by Arkansas River and streams tributary to it. The northeastern half is drained by tributaries to Verdigris River. The largest tributary to Verdigris River is Bird Creek. This creek flows diagonally across the county a little northeast of the center of the county.

GEOLOGY.

The rocks found at the surface in Osage County are Permian and Pennsylvanian.

The boundary between the Permian and Pennsylvanian is hard to determine. Beede* shows this contact as entering Oklahoma from Kansas near the east line of T. 29 N., R. 6 E., and extending in an irregular line a little west of south across Osage County and crossing the Arkansas River near the west line of T. 24 N., R. 5 E.

The Permian in this area belongs to the Chase formation. No detailed work has been done in Osage County except mapping the Permian-Pennsylvanian contact mentioned above, and the work of K. C. Heald.** The Foraker quadrangle covers an area of approximately 240 square miles in the northwestern part of Osage County. He has given a detailed description of prominent beds or "key rocks" as he calls them. His description follows:

ROCKS EXPOSED.

AGE AND GENERAL CHARACTER.

The stratigraphic column in the Foraker quadrangle is made up of rocks of lower Permian and upper Pennsylvanian age.

The exposed rocks are all sedimentary. Limestone and shale are the most abundant, but some sandstone is present. The conspicuous outcrops of the limestone beds and the control they exert over the surface features make them much the most important rocks of the section when structural mapping is attempted, because they can be easily traced. By means of elevations taken on these beds the position and slope of the strata may be determined.

No complete description of the stratigraphy will be given in this paper, but for the convenience of those who wish to do detailed geologic work in this region the most prominent beds or key rocks are described in detail below.

KEY ROCKS.

Wreford limestone.—The Wreford limestone is from 10 to 14 feet thick in the Foraker quadrangle. It occurs in three distinct layers. Between

*Beede, J. W., Okla. Geol. Survey, Bull. No. 21, p. 22, 1914.

**Heald, K C., U. S. Geol. Survey Bulletin 641-B, the Oil and Gas Geology of the Foraker Quadrangle, Osage County, Okla.

the middle and bottom layers there may be a bed of shale, which has a thickness of 2 feet at the locality where it appeared best developed.

The distinguishing features of the Wreford are the buff color of the middle bed and the character and mode of occurrence of the chert which forms a large part of the rock. The chert, owing to its greater hardness than the limestone in which it is embedded, weathers into all manner of irregular projecting lumps and knobs. At some localities imperfectly silicified limestone takes the place of the chert and projects from the body of the rock in prominent layers, large pieces of which litter the ground in the neighborhood of the outcrop.

The character of the formation is shown in detail in the following section:

Section of Wreford limestone half a mile east of Hardy, Oklahoma.

	Feet.
Limestone, blackish gray on weathered surface, light buff to brownish gray on fresh surface; in several slabby beds 2 to 6 inches thick; top bed is massive, 12 to 16 inches thick, hard and dense; lower beds break into slabby, lenticular pieces. Fossiliferous; considerably limontized; has many echinoid spines; is in places full of smooth cylindrical holes half an inch to 3 inches in diameter. Above this is a mass of shale and limestone	4
Limestone, buff, hard, dense, massive; full of chert; yellowish brown on weathered surface, blue-gray on fresh surface. About 25 per cent of the rock is chert, in irregular nodules and layers, lens-shaped concretions roughly parallel to bedding most common; chert is fossiliferous	3
Shale, limy, yellow-gray to green-gray; looks sandy but no grains distinguishable; bedding regular; fossiliferous	2
Limestone, light buff on both weathered and fresh surfaces, dense, hard compact; full of fossils, which are locally replaced by glassy or milk-white calcite; in two beds with a 1-inch shale parting; the many crystalline fossils give the rock a spotted appearance	3
	12

Crouse limestone.—A prominent limestone about 3 feet thick, the Crouse, lies approximately 70 feet below the base of the Wreford. Its outcrop is almost invariably conspicuous and the rock is distinctive enough to make it easily recognizable. The characteristic features of this limestone are the form of the outcrop, which shows many large, massive blocks, the absence of recognizable fossils in any abundance, with the exception of small Fusulinas, which are plentiful, and the presence of many smooth, round holes that are vertical or steeply inclined to the bedding. There are similar holes in other limestones of this region, but nowhere were they noted in such numbers as in the Crouse limestone.

Cottonwood limestone.—The Cottonwood limestone is from 10 to 16 feet thick in the Foraker quadrangle. It is thickest near the Kansas line and thins to the south. Of the total thickness usually only the top 2 feet is visible, the remainder being covered with soil. This is due to the fact that the top 2 feet consists of hard, resistant limestone, while the remainder of the formation is made up of thin oolitic limestone and shale. In some localities there is a thin limestone conglomerate at the base of the formation. Although the thin limestones at the base do not form prominent outcrops, they are the most easily recognizable feature about the formation, because of their lithologic character and the fact that they carry many fossils, among which a small coiled shell (Schizostoma) is common. This coiled shell was rarely observed at any other horizon. In this quadrangle a thin oolitic limestone, with an abundance of fossils, especially Schizostoma, is almost certain to be at the base of the Cottonwood limestone.

The following section measured north of Grainola gives a detailed description of the formation:

Section of Cottonwood limestone in the SW. ¼ SE. ¼ sec. 21, T. 29 N., R. 6 E.

	Ft.	in.
Massive limestone, bluish white on weathered surface, light gray to light buff on fresh surface; surface uneven and full of round holes as much as 2 inches in diameter, but it is not as rough as the Neva (see below); occasional rough pieces have dark surfaces; no chert	2	0
Thin shale and oolitic limestone	11	0
Limestone conglomerate, blue-gray to yellowish; made up of rolled pebbles of limestone, shell fragments, and some little hematite pebbles; degree of cementation varies; a good deal of crystalline calcite; many fossils; coiled shells (Schizostoma) and fluted, long-nosed brachiopods (Meekella) most characteristic		6
Shale, olive-drab, clayey	2	0
Limestone conglomerate as above, except that it contains more pebbles and less lime; fossiliferous (Myalina, productids); cross-bedded; largest pebbles seen about half an inch in diameter	2	0
Shale or marl, pink, greenish-gray, and white; bedding irregular; beds form overlapping lenses; contact with overlying conglomerate very irregular	2	6
	20	

Neva limestone.—The Neva limestone furnishes one of the most prominent outcrops in the Foraker quadrangle. It is easily distinguished from any of the limestones occurring higher in the section, and also from those lower in the section, with the exception of the Red Eagle limestone, which lies about 55 feet below the Neva. The total thickness of this formation is 15 to 20 feet. It is made up of massive beds 4 to 6 feet thick, at the top and the base, with thin beds of limestone and shale between. The total thickness of the top bed is rarely seen as the rock is evidently very soluble. The float is covered with jagged points and pinnacles which are so sharp and numerous that it is painful to handle a piece. A fresh fracture discloses numerous irregular cavities which may be filled with light-colored, incoherent granular material.

In many places the weathered surface of the lower bed is very rough, but it does not reach the degree of irregularity that is shown by the upper bed. The cavities in the lower bed are usually lined with bright-brown limonite. Both of the massive beds are fossiliferous, but the thin beds between them are much more so. These thin beds also carry much chert. In many localities a very persistent cherty bed is found about 2 feet above the lower massive bed.

Red Eagle limestone.—The Red Eagle limestone is so named because of its excellent exposures near the Red Eagle school, southwest of Foraker. Its total thickness was not surely determined; in some places it is at least 17 feet, but in others it is probably much less. The Red Eagle consists of a number of distinct beds of limestone, between which are beds of shale in some localities. One of the most distinctive features of the top bed of the limestone in much of the quadrangle is the character of the fresh surface, which shows an abundance of tiny grains of crystalline calcite, giving the surface the appearance of having been covered with frost or light snow. The following section gives the details of the upper part of the limestone in the southwestern part of the quadrangle. At this locality there are no shale partings, but the limestone varies in character. The thickness of the several members is estimated.

Section of Red Eagle limestone on tributary of Hay Creek, a quarter of a mile east of corner of secs. 1, 2, 11, *and* 12, *T.* 26 *N.*, *R.* 5 *E.*

	Ft.	in.
Limestone, gray, thin-bedded, slabby, clayey	3	9
Limestone, creamy buff on weathered surface, medium hard; breaks easily but is not glassy brittle; fossiliferous; lower part of bed has much limonite	1	0
Limestone, thin-bedded, blocky rather than slabby, light gray, brittle, hard, fossiliferous	4	0
Limestone, dove-gray on fresh surface, massive, clean, hard, brittle fossiliferous; good bed to burn	1	6
Limestone, dove-gray, pure; makes persistent bed but weathers back under overlying bed		3
Limestone, thin-bedded, rough, slabby, whitish-gray on weathered surface, blue-gray on fresh surface; in part good limestone, in part rather clayey; fossiliferous (corals, productids)	4	0
Limestone, pigeon-blue on weathered surface, brownish gray on fresh surface, much limonitized; does not weather rough; fossiliferous; medium hard	2	0
	16	6

In tracing this limestone for the purpose of determining structural conditions great care must be exercised, as it is easy to mistake the outcrop of one bed for that of another and so introduce an error. A mistake of small actual amount may be relatively great in its effect because of the low dips prevalent in this region.

Foraker limestone.—The Foraker limestone, which forms the rim of Ekler Canyon and is prominent along the line of bluffs in the eastern part of the quadrangle, is about 74 feet thick. Although the great part of this thickness is made up of limestone, much of the rock is so soft and thin-bedded as to give no outcrop. Some soft shale is also present. The heavy limestone may be easily reognized by the large number of Fusulinas which it contains, the rock in places being fairly jammed with them. Another distinguishing mark is the great abundance of chert concretions which occur in this limestone. The fresh surface of the chert has in general a light blue-gray color, and the concretions usually include fossils which show white against the bluish background. The most common fossil in the chert is *Fusulina secalica* Say, but there are also small brachiopods and a few corals and crinoid stems.

Sandstone.—A sandstone, to which no name has been given, occurs about 28 feet below the base of the Foraker limestone. It is a particularly good horizon marker, as it is some distance either above or below other sandstones with which it might possibly be confused. Its lithologic character also makes its identification simple.

The average thickness of this bed is about 3 feet, though locally it is more, a thickness of 7 feet having been observed at one place. In some localities, however, this sandstone is probably absent—at least there is no trace of it on the surface.

The color of the weathered surface is reddish gray. The fresh surface is lighter in color and thickly dotted with small coffee-brown spots which are probably manganiferous. The most distinctive feature is the presence of muscovite. In many places this mineral is very prominent, and it can always be detected if the rock is examined carefully. The sand making up the body of the rock is extremely fine-grained translucent quartz. Many of the grains are but slightly rounded, crystal faces with clean, sharp corners being present in abundance. This feature may be observed without the help of a lens, as the sunlight is reflected from many tiny flashing points on a fresh surface of the rock. In places this sandstone is somewhat limy, but in most of the localities where it was tested no calcium carbonate was present.

ROCKS NOT EXPOSED.

IMPORTANCE.

In order to predict with any degree of probability as to the occurrence of oil or gas at any particular locality, it is necessary to have a knowledge not only of the structure which may be detected by examination of the strata that crop out at the surface, but also of that shown by the strata that occur below the surface to any depth which may be reached by the drill. An anticline whose shape is favorable for the accumulation of oil and gas and which is surrounded by a plentiful gathering ground but which lacks the proper succession of strata to transport and retain the oil would be of as much value to the oil man as a dry creek would be to a man in search of water. Without the proper succession of previous and impervious strata oil accumulation will seldom take place. On the other hand, a knowledge that such a succession of strata is probably present will make it desirable to explore many localities where, if such knowledge were lacking, the chance of finding oil would not be considered good enough to justify the expense of drilling.

The deepest of the sands which probably underlie this field and which have been proved to contain oil at adjacent localities is that known as the Tucker or Meadows sand. Although it is possible that there are oil-bearing sands below this one, it has never been proved for north-central Oklahoma, and only the strata lying between the Tucker sand and the surface will be considered in this paper.

SOURCE OF INFORMATION.

Knowledge of the strata which underlie any given locality may be obtained in two ways. The first is by actual observation of the strata where they rise to the surface at some distance from the locality concerning which information is desired. In comparatively few places do the strata maintain a horizontal position for any great distance. More commonly they are tilted to a greater or less degree, and where this is the case it is only necessary to travel in a direction opposite to that toward which they are tilted to reach the outcrop of any persistent bed. This is particularly true of a region where the strata uniformly dip in one direction, as in northeastern Oklahoma. The difficulty encountered where the beds have been only slightly tilted is the great distance that must be traversed before a bed which lies at any considerable depth will be found at the surface. Even when the point of outcrop is attained, it may be found that the soil is so thick that nothing can be learned of the character of the rocks which lie below. In northeastern Oklahoma, where the average dip to the west is only about 30 feet to the mile, it would be necessary in order to measure a section having a vertical extent of 3,000 feet, to determine the character and thickness of the beds outcropping over a distance of about 100 miles. It is therefore evidently impracticable if not impossible to obtain in this way accurate knowledge of the strata which lie below the surface.

The second source of information is that furnished by the records of the strata passed through when wells are drilled. All such records are valuable and should be preserved. A good well record furnishes more accurate information concerning the succession of the strata below the surface than can be obtained in any other way, and by the study and comparison of such records it is possible for a geologist to determine the changes that occur in the thickness and character of the strata, and under some conditions to tell with precision what succession of beds will be encountered in regions which have not been explored by the drill but which are not far removed from those that have been.

No wells have been drilled in the Foraker quadrangle, but several have been sunk at points not very far distant, and the logs of these wells, supplemented by surface data, permit tracing of the underground formations with small probability of error.

GENERAL CHARACTER AND AGE.

The strata between the surface and the Tucker sand are of Pennsylvanian age, with the exception of the uppermost beds in the northwest corner of the quadrangle, which include some of the Permian rocks that crop out farther east.

The upper thousand feet of the rocks below the surface are dominantly shale and, in slightly less total thickness, limestone. Lower down the limestones are of insignificant amount in comparison to the shale and sandstone. Most of the lower part of the section above the Tucker sand is occupied by shale, which may be blue, black, or brown, with scattered red bands.

CORRELATIONS.

The determination of the rocks underlying the surface of the Foraker quardangle was much simplified by the work of the Oklahoma Geological Survey in identifying the Neva limestone, which crops out just west of the town of Cushing, and determining the relation of the Neva to the Pawhuska limestone, which crops out at Drumright, the Neva and Pawhuska limestones forming the top and base, respectively, of a measured stratigraphic section. This section shows that the top of the Pawhuska lies 552 feet below the base of the Neva limestone.* As the relation of the oil sands to the Pawhuska limestone in the Cushing field is known, their relation to the Neva is also determined. The Neva limestone crops out extensively in the Foraker quadrangle. There are differences between the succession of strata lying below it here and that in the Cushing field, dependent on the persistency of the individual beds, both as regards thickness and character, but the changes may be recognized by a study of the logs of the wells in the territory between the two areas.

The approximate horizons of the formations occurring at the mouths of holes drilled near Ralston, Blackburn, Fairfax, Ponca City, and Newkirk are shown, and thus starting points were available for the comparison of each well record with others. In this way the formations occurring at Cushing were traced northward through Pawnee, Osage, and Kay counties, with small probability of error, and were recognized in wells that have been drilled only a few miles west of the Foraker quadrangle. From the proximity of these wells to the quadrangle it is inferred that the same succession of beds will be found here as in the localities where the wells were drilled.

As a result of the work described above, it may be confidently stated that below the surface of the Foraker quadrangle there are sands at the horizons of the main producing sands of the Cleveland and Cushing fields. In addition to these sands, which lie more than 2,000 feet below the surface, there are undoubtedly some of the higher sands which have been found to carry oil and gas in the western part of Kay County. If oil and gas are

*Buttram, Frank, The Cushing oil and gas field, Okla.; Okla. Geol. Survey Bull. No. 18, pp. 9-10, 1914.

not found in the Foraker quadrangle, it will not be for lack of strata which are suitable to contain them.

The approximate distances between the top of the Foraker limestone and the sands corresponding to those of the Cleveland pool are as follows: Foraker limestone to Layton sand, 1,680 feet; to Cleveland sand, 1,940 feet; to Wheeler sand, 2,420 feet; to Bartlesville sand, 2,850 feet. So far as could be determined there is no break between the Bartlesville and Tucker sands in this region.

STRUCTURE.

The general dip of the strata in Osage County is to the northwest, about 30 feet to the mile. There are local variations in this general northwest dip. The only detailed work done for determining these local variations was done by K. C. Heald*, in the Foraker quadrangle. His discussion of this area follows:

DEFINITION.

The term "structure" as used in this report is limited to mean the form taken by the strata, whether level, warped, folded, or faulted. Geikie* speaks of the structure as "the architecture of the earth's crust." It must, however, be differentiated from the sculpture of the earth's surface. The practical oil man is likely to limit the application of the term to those structural features which he considers favorable for oil accumulation. When the possibilities of oil accumulation in any region are being discussed, the question is commonly asked, Is there any structure? This usage is entirely too narrow and should be discouraged.

METHOD OF DETERMINING STRUCTURE.

In order to determine the structure of a region in which the folding is very slight, as in the Foraker quadrangle, it is necessary to obtain a great number of accurately located elevations or some one key rock. The points at which these elevations are taken must, if possible, be scattered over the whole area whose structure it is desired to ascertain. As no one bed crops out over so great an area, it is necessary to take observations on the outcrops of many different beds, from which the elevation of the key rock is computed by adding or subtracting as the case may demand, the vertical distance between the bed on which an elevation is taken and the key rock. For example, if the Neva limestone is chosen as the key rock, and the Cottonwood limestone crops out at the surface, a careful determination of the elevation of the top of the Cottonwood will be made. It has been determined by measurements made in localities where both Cottonwood and Neva limestones are exposed that the vertical distance from the top of the Neva down to the top of the Cottonwood is about 57 feet. If the elevation determined on the Cottonwood is, say 1,100 feet, 57 substracted from 1,100 will give 1,043 feet, the elevation of the Neva at that point.

*Heald, K. C., The oil and gas geology of the Foraker quadrangle, Osage County, Oklahoma; U. S. Geol. Survey Bull. 641-B.

*Geikie, James, Structural and field geology, 3d ed., p. 104, 1912.

In order to obtain the data for mapping the structure the first step is to study the rocks exposed and learn the distance between the prominent beds on which elevations may be taken and the characteristics of those beds, so that when an outcrop is encountered it will be possible to say which bed it is and just how far above or below the key rock it should be. The second step, which may often be combined with the first, is to determine the elevations at many points on the outcrops scattered over the area which it is desired to map, locating each determined point on a map and recording the bed upon which it was taken. The third step is to compute from these elevations those of the key rock as outlined above, and by connecting points of equal elevation on the key rock to draw the structure contours, which show, to those who understand reading contour maps, the form of the surface of the key rock as plainly as if all the earth and rock were stripped from above it, leaving it exposed to view. The structure in the deeply buried sands does not as a rule exactly parallel that shown in the beds at the surface, and hence there is always a possibility of error. When wells are drilled in this region, the well logs will furnish information by means of which the structure may be ascertained much more exactly than is possible through work with surface outcrops alone, and the structure contours may be revised. It is hoped, therefore, that when the full report for this quadrangle is prepared well logs will be available.

MAJOR STRUCTURE.

The Foraker quadrangle is situated on the west flank of a great regional uplift, the center of which is occupied by the Ozark Plateau. The west flank includes a great area in southwestern Missouri, southeastern Kansas, northeastern Oklahoma, and northwestern Arkansas in which the prevalent dip of the strata is to the west. In the Foraker quadrangle the general dip is almost due west at an average rate of 30 feet to the mile. However, the dip is far from uniform, being in comparatively few places exactly or even approximately 30 feet to the mile. There are many steepenings where the slope may be as much as 80 feet to the mile, and a few where it is twice that. These are compensated by flattenings where the strata may be horizontal or even dip toward the east for a short distance.

If all the earth and rock were removed from above some persistent stratum would appear as a broad plain sloping gently westward. The uniformity of this plain would be modified by low, rounded hills with broad, slightly arched tops; low ridges, most of them running in a general westerly direction and pitching to the west; and wide, shallow valleys with smoothly curving sides. At no place would there be such abrupt rises or steep-sided depressions as are visible on the present surface. The whole plain would be characterized by smoothness and very gradual changes in the direction and degree of slope.

MINOR STRUCTURE.

The term minor structure is used to indicate subordinate folds whose forms differ noticeably from that of the major structure upon which they are situated.

ANTICLINES.

BEAVER CREEK ANTICLINE.

The Beaver Creek anticline, named from its position west of Beaver Creek, is by far the most pronounced fold in the Foraker quadrangle. It is in the northwest corner of the quadrangle, and only a small part of the complete fold is shown on the map, as its northeasterly extension lies in Kansas and its southwesterly extension in Kay County, Oklahoma.

The part lying in the Foraker quadrangle trends southwest from a point about three-tenths of a mile west of the northeast corner of sec. 14, T. 29 N., R. 5 E., and passes into Kay County near the middle of sec. 22, T. 29 N., R. 5 E. The easterly dip, which persists for about half a mile, is at an average rate of 120 feet to the mile. The maximum vertical depression caused by this easterly dip is 60 feet, which is twice that of the Foraker anticline, the next largest fold shown on the map. The shape of the Beaver Creek anticline is undetermined, as the portions lying in Kay County and in Kansas were not mapped. However, it was observed that the easterly dip is much steeper than the westerly dip, and that the length of the anticline is much greater than the breadth. On the east flank of this fold there is a minor fold whose long axis extends about 1 1-2 miles and trends about N. 70° E.

The structure contours showing this anticline are based on elevations at different points on the outcrops of the Wreford and Crouse limestones. Exposures are so plentiful that no difficulty was experienced in getting sufficient data for accurate contouring.

LONE TREE DOME.

The Lone Tree dome, named from its situation just east of Lone Tree Creek, is a small upwarp about 1 mile long and half a mile wide at its widest point. The center of this dome lies about a quarter of a mile south and an eighth of a mile east of the northwest corner of sec. 28, T. 29 N., R. 6. E. Its outline is that of a triangle with rounded corners and the base toward the south. The long axis runs almost due north, and the short one almost due east. The fold is nearly symmetrical with respect to the long axis. The easterly dip is small in vertical extent, the maximum vertical descent of the beds being about 10 feet. The change from easterly dip to westerly dip in the region directly east of the fold is not perceptible, as the slopes of the beds in either direction are so slight that their approach to horizontality is difficult to detect. On the west the slope of the dome merges with that of the westward-dipping monocline, the rate of dip being about 40 feet to the mile.

Elevations on the Cottonwood limestone were used in drawing the structure contours that depict this dome.

GRAINOLA ANTICLINE.

The Grainola anticline lies west of the town of Grainola. Its highest point as expressed on the surface is about a quarter of a mile east of the southwest corner of sec. 32, T. 29 N., R. 6 E. The arch of the fold is very low, the vertical extent of the easterly dip being about 12 feet. The easterly dip persists for about half a mile before it dies out and is replaced by the prevalent westerly dip.

This fold is pear-shaped. Its longitudinal axis is about 1 1-4 miles long, and its transverse axis about three-quarters of a mile long at the widest point. The long axis runs in a northeasterly direction; the short axis is perpendicular to it. The structure is continued on the west in an anticlinal fold that pitches westward at a rate of 40 feet to the mile for the first half mile and 80 feet to the mile for the next quarter of a mile.

The elevations on which the contours are based are exclusively on the Cottonwood limestone, which crops out on the flanks of the fold. The crest of the fold is occupied by a valley containing no outcrops upon which elevations could be taken.

BROOKS ANTICLINE.

The Brooks anticline is a long, relatively narrow fold whose major axis runs southward from the middle of the southwest corner of sec. 17, T. 28 N., R. 6 E., to the middle of the SE. ¼ sec. 32, T. 28 N., R. 6 E. It lies west of the Brooks School. Its length is a little over 3 miles, and its maximum width less than three-quarters of a mile. The highest point is about in the center of sec. 20, T. 28 N., R. 6 E. The elevations on the west flank of this fold were taken on the Cottonwood limestone; those on the east flank on the top of the Neva limestone. The strata along the crest are hidden by a cloak of soil, and the correctness of the contouring is dependent on the accuracy of the assumption as to the distance between the Cottonwood and Neva limestones. The assumed distance of 55 feet was obtained by projecting dips observed on the two beds and is subject to an error of not more than 10 feet. If the distance used is 10 feet too great, there would be a marked flattening of dips but no actual reversal, and the wrinkles on the west side would still be present. In other words, there would be on the west side a series of small folds with their long axes trending almost due east and having a pronounced flattening at their east ends.

The east flank is mapped as being smooth and free from cross folds, but it is probable that the apparent smoothness is due more to the lack of rock outcrops on which observations could be taken than to actual absence of minor folds.

BROWN ANTICLINE.

The Brown anticline is a large, low upwarp, the highest point of which lies about a quarter of a mile south of the northeast corner of sec. 8, T. 27 N., R. 6 E., near the Brown School. It is really more of a terrace than an anticline, as the total easterly dip amounts to only about 12 feet. The flattening is very marked, however, and is prevalent over a large area.

The axis of this anticline runs in a direction a little east of north and is a little over 2 miles long. East of the axis the strata dip eastward at a rate of about 40 feet to the mile for a distance of three-tenths of a mile, beyond which the direction of dip is reversed and the beds rise to the east at a rate of more than 50 feet to the mile. For the first mile west of the axis the dip averages about 12 feet to the mile. Farther west the slope steepens, but so gradually that at no point can a pronounced change be seen. To the north the region of low dips includes a part of sec. 32, T. 27 N., R. 6 E., where it merges into the terrace structure of the Brooks anticline. The contours on the crest and east flank of this fold were determined from elevations taken on the upper part of the Neva limestone, and those on the west flank from elevations on the Cottonwood limestone. If there is any inaccuracy in the use of these beds it is in placing them too far apart, and the possible error does not exceed 10 feet. If the elevations on the west side of the fold are 10 feet too great; the real structure is much like that shown on the map, except that the dip to the west is steeper and the anticline therefore more pronounced.

NEVA ANTICLINE.

The Neva anticline is a short, blunt fold which shows dips in three directions only—to the north, west, and south. The axis of this fold trends westward from a point about an eighth of a mile east of the southwest corner of sec. 16, T. 27 N., R. 6 E., to the quarter corner between secs. 17 and 20, T. 27 N., R. 6 E. The top of the fold is broad and flat, the east end showing a dip to the west not exceeding 10 feet to the mile. The steepest dip is on the south side of the tip, where the beds plunge to the southwest at a rate of 100 feet to the mile. On the north side of the anticline the dip is about 70 feet to the mile. The greatest change in the amount of dip occurs in the NW. 1/4 NW. 1/4 sec. 17, T. 27 N., R. 6 E.

The contours representing this fold are based entirely on elevations taken on the top bed of the Neva limestone. Exposures are scarce, and comparatively few elevations could be obtained; therefore, while the general shape of the fold is as mapped, it is quite probable that there are minor irregularities which do not appear on the map.

HAY CREEK ANTICLINE.

The Hay Creek anticlines, named from their location near the mouth of Hay Creek, are three in number. The east-west distance from the highest point of one anticline to the highest point of the next is about a mile. The middle one is the farthest north; the western one the farthest south. In point of size they are successively larger from east to west. The elevations on which the structure contours of these folds are based are mostly on the Neva limestone, but some of them are on a limestone which lies about 23 feet below the base of the Neva. Exposures are good and no trouble was experienced in getting abundant data.

The highest point on the western anticline is about an eighth of a mile due south of the northeast corner of sec. 1, T. 26 N., R. 5 E., from which point the rocks dip gently in all directions. To the east, south, and west the dip is at the rate of 70 feet to the mile. To the north there is almost no dip for the first half mile, and then the strata dip north at about 50 feet to the mile. The dip on the east persists in that direction for about half a mile and then reverses, the beds rising gently toward the east. The flattened top of this dome is less than half as wide as it is long. The long axis trends a little east of north throughout most of the length, but swings sharply northwest at the north end. The long sides bow in toward each other in the middle and the ends are rather blunt.

The highest point of the middle Hay Creek anticline is about a quarter of a mile due south of the northwest corner of sec. 32, T. 27 N., R. 6 E., from which point the axis trends a little east of north and west of south. The length of the axis is about 1¼ miles. The outline of this fold is something like the blade of a knife which lies with its point to the north, the length being about three times the width. The dip either east or west of the axis is at the rate of about 60 feet to the mile. That on the east side has a total vertical amount of only 12 feet, however, the horizontal distance over which it extends being short. To the north and south the dips are very gentle and merge into the general westerly dip of the region without any perceptible change.

The eastern Hay Creek anticline is the smallest of the three folds. Its highest point lies a little southwest of the quarter corner between secs. 32 and 33, T. 27 N., R. 6 E. In outline it is like the blade of a narrow, round-ended, round-shouldered trowel. The long axis of the anticline points a little east of north. It is a little less than a mile long, and its greatest width is about a quarter of a mile. The easterly dip is insignificant, amounting to a little over 5 feet at its point of greatest development. To the west, however, the beds dip steeply for this region, showing for about a quarter of a mile a grade of 100 feet to the mile. The change in dip at the upper end of this relativly steep slope is very pronounced, giving the structure more the form of a terrace than that of an anticline.

WAMSLEY CREEK ANTICLINE.

The Wamsley Creek anticline is a low, irregular fold south of Wamsley Creek. It is made up in reality of two distinct low folds or structural swells whose highest points appear at the surface in the middle of the SE. ¼ sec. 25, T. 27 N., R. 6 E., and about one-tenth of a mile south of the corner of secs. 25, 26, 35, and 36. In shape this fold is like a V having thick, uneven sides and pointing northwest. The highest points occur at about the middle of each side and are separated by a narrow, shallow depression. The long axis of the east side of the fold points about N 40° W., and that of the west side about N. 30° W. The fold, considered as a whole, is about 2 miles long and 1 mile wide. The actual reversal of dip is very slight, the maximum eastward descent being about 10 feet. The dip to the east is at the rate of about 40 feet to the mile, and that to the west has a maximum of about 80 feet to the mile.

The structure contours showing this fold are based on elevations taken on several beds of the Foraker limestone. Exposures were abundant and the beds could be accurately correlated, so there is small doubt about the exact form of this anticline.

POTATO CREEK ANTICLINE.

The name Potato Creek anticline has been given to a pronounced fold whose highest point is in the SW. ¼ SW. ¼ sec. 32, T. 27 N., R. 7 E., south of Potato Creek. This anticline is irregular in outline, forming an uneven oblong with ends and sides only approximately parallel. The major axis is about 1½ miles long and trends about N. 20° E. The greatest width of the anticline is near the north end and amounts to a little more than a mile. The top of the fold is almost flat and covers an area of about half a square mile. It pitches to the north at an average rate of 70 feet to the mile, and the beds dip to the west at the same rate. Toward the south the dip is not so pronounced, the maximum drop being about 40 feet to the mile. On the east there is a drop of 15 feet at a rate of 120 feet to the mile, followed by a sharp reversal, the easterly dip being met by a westerly dip of equal steepness. It is possible that a small fault separates the beds here, although there is no evidence of such a break except the abrupt reversal of dip.

On the west flank of the anticline, about a mile southwest of the summit, there is a structural terrace. The dip to the west flattens to about 10 feet to the mile and then steepens abruptly to almost 150 feet to the mile. The front of this terrace extends along the east line of sec. 1, T. 26 N., R. 6 E.

NORTH BIRD CREEK ANTICLINE.

The North Bird Creek anticline is a long narrow fold whose axis extends southwestward from a point three-tenths of a mile south of the northwest corner of sec. 12, T. 27 N., R. 7 E., near North Bird Creek, to a point about one-tenth of a mile south of the quarter corner between secs. 17 and 20, T. 27 N., R. 7 E. The dips on this fold are to the north, west, and south. On the east the fold merges into the general westward-dipping monocline without any perceptible change in the general dip. The greatest flattening shown on this fold is in the southwest corner of sec. 11, T. 27 N., R. 7 E., where the average dip is about 15 feet to the mile toward the southwest. The steepest dip is at the very tip of the fold, where the beds slope westward at an average of 110 feet to the mile. At one place on the south side of the fold the dip is as steep as that shown on the tip, but only for less than one-fifth of a mile.

Most of the elevations on which the contours of this fold are based were taken on beds in the Foraker limestone, but some of them were taken on the sandstone which lies about 43 feet below the base of the Foraker. Outcrops were abundant and correlations could be easily and accurately made.

FORAKER ANTICLINE.

The Foraker anticline is a low upwarp, the crest of which is just northwest of the southeast corner of sec. 21, T. 28 N., R. 7 E., northeast of Foraker. The outline of this low swell is much like the bottom of a flatiron with a blunt rounded point and the back side of the flatiron slightly curved in toward the center. The major axis, which trends a little south of west, is about 2 1-2 miles long. The greatest breadth of the anticline is about 1 1-4 miles, at the east end.

The dips to the north, west, and south are fairly uniform and about 75 feet to the mile. On the east flank of the fold the dip to the east averages 25 feet to the mile. The top of the anticline, about a quarter of a square mile in extent, is very flat, and dips in any direction are hard to detect.

A good deal of difficulty was experienced in mapping this anticline, as continuous outcrops are rare, and the dip to the east was determined not by continuous tracing of a single bed but correlating scattered outcrops. It could not be proved that much of the apparent easterly dip is not due to a fault, but the fact that no faults or indications of faults were seen elsewhere in the quadrangle would make the existence of a fault here seem very improbable. It is, however, possible to say definitely that to the north the strata are not broken. Of the exact structure south of the crest of the fold very little could be ascertained, as there are practically no rock outcrops in that area. It was possible to determine the general dip, however, and although the structure on the south side is probably not so regular as the map indicates, it is unlikely that the mapping diverges greatly from the true structure.

ELM CREEK ANTICLINE.

The Elm Creek anticline is a small upwarp lying on the headwaters of Elm Creek, in the W. ½ sec. 9, T. 27 N., R. 7 E. The axis of the fold is about 1¼ miles long and trends about N. 25° E. The anticline is really made up of two small domes which are separated by a slight saddle. These domes are small oval swellings of nearly equal size. Their major axes have a length of half a mile and their minor axes a length of a little more than a quarter of a mile.

The dips on all sides of the fold are gentle. East of the principal axis the beds dip eastward for less than a quarter of a mile, to a point where the slope is reversed, and the highest point of any bed in the anticline is less than 15 feet above the lowest point that the same bed may reach east of the anticline. West of the principal axis the beds slope away from it at a rate of about 35 feet to the mile for a quarter of a mile and at 100 feet to the mile for about a quarter of a mile more before the dip merges into the general westward dip of the region.

The Red Eagle limestone crops out over the surface of this anticline, and the structure contours are based on elevations on the top of this bed.

ANTELOPE CREEK ANTICLINE.

The Antelope Creek anticline lies in secs. 10 and 11, T. 27 N., R. 6 E., just south of Antelope Creek. It is a transverse fold with a curving axis trending about N. 75° W. The general outline of the compound structure is something like that of a two-pronged tooth with the prongs pointing west.

The dips to the north, west, and south are at the rate of 60 feet to the mile. No dip to the east appears except in one small area on the very crest of the wrinkle. Here the beds are inclined to the east for a horizontal distance of about one-eighth of a mile, in which there is a depression of 10 feet.

The structure contours for this fold were determined from elevations on the Neva limestone, which crops out along the flanks of the fold.

SYNCLINES.

No detailed description is given of the synclines, as the purpose of this paper is primarily to point out those features which are of economic importance with relation to oil and gas, and a syncline is such a feature only where oil-bearing strata do not carry water. As such a condition has not been found to exist in any of the oil pools in the region surrounding the Foraker quadrangle, it is fair to assume that the sands underlying the surface in this quadrangle carry water. A mention of the positions of the axes of the larger synclines may be of some value, however, as the bottoms of these structural troughs are theoretically the most unfavorable places for accumulations of oil and gas, and they should accordingly be avoided in wildcatting operations.

Synclines occur north and south of the Foraker anticline. The axis of the one to the north strikes about N. 75° E. and extends from the quarter corner between secs. 24 and 25, T. 28 N., R. 6 E., to a point about 500 feet south of the middle of sec. 16, T. 28 N., R. 7 E. The one on the south is a sharper fold but is not so long. The axis of this trough trends northeastward from a point a little northwest of the middle of sec. 33, T. 28 N., R. 7 E. About 1,000 feet south of the middle of sec. 27, T. 28 N., R. 7 E., the axis divides, one branch continuing northeast for about a mile and the other trending a little south of east for about 1 1-2 miles, to the place where the syncline dies out.

Just south of the North Bird Creek anticline there is a small, well-defined syncline whose axis begins 1,000 feet west of the southeast corner of sec. 15, T. 27 N., R. 7 E., and trends northeastward to a point 1,000 feet north of the southwest corner of sec. 12, T. 27 N., R. 7 E.

A large, pronounced syncline lies south of the one just described, and its axis, which is slightly curved, extends from a point 3,000 feet southwest of the northeast corner of sec. 29, T. 27 N., R. 7 E., to the middle of sec. 24, T. 27 N., R. 7 E., where it passes out of the quadrangle.

In the southwest corner of the quadrangle there is a well-defined syncline whose axis extends from a point 1,000 feet north of the southeast corner of sec. 26, T. 27 N., R. 5 E., to a point 2,300 feet south of the northwest corner of sec. 29, T. 27 N., R. 6 E., just northwest of the middle Hay Creek anticline.

Just north of the Antelope Creek anticline there is a short syncline with a curved axis about a mile long extending from the southwest corner of sec. 3, T. 28 N., R. 6 E., to a point about 1,000 feet east of the southwest corner of sec. 12, T. 29 N., R. 6 E.

East of the Beaver Creek anticline there is a syncline whose axis trends northeastward from the quarter corner between secs. 27 and 34, T. 29 N., R. 5 E., to the middle of sec. 23, T. 29 N., R. 5 E.

In the north-central part of the quadrangle there is a pronounced structural depression with an axis trending in a general southeasterly direction from the quarter corner between secs. 25 and 26, T. 29 N., R. 6 E., to the middle of the NW. 1/4 sec. 5, T. 28 N., R. 7 E.

Besides the synclines described above there are many small ones whose influence on oil and gas accumulation is minor and in some cases probably negligible.

RECOMMENDATIONS FOR PROSPECTING.

There is a distinct order of preference which should be considered in the exploration of the anticlines of the Foraker quadrangle. Should a fold which is favorably located and structurally suited to contain oil and gas be found to contain no such accumulation, the presence of pools in adjacent territory structurally less favorable would be much less probable. Prospecting should not be indiscriminate but should first test thoroughly the localities where the structure appears most favorable, and if one of these localities fails to yield oil and gas, prospecting should be at least temporarily moved to a point some distance away.

However, no fold should be condemned on the evidence offered by a single hole. The attitude of the strata is by no means the only factor governing the accumulation of oil and gas, and some one of the others may interfere so strongly that a fold which is otherwise pronouncedly favorable for such an accumulation will prove barren. One of the most potent of these other factors is believed by the writer to consist in the porosity and the nature and size of the openings in a bed which the oil and gas can occupy. For accumulations of gas the porosity is the more important. For accumulations of oil large interstices between grains are probably more essential than high porosity. These factors can vary greatly within a short distance, and that is one of the principal reasons for the above recommendation that at least two test holes should be drilled before an apparently favorable fold is abandoned.

In the Foraker quadrangle the anticline which offers the best structural conditions for the accumulation in commercial amount of oil and gas is the Beaver Creek anticline, in the extreme northwest corner. The best point for prospecting is on the very crest of the fold, which is a little south of the center of sec. 15, T. 29 N., R. 5 E. A well drilled here should reach the horizon of the Bartlesville sand at a depth of about 3,240 feet. In case oil or gas in considerable quantities are not found in the initial test, a second should be drilled about half a mile south and a quarter of a mile west from the first. Failure to find oil or gas in the Beaver Creek anticline would have little bearing on the possibility of their accumulation in other folds in the Foraker quadrangle, as the Grainola anticline, which is the nearest one of any great promise, is about 4 miles from the Beaver Creek anticline and has ample gathering ground to supply hydrocarbons sufficient for any accumulation which it would be likely to hold.

The fold which appears to be second in promise is the Foraker anticline. This anticline, though small compared to those in many of the Oklahoma oil fields, still offers all the structural conditions that are necessary for the formation of an oil pool of considerable proportions. Owing to the comparatively low dip on all sides of this fold a hole sunk on the top of the fold, which is shown on the surface, would strike the highest point of the continuation of this fold at reasonable depth. Although it is impossible to say that this fold has the same shape underground as it shows at the surface, the outlines should be roughly the same, and the best that can be done is to choose the point at which the surface indications are the most promising. It is recommended that the first test hole on this anticline be sunk 600 feet west and 100 feet north from the southeast corner of sec. 21, T. 28 N., R. 7 E. It should reach a depth of at least 2,800 feet. If the first test fails to get oil or gas, a second should be drilled about 500 feet north of the quarter corner between secs. 21 and 28. The failure of these tests would tend to indicate the absence of accumulations of oil and gas not only in the Foraker anticline, but also in the Elm Creek anticline. If the more pronounced fold does not contain an accumulation of oil, it is unlikely that such an accumulation has formed under the less favorable structural conditions present in the smaller fold.

Third in importance is the Potato Creek anticline. This fold, while less well developed than the Foraker anticline, still offers all the structural requisites for a large oil pool. The dips on the several sides of this fold do not differ in degree enough to affect the accumulation of oil, and the best point for prospecting is the highest point of the fold as expressed on the surface. This point is roughly 500 feet east and 200 feet north from the southwest corner of sec. 32, T. 27 N., R. 7 E. Should a hole at this point fail to show oil and gas in considerable quantity, a second one should be drilled about 2,000 feet due south of the quarter corner between secs. 29 and 32. These tests should reach a depth of at least 2,800 feet, which should bring them to the horizon of the Bartlesville sand. A good showing of oil at that depth would justify drilling 100 or 200 feet deeper. In case the Potato Creek anticline is barren of petroleum or gas, prospecting the near-by Wamsley Creek anticline would not be advisable unless work to the west should disclose producing territory.

The three localities mentioned above are structurally the most favorable ones in the quadrangle. The order of importance of the other folds that have been described in detail is believed by the writer to be as follows: Western Hay Creek, Grainola, Lone Tree, Brown, North Bird Creek, Antelope Creek, Elm Creek, Wamsley Creek, middle Hay Creek, eastern Hay Creek, Brooks, and Neva. The best points for drilling are on the highest points of the folds, which are mentioned in the detailed descriptions. In deciding on the relative importance of these folds weight was given not only to their expression on the structure map, but also to the completeness of the data on which the structure contours are based.

DEVELOPMENT.

The development in Osage County has been so influenced by governmental restrictions that it will be of interest to quote the following from "Petroleum in 1915" by John D. Northrop, of the United States Geological Survey:

Operations in the Osage district in 1915 resulted in the opening of no new areas of production. The interest of the operators was centered in efforts to secure a renewal of the Foster lease, which was to expire March 16, 1916.

The original lease was made March 16, 1896, for a period of 10 years by the Osage Nation to Edwin B. Foster, and covered oil and gas rights on the entire reservation. This lease was subsequently assigned by Foster to the Indian Territory Illuminating Oil Co., which retained the gas rights but subleased the oil rights to a great number of independent operators. By act of Congress (Public No. 112) dated March 3, 1905, this blanket lease was renewed to the extent of 680,000 acres in the eastern part of the reservation and extended for a further period of 10 years, terminating in 1916. After hearings on the subject the Secretary of the Interior announced, in June, 1915, a resolution passed by the Osage Council and approved by the Department of the Interior, providing for the re-leasing of the area involved in the Foster lease under terms which eliminate the Indian Illuminating Co. as an intermediary.

This resolution provides for new leases direct to existing sublessees and covering their holdings in quarter-section units not exceeding in the aggregate 4,800 acres each, except such units the producing wells of which were capable of averaging 25 or more barrels of oil a day on July 1, 1915. These units are to be retained by the Osage tribe and offered for lease at public auction to the highest bidder under such rules and regulations as the Secretary of the Interior shall provide. Leases on all producing lands not leased to former holders are made subject to the same form of disposition. The stipulations are made that oil and gas rights shall be leased separately; that the royalty rate on oil shall be one-sixth, except on quarter-section units the average daily production of which equals 100 barrels per well for calendar-month periods, when the royalty rates increases to one-fifth; and that instead of a flat annual rental for gas wells, as heretofore, a production royalty of one-sixth shall be collected. The term prescribed for oil leases in five years, subject to renewal so long as oil is produced but not beyond the date when the title to minerals in the Osage tribe terminates, which is August 8, 1931.

Activity in the Osage in 1915 was more pronounced in the area north of Bigheart than elsewhere and a number of wells of fair capacity were completed.

The table following shows the number of wells owned in Osage County by the Indian Territory Illuminating Oil Co. and its sublessees.

Oil and gas wells in Osage County, 1903-1915.

Date	Completed	Pro-d'ctve	Gas	Dry°	Date	Completed	Pro-d'ctve	Gas	Dry
Jan. 1, 1903	30	17	2	11	Dec. 31, 1908.........	1,422	936	78	408
Dec. 31, 1904	361	243	21	97	Dec. 31, 1909.........	1,574	1,027	81	466
June 10, 1905	544	355	34	155	Dec. 31, 1910.........	1,735	1,175	82	478
Dec. 31, 1905	704	462	45	197	Dec. 31, 1911.........	2,233	1,562	90	581
June 10, 1906	862	569	55	238	Dec. 31, 1912.........	2,682	1,887	112	683
Dec. 31, 1906	1,080	716	66	298	Dec. 31, 1913.........	3,307	2,323	145	839
June 30, 1907	1,155	779	67	309	Dec. 31, 1914.........	3,785	2,654	172	959
Dec. 31, 1907	1,277	837	71	369	June 30, 1916.........	4,211	2,838	227	1,146

*Wells that have been exhausted and abandoned in addition to wells that were dry when drilled in.

The main production in Osage County is associated with fields which have been discussed under bordering counties. The Avant Pool is a continuation of the Dewey-Bartlesville field, which will be discussed under Washington County. The Osage Junction and the Boston pools are continuations of the Cleveland pool which has been discussed under Pawnee County.

That part of Cleveland pool known as the Boston pool is located in Osage County in the SE. cor. of T. 22 N., R. 7 E., the SW. cor. of T. 22 N., R. 8 E., the NW. cor. of T. 21 N., R. 8 E., and the NE. cor. of T. 21 N., R. 7 E. One well located in sec. 1, T. 21 N., R. 7 E. had a production for the first twenty-four hours of 2,000 barrels of oil. Sec. 1 of this township has been very prolific, the average initial production of its wells being about 350 barrels daily. The following log will give a general idea of the underground strata in the Boston pool:

Log of Monitor Oil Company Well No. 1, Osage County, sec. 25, T. 22 N., R. 7 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	20	20	Sand	15	895
Lime	5	25	Slate	15	910
Red rock	40	65	Sand	105	1,015
Slate	40	105	Slate and sand	35	1,050
Sand	10	115	White slate	20	1,070
Slate	20	135	Sand and slate	25	1,095
Sand	60	195	Lime	3	1,098
Slate	155	350	Blue slate	69	1,167
Red rock	15	365	Lime	38	1,205
Lime	7	372	Blue slate	50	1,255
Red rock	23	395	Sand	15	1,270
Blue slate	30	425	Slate	25	1,295
Sand	6	431	Sand	22	1,317
Slate	19	450	Slate	183	1,500
Sand	10	460	Layton sand	50	1,550
Slate	27	487	Slate	194	1,744
Sand	9	496	Lime	8	1,752
Slate	74	570	Slate	38	1,790
Sand	15	585	Cleveland sand	35	1,825
Slate	37	622	Slate and sand	75	1,900
Blue slate	18	640	Sand	30	1,930
Sand and slate	27	687	Slate	60	1,990
Lime	23	710	Oswego lime	65	2,055
Blue slate	90	800	Slate	10	2,065
Sand	18	818	Oswego lime	45	2,110
Lime	7	825	Slate	55	2,165
Slate and sand	30	855	Peru sand	13	2,178
Slate	25	880			

The remainder of the production in Osage County is derived from a number of small pools scattered throughout the county. These small pools are located as follows: The western part of T. 28 N., R. 10 E. and the northern part of T. 27 N., R. 10 E.; the central part of T. 29 N.,

R. 13 E.; the eastern part of T. 27 N., R. 10 E.; the southern part of T. 26 N., R. 9 E.; and the northern part of T. 25 N., R. 9 E.; T. 25 N., R. 10 E., two pools, near Nelagoney in the western part of the township and the other in the southeastern part of the township near Bigheart; the southeastern part of T. 24 N., R. 8 E.; the southeastern part of T. 24 N., R. 10 E.; the northwestern part of T. 24 N., R. 11 E.; the southeastern part of T. 22 N., R. 9 E.; and the eastern part of T. 22 N., R. 10 E.

Reports show that both oil and gas have been found in the pool located in T. 27 N., R. 10 E. The production is found at depths ranging from about 1,850 feet to 1,950 feet.

The pool found in the southern part of T. 26 N., R. 9 E., and the northern part of T. 25 N., R. 9 E. is just to the northeast of the city of Pawhuska. Considerable gas is produced in this pool. Production is found at depths varying from about 2,050 feet to 2,100 feet.

Production in the pool located in the southeastern part of T. 24 N., R. 8 E., is found at depths ranging from about 1,750 feet to 2,200 feet. The following log will give a general idea of the underground strata in this pool.

Log of Foster & Davis well, Osage County, sec. 36, T. 24 N., R. 8 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Red mud	115	115	Layton sand	65	980
Lime shell	5	120	Sand	25	1,005
Slate	20	140	Sand, shells	30	1,035
Sand	25	165	Slate	15	1,050
Shale, blue	40	205	White slate	35	1,085
Sand	43	248	Lime	15	1,100
Slate	62	310	Shale	55	1,155
Sand	25	335	Shale	50	1,205
Slate	60	395	Sand	5	1,210
Lime	5	400	Light shale	35	1,245
Slate	50	450	Dark shale	40	1,285
Red rock	25	475	Hard light shale	10	1,295
Sand	15	490	Dark shale	145	1,440
Slate	25	515	Dark lime	5	1,450
Lime	15	530	Gas sand	30	1,480
Blue slate	30	560	Black shale	25	1,505
White slate	10	570	Light shale	40	1,545
Sand	40	610	Light lime	90	1,635
Slate	5	615	Light sand	15	1,650
Sand	85	700	Dark shale	97	1,747
Blue slate	20	720	Oswego lime	17	1,764
Sand	5	725	Sand, best oil	8	1,768
White sand	180	905	Shale, black	2	1,770
Blue lime	10	915			

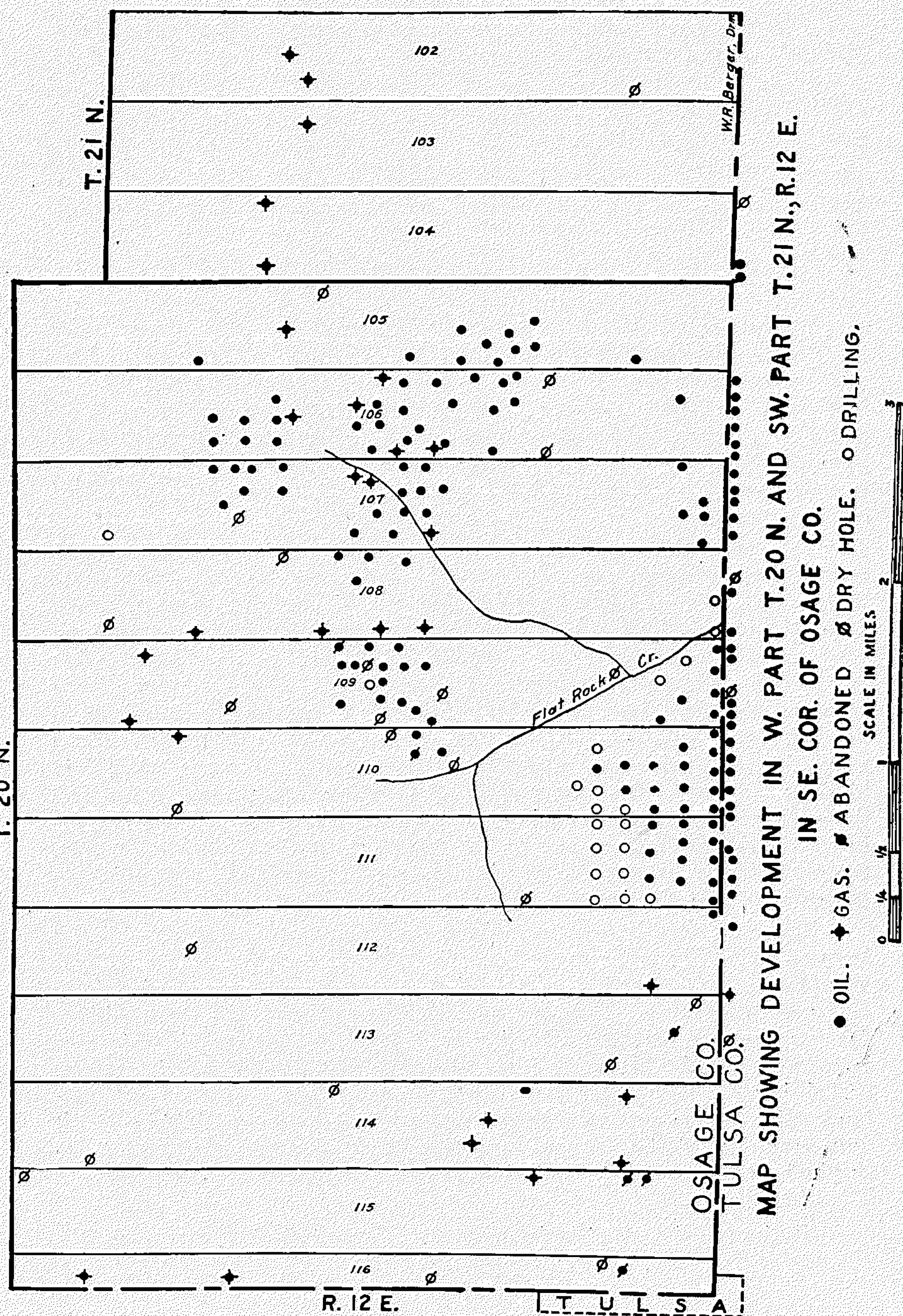

MAP SHOWING DEVELOPMENT IN W. PART T. 20 N. AND SW. PART T. 21 N., R. 12 E.
IN SE. COR. OF OSAGE CO.
● OIL. ✦ GAS. ABANDONED Ø DRY HOLE. ○ DRILLING.
SCALE IN MILES
T. 21 N.
T. 20 N.
R. 12 E.
OSAGE CO.
TULSA CO.
TULSA
Flat Rock Cr.
W.R. Berger, Dr.
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116

Figure 12.

The following[1] table gives the production in Osage County, 1905-1915, by years, in barrels.

1903	56,905	1910	5,892,976
1904	652,479	1911	11,707,676
1905	3,421,478	1912	8,169,158
1906	5,219,106	1913	9,009,996
1907	5,143,971	1914	9,935,692
1908	4,961,147	1915	8,604,389
1909	4,516,524		

SUMMARY.

Osage County covers an area of approximately 2,350 square miles in perhaps the most favorable oil and gas territory in Oklahoma. Production has been found not only in the areas surrounding this county, but pools have been extended into Osage County and numerous small pools opened up within the county itself. The federal restrictions have checked development in Osage County. This policy of restriction, has no doubt conserved for future development enormous quantities of oil and gas.

A general idea of the policy of the Interior Department with reference to leasing more of the oil lands may be had from some Washington correspondence published in the Oil and Gas Journal under date of December 27, 1916. A Tulsa oil man applied for Osage oil lands within the limits of the American Pipe Line Co.'s gas lease, which is territory not heretofore opened for oil leases. The Secretary of the Interior Department answered that the department intends to adhere to th program of leasing under the regulations of August 26, 1915. These regulations provide that thereafter leases should be made on public bidding only and that leases should be confined to present wells and those where operators in drilling for gas have struck oil. Those acquiring these oil wells must pay to the operator who was drilling for gas, the expenses he incurred in drilling the well. On these terms the well is to be sold to the highest bidder.

The only way in which additional territory can be acquired is by lease of adjoining lands to protect from drainage, and then the lease is granted in the interest of the Indians to protect their royalties from being drained away. This means that where a man has been drilling for gas close to the boundary line of a lease and strikes oil, this well may be sold to the highest bidder, who pays the operator for his expense of drilling the well. The new owner may then get a lease of sufficient land adjoining to protect the well against some one else sinking a well and draining off the oil that properly belongs to the operator of the original well, but he may not sink any new wells on this property.

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[1]Northrop, John D., Petroleum in 1915, U. S. Geol. Survey.

OTTAWA COUNTY.

LOCATION AND EXTENT.

Ottawa County is located in the extreme northeastern corner of the State, with Kansas on the north side and Missouri on the east side. It lies to the north of T. 25 N. and east of R. 21 E., and covers an area of approximately 470 square miles, or about 13 townships.

TOPOGRAPHY.

The eastern part of the county is quite hilly, due to the outcrop of a resistant and thick limestone formation. The northwest corner flattens out to a very level plain, on which the knolls when present are rolling and the rivers run through shallow mud valleys. This is due to the outcrop of a soft shale. The contact of this shale and the limestones which lie below it extends from the southwest corner northeastward through Miami and this line will roughly divide the hilly country from the flat rolling country. The drainage is southward. The Neosho or Grand River runs completely across the county and Spring Creek joins the Neosho about the center of the county. The elevation above sea level is between 750 and 900 feet.

GEOLOGY.

The rocks in the eastern part of Ottawa County are of a thick (400 to 450 feet) and resistant limestone formation known as Boone, and are of lower Mississippian (Carboniferous) age. This limestone is compact and contains many nodules and irregular masses of chert. In weathering there is a tendency for the formation to form steep slopes which are covered with a great thickness of angular chert fragments residual from the erosion of the rock. Lying unconformably on the Boone is a limestone of upper Mississippian age. This limestone, which is called the Chester, is composed of several members and has a total thickness varying from 30 feet to perhaps 100 feet. This variation is partly due to thickening and thinning of beds and partly to the unconformable surfaces above and below the Chester. Above the Chester is the Pennsylvanian (Carboniferous) shale known as Cherokee. This shale is the same age as the "Coal Measures" of Kansas. It is also the same age as the oil-producing rocks farther south in Oklahoma. However, it is lower in the geologic column than most of the oil-producing sands. The Cherokee shale is a black, fine-grained, compact shale, very high in bituminous content. There are many lenses of sandstone in it which are variable both in nature and extent. As before mentioned this shale is only found in the northwestern part of the county and does not reach a thickness of over 200 feet, although in Kansas where it has not been worn away by erosion it is about 400 feet thick.

STRUCTURE.

Northeastern Oklahoma is on the western edge of the Ozark uplift. The formations dip at a very small angle (about 30 feet to the mile) to the northwest. Locally there are small folds which may have dips of as much as 15°.

The Horse Creek anticline just to the south of Ottawa County has been traced several miles. It has an east-west axis. On Spring Creek near "Lovers' Leap" the beds dip sharply to the north. In the Blue Bird mine the beds dip to the south. Other places show west dips of several degrees. On the whole the local folding has been mainly with east-west axis.

DEVELOPMENT.

There is no commercial production of either oil or gas from Ottawa County. Hundreds of wells have penetrated the rocks to depths varying from 300 to 1,100 feet in prospecting for lead and zinc. In some of these wells seepages of bitumen occur while passing through the Cherokee shale, always at depths less than 200 feet. Nowhere has there been any indication of oil far below this shale. In many of the mines a thick bitumen, locally known as tar, runs down the shafts from out of the Cherokee shale. In one or two instances shaft sinking was abandoned because of the quantity of this thick bitumen which seeped in from the walls. But only in seepages of a few gallons does bitumen occur.

SUMMARY.

The rocks which underlie Ottawa County are older and hence lower down in the geologic column than any of the oil-producing formations of Oklahoma. While oil has been found in these older rocks in other states, such as Ohio, Indiana, Michigan, and Ontario, Canada, it is almost a certainty that such will not be the case in Oklahoma. The thin capping of Pennsylvanian rocks in the northwest corner shows seepages of a thick bituminous material called tar by the miners of the district. However, this formation has been penetrated by drill holes in many places and no body of either oil or gas occurs.

PAWNEE COUNTY.

LOCATION.

Pawnee County is located in the north-central part of the State. It extends from T. 20 N. to T. 24 N. inclusive, and from R. 3 E. to R. 10 E. inclusive. It contains 10 whole townships and parts of 13 others. The total area is 617 square miles.

TOPOGRAPHY.

Most of Pawnee County is in the Sandstone Hills region. The extreme western part is in the Prairie Plains region. The topography is characterized by more or less parallel eastward-facing escarpments between which are shale valleys containing rolling hills. Along Arkansas and Cimarron rivers are large areas of sand. The county is treeless except along the streams. It is drained by Arkansas and Cimarron rivers and their tributaries.

GEOLOGY.

The surface rocks are lower Permian and upper Pennsylvanian. The Pennsylvanian rocks are sandstones and shales, the shales predominating. The Permian rocks are sandstones, shales, and calcareous sandstones.

The following logs will give an idea of the underground strata:

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

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

Cosden Co. No. 1, *in NE. cor. of sec.* 33, *T.* 21 *N., R.* 7 *E.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface	8	8	Shale	16	938
Lime	10	18	Sand	4	942
Mellow clay	24	42	Shale	10	952
Lime	4	46	Red rock	25	977
Slate	54	100	Shell	4	981
Water sand	5	105	Shale	9	990
Lime and red slate	50	155	Red rock	10	1,000
Water sand	6	161	Shale	20	1,020
Slate	8	169	Sand	85	1,105
Lime	11	180	Shale	10	1,115
Slate	35	215	Lime	5	1,120
Lime	5	220	Shale	26	1,246
Clay	15	235	Shell	18	1,264
Slate	25	260	Shale	72	1,336
Water Sand	5	265	Lime, sandy	10	1,346
Lime	5	270	Shale	20	1,366
Shale	10	280	Shell	8	1,374
Lime	10	290	Shale	26	1,400
Water sand	5	295	Sand	7	1,407
Shale	25	320	Shale	13	1,420
Water sand	10	330	Shale, caving	22	1,442
Shale	110	440	Lime	2	1,444
Sand	10	450	Shale	6	1,450
Shale	10	460	Lime	6	1,456
Shell	5	465	Shale	84	1,640
Shale	15	480	Sand	32	1,672
Lime	10	490	Shale	246	1,918
Shale	10	500	Sand, oil	3	1,925
Lime	10	510	Shale	75	2,005
Shale	5	515	Lime, gritty	40	2,045
Red rock	25	540	Shale	145	2,190
Salt sand	10	550	Lime, (Oswego)	77	2,267
Shale	25	575	Shale	11	2,278
Shell	15	590	Lime	12	2,290
Red shale	15	605	Shale	6	2,296
Shale	35	640	Lime	34	2,330
Hard shell	4	644	Shale	5	2,335
Shale	9	653	Lime	20	2,355
Lime	7	660	Shale	18	2,373
Salt sand	10	670	Lime	7	2,380
Shale	10	680	Shale	15	2,395
Lime	25	705	Sand	35	2,430
Red shale	25	730	Shale	28	2,458
Salt sand	7	737	Sand	15	2,473
Red rock	23	760	Shale	52	2,525
Blue shale	15	775	Sand	34	2,559
Shell	10	785	Lime	11	2,570
Shale	39	824	Shale	2	2,572
Lime	6	830	Lime	5	2,577
Sand	20	850	White slate	77	2,654
Shale	68	918	Shell	15	2,669
Shell	4	922	Sand (Bartlesville)	10	2,770*

*Hole full of water at this depth.

STRUCTURE.

The general attitude of the strata of Pawnee County is that of a west-dipping monocline. The probable average dip of these rocks is 30 feet to the mile. The general west dip is varied in places by small folds.

OTOE ANTICLINE.

The axis of the Otoe anticline extends from the SW. 1/4 of sec. 33, T. 23 N., R. 3 E., southwestward for an undetermined distance, but the extent is at least 2 miles. The apex of the axis is located in the northwest corner of sec. 4, T. 22 N., R. 3 E. From this point the strata dip eastward about 60 feet to the mile and northeastward at least 85 feet to the mile. There is a flat dip southward from the apex.

The Ralston anticline is located in the northwest-central part of T. 23 N., R. 5 E., about 3 miles west of the town of Ralston. From section 4 of this township, the strata dip northward about 70 feet to the mile, southward 70 feet to the mile, and westward 80 feet to the mile.

The only attempt at development in this region was made by J. M. Critchlow and associates, who drilled a well in the SE. cor. NW. 1/4 sec. 3, T. 23 N., R. 5 E. The well is reported to have reached a depth of about 2,000 feet. Business difficulties prevented the completion of this well.

Immediately northeast of the town of Ralston a well was sunk several years ago, and it is reported that a good showing of oil was encountered at a depth of 2,800 feet.

STRUCTURE IN THE VICINITY OF MARAMEC.

An anticline has been reported at various times as existing along the east side of T. 20 N., R. 5 E. Close investigation has failed to find any evidence of such structure.

A fault which extends northwest-southeast through the southeast corner of sec. 7, T. 20 N., R. 6 E., has been traced for a couple of miles. The downthrow is on the northeast side of the fault line. The displacement is about 65 feet.

DEVELOPMENT.

CLEVELAND POOL.

The Cleveland pool is located in T. 21 N., R. 8 E. This pool was discovered in 1904. The small pool sometimes called the Olney, lying 6 miles southwest of Cleveland, is included in the Cleveland pool.

In 1909, out of 21 wells drilled only one was dry and two produced gas. The others had an average initial production of 1,095 barrels daily. The oil was first found in two sands—the Cleveland and the Kelso. The Cleveland sand lies at a depth of 200 to 300 feet. The Kelso sand is a little above the Cleveland.

Late explorations have been, for the most part, for deeper sands.

The Bartlesville sand was found to be productive at a depth of 2,400 to 2,500 feet. The Tucker sand was found productive at a depth of 2,600 to 2,800 feet.

Recent reports show no sensational finds in the Cleveland pool, though some good producers have been found. The Scioto Oil Company had 100 barrels daily production in one of its wells which was drilled in the river bed in sec. 5. In sec. 18 the No. 3 Diem is a wet gas well. This well made 25,000,000 cubic feet of gas and a drip of 30 gallons of gasoline per day. There are two small oil wells in this same section. In sec. 17 the Franchot Oil Company has two wells—one a 40 barrel, and the other a 30 barrel well. The Minnetonka Oil Company is exploring in this same section. They struck gas at 590 feet in a well in the SW. cor. of the SE. ¼ of sec. 17. They shut in this gas and are using it as fuel in drilling a deep test within a few feet of the gas well. Schoenfelt has a 250 barrel well in the SW. ¼ of sec. 25. In sec. 28 Brady Brothers had a small gas well—reputed as producing 2,500,000 cubic feet. The Oklahoma Oil Company had a 50 barrel well in sec. 32. The Piqua Oil Company had a 50 barrel well in sec. 35. In the NW. ¼ of the NW. ¼ of sec. 36 the State Tads Oil Company have been exploring. Out of six holes put down three were productive—the average production being about 150 barrels. The three dry holes were found near and to the southeast of the productive holes.

The New England Oil Company is reported as having 50 barrels of oil at a depth of 3,196 feet in their well in sec. 4, T. 23 N., R. 5 W. The Fortuna Oil Company drilled a well on the apex of the Otoe anticline in the northwest corner of sec. 4, T. 22 N., R. 3 E. Reports show that they had 35,000,000 cubic feet of gas in this well.

There has been considerable drilling in T. 21 N., R. 7 E. The drilling in this township has been disappointing, though some good small production has been found. The best well we have any record of here was brought in by the Republic Oil & Pipe Line Company in sec. 21 reported as producing 150 barrels daily. Carter Brothers have found one small producer in sec. 35. Frank Brown is reported as finishing a well in sec. 25 which produces 12 barrels of oil.

The Carter Oil Company has put down two holes in T. 20 N., R. 5 E.—one in sec. 11 and the other in sec. 23. They were both dry holes, though the one in sec. 11 is reported as having a good showing of oil at a depth of 1,900 feet.

In T. 20 N., R. 6 E. Cohen and Appelmen have a good gas well in sec. 4. This well is located on a fault.

There has been considerable drilling in T. 20 N., R. 7 E. The most encouraging find has been that of the Republic Oil & Pipe Line Company in the SE. cor. of the SW. ¼ of sec. 21. This well's initial production was 200 barrels. The Prairie Oil & Gas Company are now drilling two offset wells to this well. John Markham, Jr., is reputed as having 8,000,000 cubic feet of gas in a well in sec. 26. The Prairie Oil & Gas Company have a small well—25 barrels—in sec. 30. The

Selby Oil & Gas Company have met with encouraging results in sec. 1. They have completed two wells—one is producing about 5,000,000 cubic feet of gas at a depth of 2,400 feet, the other produced some gas and about 20 barrels of oil per day.

In sec. 34, T. 20 N., R. 8 E., Chas. Page has a small gas well. The production was reported as 2,000,000 cubic feet of gas at a depth of 1,400 feet.

SUMMARY.

Pawnee County is, of course, in proved oil and gas territory. On account of the decline in the Cleveland pool and the failure so far to bring in any large new pools the production is gradually falling off. The vigorous drilling campaign now being carried on may find enough production to bring it back to normal.

PAYNE COUNTY.

LOCATION.

Payne County is located near the center of the north half of the State. It extends from T. 17 N. to T. 20 N. inclusive, and from R. 6 E. to R. 1 W. inclusive. It includes 16 whole townships and parts of 7 others. The total area is approximately 716 square miles.

TOPOGRAPHY.

Payne County lies almost entirely within the Sandstone Hills region, with the exception of the extreme western part, which is in the Redbeds Plains. The county as a whole is a dissected, level table land, the streams having in some cases eroded deep, canyon-like valleys.

Several limestone ledges in the eastern part of the county form escarpments. Twin Mounds, 12 miles east of Ingalls, is a special topographic feature. The western part of the county is generally very rough.

The surface range in elevation, from available data, is from about 800 feet to about 1,140 feet, the lowest being in the Cimarron Valley in the eastern part of the county, and the highest about 2 miles southeast of Orlando.

Payne County is drained by Cimarron River and its tributaries. Stillwater Creek, the most important tributary, enters the county near Orlando and flows in a southeasterly direction, joining Cimarron River west of Ripley.

GEOLOGY.

The greater part of the county lies in the Permian Redbeds area. The Neva limestone, which outcrops in the eastern part of the county, is the approximate dividing line between the Pennsylvanian and Permian. The outcrop of this formation enters Payne County about 4 miles west of Quay, and in general continues in a southwest direction to Ripley, then southeast to Lincoln County line. The formations to the east of and including the Neva limestone are Pennsylvanian. Several ledges of limestone occur in this area, one of which is a prominent ledge which outcrops on Twin Mounds, 12 miles east of Ingalls, and is also exposed between Ripley and Cushing. There is a good exposure of the Neva limestone about a mile southeast of Ingalls on Council Creek, where it forms a distinct escarpment. The formations to the west of the Neva are shales and sandstones of the Permian Redbeds. The sandstones are massive, cross-bedded, and very irregular in thickness and extent. The shales are mostly soft and red clays. Where a shale and sandstone are exposed the latter usually forms an escarpment above the shale which has been weathered or eroded away.

STRUCTURE.

GENERAL STATEMENT.

In the area to the east of the Neva limestone outcrop the folds can be worked out definitely, but in the area to the west, the massive sandstones do not offer good horizons that can be followed over large areas. Consequently the folds in the latter area are difficult to determine and then may be doutbful in many cases.

The structure of the several areas, where determined, is taken up under separate headings.

CUSHING ANTICLINE.*

LOCATION AND EXTENT.

An anticline discovered by geologists of the Fortuna Oil Company is located in the SE. 1/4 of T. 18 N., R. 5 E., east of Cushing. The axis of the anticline extends from the SW. cor. of sec. 25 in a due north direction for 2 miles. It has been estimated that there is an east dip of about 70 feet in the S. 1/2 of sec. 24. Another anticline about a mile to the west of the one mentioned above, and separated from it by a syncline, extends from the NW. 1/4 of sec. 35 to the NE. cor. of sec. 26, where an east dip of 40 feet has been estimated.

DEVELOPMENT.

After the anticline had been located the Fortuna Oil Company drilled several wells at favorable locations in secs. 23 and 24, T. 18 N., R. 5 E., two of which were good gas wells, indicating that the region was worthy of further testing. The Oklahoma Natural Gas Company have drilled several gas wells in this area. One obtained about 10,000,000 cubic feet of gas at a depth of 2,800 feet in sec. 24, T. 18 N., R. 5 E., and another about 20,000,000 cubic feet of gas at 1,700 feet on the Mazarine farm in sec. 25, T. 18 N., R. 5 E. The Home Gas Company test in sec. 23, T. 18 N., R. 5 E. was abandoned at 3,000 feet. It was reported that the same company obtained a 50 barrel well in sec. 26, T. 18 N., R. 5 E., at a depth of 1,700 feet. Lusher Brothers have drilled several wells in this locality, one of which, located in sec. 23, T. 18 N., R. 5 E., obtained about 15,000,000 cubic feet of gas at a

*Not including Cushing field in Creek County.

depth of 2,950 feet. Other locations have been made and it seems that the area will receive a thorough testing.

SANDS.

Several productive sands have been encountered in the development of this area up to Dec., 1916. The 1,700-foot shallow sand is productive of oil and gas in a few wells. It is probably the Layton or near the horizon of that sand. The 3,000-foot sand, probably the equivalent of the Bartlesville, is a productive gas sand. The sands and associated formations are shown by the following logs:

Thompson Well No. 1, NE. cor. S. ½ SE. ¼ sec. 23, T. 18 N., R. 5 E, Fortuna Oil Co.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	15	15	Sand	10	1,430
Sand	10	25	Lime	11	1,441
Red rock	45	70	Sand	19	1,460
Slate	5	75	Slate	67	1,527
Red rock	35	110	Lime	3	1,530
Sand	40	150	Sand	25	1,555
Slate	10	160	Slate	65	1,620
Red rock	50	210	Lime	6	1,626
Slate	20	230	Slate	59	1,685
Red rock	50	280	Sand	75	1,760
Lime	7	287	Lime	20	1,780
Red rock	58	345	Slate	70	1,850
Sand	111	456	Lime	15	1,865
Slate	34	490	Slate	65	1,930
Lime	15	505	Lime	10	1,940
Slate	30	535	Slate	40	1,980
Sand	10	545	Lime	5	1,985
Slate	15	560	Slate	85	2,070
Sand	25	585	Lime	10	2,080
Slate	17	602	Slate	62	2,142
Sand	15	617	Sand (1 M. gas)	36	2,178
Slate	63	680	Slate	23	2,201
Sand	35	715	Lime	5	2,206
Slate	23	738	Slate	25	2,231
Sand	10	748	Lime	4	2,235
Slate	52	800	Slate	3	2,238
Sand	40	840	Sand (¼ M. gas)	5	2,343
Slate	50	890	Slate	102	2,445
Red rock	105	995	Lime	10	2,455
Sand	45	1,040	Slate	70	2,525
Red rock	20	1,060	Lime	15	2,540
Sand	10	1,070	Slate	55	2,595
Red rock	30	1,100	Lime	45	2,640
Sand	25	1,125	Slate	90	2,730
Red rock	10	1,135	Sandy shale	105	2,835
Slate	55	1,190	Lime	30	2,865
Sand	20	1,210	Slate	20	2,885
Slate	5	1,215	Lime	37	2,922
Sand	10	1,225	Slate	7	2,929
Slate	20	1,245	Lime	3	2,932
Lime	10	1,255	Slate	12	2,944
Sand	30	1,285	Lime (1 M. gas)	3	2,947
Slate	135	1,420	Sand (17 M. gas)	9	2,956

Peters Well No. 1, SW. cor. N. ½, SW. ¼ sec. 24, T. 18 N., R. 5 E.
Fortuna Oil Co.

Character of rock.	Thick-ness.	Depth.	Character of rock.	Thick-ness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Mud	20	20	Red rock	35	1,030
Lime	5	25	Sand	15	1,045
Red rock	25	50	Blue slate	15	1,060
Sand	10	60	Sand	10	1,070
Blue slate	20	80	Blue slate	25	1,095
Red rock	40	120	Sand	25	1,120
Sand	10	130	Blue slate	10	1,130
Red rock	30	160	Red rock	70	1,200
Sand	15	175	Blue slate	30	1,230
Blue slate	25	200	Sand	20	1,250
Red rock	25	225	Blue slate	45	1,295
Blue slate	25	250	Lime	45	1,340
Sand	10	260	Blue slate	40	1,380
Red rock	30	290	Lime	20	1,400
Sand	10	300	Red rock	10	1,410
Red rock	70	370	Lime	5	1,415
Sand	10	380	Blue slate	25	1,440
Brown shale	20	400	Sand	70	1,510
Sand	10	410	Black slate	250	1,760
Shale	10	420	Sand	58	1,818
Sand	20	440	Slate	10	1,828
Lime	5	445	Dark slate	6	1,834
Red rock	25	470	Dry sand	96	1,930
Sand	10	480	Blue shale	255	2,185
Red rock	20	500	Sand, water	5	2,190
Blue slate	40	540	Sand	28	2,218
Red rock	60	600	Shale, blue and black	255	2,473
Sand	15	615	Lime	1	2,474
Blue slate	65	680	Sand, dry	36	2,510
White slate	10	690	Shale	1	2,511
Sand	50	740	Sand, dry	19	2,530
White slate	25	765	Shale, blue to black	375	2,905
Sand	20	785	Black shale	10	2,915
Blue slate	45	830	Lime	12	2,927
Sand	10	840	Shale	8	2,935
Blue slate	30	870	Lime	40	2,975
Red rock	10	880	Black shale	10	2,985
Sand	20	900	Lime	4	2,989
Red rock	50	950	Shale	19	3,008
Blue slate	10	960	Hard sand cap rock	2	3,010
Red rock	30	990	Sand, very soft (gas)*	20	3,030
Lime	5	995			

*Gas struck May 26, 1914. Production 16,500,000. Pressure 1,180 pounds.

RIPLEY ANTICLINE.

LOCATION AND EXTENT.

The Ripley anticline is located 3 miles west of Ripley in Payne County. The apex of the anticline is in the southeast corner of sec. 23, T. 18 N., R. 4 E. From this point the strata dip sharply northwestward, westward, and southwestward. The northeast extension of the anticline cannot be determined because the formations have been eroded by

Cimarron River and are now concealed beneath the flood plain. There are good reasons, however, for believing that a moderate northeast dip prevails on this anticline. The structure can easily be traced southwestward through secs. 26, 27, and 28.

DEVELOPMENT.

A test well was drilled by the Charleston Oil Company in 1914 in sec. 23, T. 18 N., R. 4 E. A production of 75 barrels was found at 1,869 feet. An attempt was made to drill to the Bartlesville sand. In so doing a strong flow of water was encountered and the oil sand was lost. The well was shut in for a gas well, the initial volume of which was about 5,000,000 cubic feet of gas per day, while the pressure was reported as 1,370 pounds. The New England Oil & Gas Company drilled a well in sec. 25, T. 18 N., R. 4 E., and it was reported to have had an initial production of 75 barrels. In a second well drilled by the same company in sec. 23 of the same township and range a gas sand was encountered at 1,880 feet with a production of about 3,000,000 cubic feet. The Fortuna Oil Company drilled a well on the Ross farm in sec. 25, and a production of about 40 barrels was reported. Trees, Bellas, and Hughes were reported to have abandoned their test in sec. 23, T. 18 N., R. 5 E., at a depth of about 3,600 feet. The Roxana Petroleum Company is drilling a test on the Mains farm in sec. 34, T. 19 N., R. 4 E. Other locations have been made and producing wells brought in other than these mentioned, but there are no available data concerning them. At the present time there seems to be considerable activity in this area, but as yet the production is very small.

SANDS.

The shallowest producing sand is that encountered at about 1,860 feet in several wells. The thickness averages about 15 feet. A water sand found at about 2,072 feet is probably equivalent to the Layton sand of the Cushing field. The main productive sand is that found at a depth of 3,400 feet. From available data this sand has been correlated with the Bartlesville sand. The different sands and associated formations encountered in drilling in this area are shown by the following log:

W. C. Broyles Well No. 1, SE. ¼ sec. 23, T. 18 N., R. 4 E., Payne County.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil and sand	60	60	Blue mud	50	870
Water sand	18	78	Hard lime shell	1	871
Hard lime	4	82	Blue mud	84	955
Gumbo	18	100	Hard lime	8	963
Red clay or mud	401	501	Blue mud	117	1,080
Blue clay or mud	170	671	Hard lime	10	1,090
Sandy slate	39	710	Gumbo	23	1,113
Hard lime	4	714	Water sand	57	1,170
Blue mud	46	760	Gumbo	30	1,200
Hard lime	10	770	Red mud	30	1,230
Blue mud	30	800	Shale	10	1,240
Red rock	20	820	Gumbo	40	1,280

W. C. Broyles Well No. 1, SE. ¼ sec. 23, T. 18 N., R. 4 E., Payne County.—Continued.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Red bed	5	1,285	Sand	17	2,130
Gumbo and blue slate	240	1,525	Shale	8	2,138
Sand	10	1,535	Sand	12	2,150
Blue slate	20	1,555	Lime (hard)	3	2,153
Hard lime shell	5	1,560	Black slate	127	2,280
Slate	10	1,570	Gas sand	20	2,300
Lime shell	3	1,573	Shale and slate	500	2,800
Sand	12	1,585	Sand	40	2,840
Slate	125	1,710	Sandy shale	100	2,940
Sand	25	1,735	Lime	36	2,975
Slate and shells	115	1,850	Slate	5	2,980
Shell	6	1,856	Lime	30	3,010
Oil sand	4	1,860	Slate	20	3,030
Hard sand	4	1,864	Shale	100	3,130
Slate	13	1,877	Sand	23	3,153
Sand	30	1,907	Slate	104	3,257
Sand	43	1,950	Sand	17	3,274
Shell	10	1,960	Sandy shale	181	3,455
Sand	130	2,090	Sand	10	3,465
Shale	23	2,113	Slate	96	3.561

YALE ANTICLINE.

LOCATION AND EXTENT.

A good anticline has been found between Yale and Quay in northern Payne County. According to D. W. Ohern the anticline extends from the northeast corner of sec. 14, T. 19 N., R. 5 E. somewhat north of east for about a mile and a half then northeastward to the southwest corner of sec. 5, T. 19 N., R. 6 E., where it turns due north. Along the south line of sec. 5, an east dip of 55 feet is obtained. as shown by a prominent ledge of sandstone. The anticline appears to branch near the center of sec. 7, T. 19 N., R. 6 E., and the south branch extends southeastward through sec. 8 for a distance of 1½ miles or more.

DEVELOPMENT.

In 1914 a test well was drilled by the Alice-Katherine Oil Company on the McCroskey farm in the SE. ¼ NE. ¼ sec. 7, T. 19 N., R. 6 E. The productive sand was encountered at a depth of 3,145 feet and a daily production of 80 barrels was obtained by natural flow. A light shot increased the daily production to about 250 barrels. Seven months after the well had been completed it was flowing about 60 barrels per day, and at the present time, June, 1916, yields about 40 barrels per day. The same parties drilled a well on the Henning farm in sec. 5, T. 19 N., R. 6 E. The well was abandoned at a depth of 3,282 feet. Another dry hole was drilled to a depth of 3,385 feet in the same section by the Oklahoma & Texas Oil & Gas Company. The Corsicana Petroleum Company completed a well in sec. 5, T. 19 N., R. 6 E., which after being shot produced about 40 barrels per day. Most of the late development has been north and northwest of Yale in secs. 6 and 7, T. 19 N., R. 6 E., and in secs. 12, 13, and 14, T. 19 N., R. 5 E. In May, 1916, several good producers were completed. The Magnolia Petroleum Company obtained about a 600 barrel well on initial flow in sec. 6, T. 19 N., R. 6 E., at a depth of 3,090 feet.

SANDS.

The first productive sand lies at a depth of about 2,720 feet, and produces gas only. It is productive in several wells in secs. 12 and 13, T. 19 N., R. 5 E., and sec. 18, T. 19 N., R. 6 E.

The second sand in descending order lies at an average depth of 2,875 feet. Yields as high as 20,000,000 cubic feet of gas have been obtained from this sand in the southern part of secs. 12, and 13, T. 19 N., R. 5 E. The wells in the northeastern part of the field have not obtained any oil or gas from this sand. Where gas is found it is accompanied by small quantities of oil. The average pressure is 1,100 pounds to the square inch.

The third productive sand lies at a depth of approximately 3,050 feet. This sand is productive of oil and small quantities of gas in sec. 7, T. 19 N., R. 6 E., where most of the oil production is being obtained.

The deepest productive sand is encountered at an average depth of 3,130 feet and is believed to be the Bartlesville sand. This is the most productive sand of the field. Yields as high as 200 to 600 barrels initial daily production have been obtained in this sand in secs. 6 and 7, T. 19 N., R. 6 E.

The sands and associated formations are shown by the following log:

McCroskey No. 1, SE. cor. NW. ¼ sec. 7, T. 19 N., R. 6 E., Alice-Kathryn Oil Co.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface	20	20	Sand and shells	55	435
Lime shell	3	23	Blue slate	60	495
Red rock	17	40	Red rock	10	505
Lime shell	6	46	Sand	20	525
Shale	24	70	Blue slate	110	635
Sand—some water	15	85	Red rock	10	645
Red rock	5	90	Sand	35	680
Sand	10	100	Blue slate	5	685
Shale	2	102	Red rock	15	700
Gritty slate	38	140	Sand	12	712
Slate	5	145	Blue slate	123	835
Shells, water	5	150	Sand	30	865
Red rock	5	155	Sand shale	25	890
Shale, water	5	160	Red rock	5	895
Slate	20	180	Shale	15	910
Lime shells	7	187	Sand	50	960
Gritty shale	58	245	Lime and slate	77	1,037
Lime	5	250	Sand broken	9	1,046
Red rock	35	285	Blue slate	12	1,058
Blue slate	15	300	Red rock	43	1,101
Red rock	20	320	Lime shell	1	1,102
Slate and shells	60	380	Red rock	2	1,104

McCroskey No. 1, SE. cor. NW. ¼ sec. 7, T. 19 N., R. 6 E., Alice Kathryn Oil Co.—Continued.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Red rock	21	1,125	Sand (hole full of water)	9	1,823
Sand, water	26	1,151	Slate	10	1,033
Red rock	37	1,188	Brown shale	27	1,860
Lime shells	10	1,198	Sand	5	1,865
Blue slate	62	1,260	Brown shale	28	1,893
Sand	48	1,308	White sand	12	1,905
Slate	43	1,351	Shale	245	2,150
Red rock	14	1,365	White sand—water	27	2,177
Sand, water	28	1,393	Slate	221	2,398
Blue slate	5	1,398	Sand (some oil)	37	2,435
Lime shell—very hard	7	1,405	Black slate	130	2,565
Blue slate	5	1,410	Gritty shale	35	2,600
Sand	15	1,425	Black slate	118	2,718
Lime shell	6	1,431	Lime	57	2,775
Blue slate	20	1,451	Slate	20	2,795
Lime shell	4	1,455	Lime	40	2,835
Blue slate	5	1,460	Black slate	5	2,840
Sand	10	1,470	Lime	14	2,854
Blue slate	3	1,473	Sand and water	46	2,900
Lime shell, very hard	57	1,530	Slate	127	3,027
Blue shale	80	1,610	Sand	15	3,042
Lime shell	2	1,612	Sandy shale	18	3,060
Sandy slate	22	1,634	Lime	5	3,065
Lime shell	4	1,638	Blue slate	20	3,085
Sand	3	1,641	Shale	42	3,127
Underreamed 23 feet	23	1,664	Sand, dry	20	3,147
Black slate	61	1,725	Sand, oil	22	3,169
Sand, water	81	1,806	Black shale	115	3,284
Black slate	8	1,814			

INGALLS ANTICLINE OR DOME.

LOCATION AND EXTENT.

This anticline or dome is so named from Ingalls post office which is located about 7 miles northeast of Ripley and 9 miles southeast of Stillwater. The center of the dome is near the middle of the north side of sec. 34, T. 18 N., R. 5 E. Along the creek which runs east through secs. 26 and 27, the Neva limestone may be seen dipping east for a distance of nearly a mile. The outcrop turns them almost due south and gives excellent opportunity for determining structure. A careful survey of the region has been made by two or three oil companies and it has been determined that the amount of east dip is between 30 and 40 feet. From the north side of sec. 34 northward the dip is rather sharp. The dip of the south side of the dome is very gentle and is believed to continue for a distance of at least 2 miles or more. Toward the west the dip is a little more than normal.

DEVELOPMENT.

The Roxana Petroleum Company has drilled a well in sec. 34, T. 19 N., R. 4 E., near the apex of this fold. The well was drilled to a depth of 1,825 feet and the gas production amounted to about

15,000,000 cubic feet. The same company is preparing to drill in the center of SW. 1/4 sec. 33, and in the SE. 1/4 sec. 27, T. 19 N., R. 4 E. The Fortuna Oil Company is drilling a test in the SE. 1/4 sec. 27, T. 19 N., R. 4 E. it is evident that this area will soon receive a thorough testing.

DEVELOPMENT.

GENERAL STATEMENT.

Payne County is receiving considerable development at the present time. The proven areas are near Yale, Ripley, Cushing, and Ingalls. The development of each has been taken up under the heading of structure of the respective areas.

STILLWATER AREA.

There has been some development in the vicinity of Stillwater. Armstrong and others are drilling a well on the Hall farm in the NW. 1/4 sec. 10, T. 19 N., R. 3 E. A showing of gas was reported at 1,023 feet. A well was drilled some years ago on the Barnes farm in sec. 23, T. 19 N., R. 3 E. A trace of oil was reported at 989 feet. The well was drilled only 1,200 feet and would not be considered a test. The log of this well is as follows:

Log of well, John Barnes No. 1, NE. 1/4, SE. 1/4 sec. 23, T. 19 N., R. 2 E., SE. part of city.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface clay	28	28	Sandstone	15	555
Quick sand	10	38	Clay	20	575
Red clay	25	63	Sandstone	10	585
Sandstone	25	88	Black shale	60	645
Red clay	20	108	Limestone	5	650
Sandstone	10	118	Black shale and slate	24	674
Red clay	12	130	Sandstone	10	684
Sandstone	10	140	Black shale and slate	30	715
Gray slate and lime	15	155	Sandstone	8	723
Clay	10	165	Shale and slate (caving)	90	813
Sandstone	15	180	Sandstone	5	818
Clay	25	205	Black slate	13	831
Sandstone	15	220	Limestone	8	839
Clay	25	245	Slate	10	849
Sandstone	17	262	Sandstone	5	854
Clay	26	288	Black slate	25	879
Sandstone	5	293	White sand (heavy water)	40	919
Clay	22	315	Gray shale	40	959
Sandstone	25	340	Sandstone (heavy water)	20	979
Clay	40	380	Oil sand at		970
Gray slate	10	390	Shale	10	989
Clay	32	422	Dry sand, trace of oil	40	1,029
Sandstone	10	432	Shale	171	1,200
Clay	28	460			
Sandstone	15	475			
Blue slate	35	510			
Clay, chocolate	30	540			

If continuous, the productive sand at 1,825 feet in the Ingalls field would probably be encountered about 180 feet deeper in the immediate vicinity of Stillwater. Two wells have been drilled to a depth of 2,200 feet in the NE. 1/4 sec. 26, T. 18 N., R. 5 E., on the Moorehead farm southwest of Ripley. Both were abandoned. A well was drilled in 1915 by Stillwater parties in the NE. 1/4 sec. 11, T. 19 N., R. 1 W., to a depth of 2,260 feet and abandoned. The log of this well is given as follows:

Log of Howe Well No. 1, located on the NE. 1/4, sec. 11, T. 19 N., R. 1 W., Payne County, Oklahoma, known as the Von Tacky well.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Conductor	36	36	Blue slate	35	1,170
Surface clay	24	60	Red rock	30	1,200
Quick sand	20	80	Lime	15	1,215
Red rock	20	100	Red rock	35	1,250
Shally formation	35	135	Lime	10	1,260
Red rock	65	200	Blue slate	10	1,270
Sandy formation	10	210	Lime	10	1,280
Brown shale	80	290	Blue slate	20	1,300
Red rock	70	360	Lime	15	1,315
Lime shell	5	365	Blue slate	15	1,330
Blue slate	35	400	Lime	15	1,345
Red rock	50	450	Red rock	30	1,375
Sandy formation	10	460	Lime	5	1,380
Brown shale	40	500	Blue slate	40	1,420
Red rock formation	100	600	Red rock	10	1,430
Lime shell	10	610	Lime	5	1,435
Red rock	55	665	Red rock	10	1,445
Water sand	10	675	Lime	5	1,450
Lime	5	680	Sand	5	1,455
Red rock	20	700	Red rock	3	1,458
Blue mud	45	745	Sand	2	1,460
Water sand	5	750	Lime	5	1,465
Blue slate	30	780	Blue slate	55	1,520
Water sand	20	800	Lime	10	1,530
Red rock	8	808	Blue slate	35	1,565
Water sand	32	840	Red rock	5	1,570
Blue slate	10	850	Blue slate	10	1,580
Red rock	10	860	Sandy formation	10	1,590
Water sand	40	900	Lime	10	1,600
Blue slate	10	910	Red rock	5	1,605
Red rock	40	950	Lime	15	1,620
Water sand	10	960	Black slate formation	15	1,635
Brown shale	30	990	Lime	5	1,640
Red rock	25	1,015	Black slate	10	1,650
Water sand	5	1,020	Lime	2	1,652
Lime	5	1,025	Black slate	6	1,658
Blue shale	25	1,050	Lime	2	1,660
Lime shell	5	1,055	Black slate	15	1,675
Brown shale	5	1,060	Red rock	5	1,680
Water sand	5	1,065	Black slate	10	1,690
Blue slate	30	1,095	Lime	5	1,695
Red rock	30	1,125	Black shale	15	1,710
Lime	10	1,135	Lime	5	1,715

Log of Howe Well No. 1, *located on the NE.* ¼, *sec.* 11, *T.* 19 *N.*, *R.* 1 *W.*, *Payne County, Oklahoma, known as the Von Tacky well.*—Continued.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Blue slate	10	1,725	Blue slate	5	1,930
Red rock	35	1,760	Red lime	2	1,932
Blue slate	15	1,775	Blue slate	3	1,935
Lime	5	1,780	Lime	11	1,946
Sand	10	1,790	Black slate	4	1,950
Lime	5	1,795	Lime	30	1,980
Blue shale	5	1,800	Blue slate	5	1,985
Lime	5	1,805	Red rock	20	2,005
Blue slate	5	1,810	Lime	10	2,015
Black slate	5	1,815	Red rock	5	2,020
Lime	5	1,820	Blue slate	17	2,037
Blue slate	5	1,825	Sand and water (gas)	18	2,055
Lime	3	1,828	Lime	5	2,060
Blue slate	12	1,840	Slate	60	2,120
Red rock	5	1,845	Lime	10	2,130
Sand	10	1,855	Slate	5	2,135
Lime (gas)	5	1,860	Sand	13	2,148
Blue slate	40	1,900	Sandy slate	27	2,175
Red rock	5	1,905	Lime	25	2,200
Blue slate	5	1,910	Slate	20	2,220
Red rock	5	1,915	Sand	20	2,240
Blue slate	5	1,920	Slate	20	2,260
Lime	5	1,925	Lime		

SUMMARY.

The entire eastern half and possibly all of the county may be considered as likely territory for oil and gas. The eastern part is in proven territory, the production of which, however, is light. There is much activity in "wild cat" adventures in the central and western parts of the county. It is not at all improbable that some new fields will be opened up in this area. So far no deep tests have been made in the western part of the county. A test well should not be abandoned at a depth less than 3,500 feet in this area.

PITTSBURG COUNTY.

LOCATION.

Pittsburg County is located in central-southeastern Oklahoma. The county is very irregular in shape. The Canadian River forms the northern boundary. The county includes all of Tps. 3 N. to 7 N. inclusive, Rs. 12 and 13 E., except about 7 square miles out of the northwest corner of T. 7 N., R. 12 E.; also 3 ½ square miles out of the SE. cor. T. 8 N., R. 12 E.; the S. ½ T. 8 N., R. 13 E.; Tps. 2 N. to 8 N. inclusive, Rs. 14 to 16 E. inclusive, except about one tier of section off the north end of T. 8 N., Rs. 14 and 15 E. in a somewhat irregular outline along Canadian River; the W. ½ of

T. 2 N. to T. 6 N. inclusive, R. 17 E.; all of Tps. 7 to 9 N., except the northwest part of T. 9 N., R. 17 E.; all of T. 7 N., and the S. 1/2 of T. 8 N., R. 18 E. To this may be added 2 1/2 square miles out of the SE. cor. T. 9 N., R. 15 E., and 2 square miles out of the south side of T. 10 N., R. 17 E. The county comprises 31 entire townships and parts of 15 others, making a total area of approximately 1,375 square miles.

TOPOGRAPHY.

Pisttsburg County lies wholly within the Sandstone Hills region, with the exception of the southeast part which is included in the Ouachita Mountains region. A large part of the surface is hilly or mountainous. Some of the most mountainous areas range from 1,500 feet to 2,000 feet above sea level, the general level of the county being about 750 feet.

The entire county is included in areas which have been mapped topographically by the U. S. Geol. Survey. The extreme northwestern part is in the Wewoka Quadrangle; the northeastern one-third, with the exception of that in the Wewoka Quadrangle, is included in the Canadian Quadrangle; a strip off of the west side of the county is in the Coalgate Quadrangle; and the greater part of the county, including an area of 21 townships, is in the McAlester Quadrangle. A study of these topographical sheets will give a good idea of the character of the topography throughout the entire county.

The principal topographical feature occur in the area south of the Choctaw Fault in the Quachita Mountains region. These are Limestone Hills, Pine Mountains, and Jackfork Mountains. North of the Choctaw Fault the principal topographical features are the Kiowa Hills, near Kiowa in the southwestern part of the county; the Brewerville Hills, southeast of Savanna; Bell Star Mountain, northeast of Hartshorne; and many other peaks and ridges along the structural features within the Sandstone Hills region.

Canadian River forms the northern boundary and drains all the county except the southern part, which is drained by streams which become tributary to Boggy Creek and Kiamichi River, which are tributary to Red River. Gaines Creek and its branches constitute the main tributary flowing into the Canadian.

There is an abundant timber growth along the streams and along the upland slopes. The uplands are in part prairie and in part timber.

Shales and sandstones form the principal surface rocks, and the chief topographical features are produced by the upturned edges of the sandstone ledges. Some limestones occur in the mountainous regions directly south of the Choctaw Fault line.

GEOLOGY.

GENERAL STATEMENT.

The rocks exposed in the county consist of sandstones and shales, with beds of coal of the lower part of the Pennsylvanian system, and the area of older rocks in the Quachita Mountain uplift, which also consist chiefly of sandstones and shales with some limestones.

The Pennsylvanian formations exposed north of the Choctaw fault are as follows, named from the lowest upwards: Atoka formation; Hartshorne sandstone; McAlester shale; Savanna formation; Boggy shale; Thurman sandstone; Stuart shale; and Senora formation.

In the Choctaw Fault zone and to the southward, the Stringtown shale, Talihina chert, Standley shale, Jackfork sandstone, Caney shale, Wapanucka limestone, and the Atoka formation, are found.

The following descriptions of the formations above-named are summarized from more complete descriptions which have been given under preceding counties where the same geological formations occur.

ATOKA FORMATION.

The Atoka formation outcrops over a narrow area in the Choctaw fault zone and along the crest of some of the anticlinal folds of the eastern part of the county. The formation has a thickness of from 6,000 to 7,000 feet, but along most of the outcrop in this region only the upper part of the formation is exposed; the lower portion being cut out by the Choctaw fault to the south. The formation consists principally of shale with four sandstone groups, each about 100 feet thick and at intervals of about 1,000 feet apart. The sandstones are brown or light gray in color, and are usually thin-bedded and platy, with the beds separated by shale partings. The shales are rarely exposed, but where they are shown they are brownish clay shales with occasional sandstone concretions. The sandstone groups usually give rise to pronounced ranges of hills, while the shale outcrops form flat plains between the sandstone ridges. The Atoka formation contains the gas-producing sands in the Mansfield (Ft. Smith) gas field in Arkansas.

HARTSHORNE SANDSTONE.

The Hartshorne sandstone occurs in a narrow, sinuous outcrop in the vicinity of the Choctaw fault, extending from southwest of Pittsburg (Edwards) to the east of Hartshorne, where it crosses the county line, then turns and again enters the county about four miles northeast of Hartshorne for a distance of 10 miles, to near the town of Carbon. Here it turns abruptly and runs east into Latimer County and continues its course in an eastward direction to the State line. This formation is made up of sandstone, shaly sandstone, shale, and coal. The thickness is estimated at from 100 to 200 feet. The lower part of the formation is thin-bedded and shaly and grades into the shales of the underlying Atoka formation. The beds in the upper part of the formation are usually more massive, but in some places the sandstones of the whole formation are thin-bedded and shaly. In some localities there are three beds of sandstone separated by shales. The lower Hartshorne coal lies about 50 feet below the top of the formation, and the upper part of the Hartshorne coal lies at the base of the McAlester shale, immediately upon the Hartshorne sandstone. Usually there is an interval of from 40 to 50 feet between the two coal beds. However, in a few places, as in mine No. 19 near Wilburton in Latimer County, the two beds of coal are in contact with each other. The formation along the course of its outcrop makes a prominent ridge which serves as a marker in the location of the coal beds, and also in the working out of the geologic and structural conditions in the area. The gas-producing horizon in Poteau field is correlated with the Hartshorne sandstone.

McALESTER SHALE.

The McAlester shale covers an irregular area in the central-southern and central-eastern parts of the State. It lies directly above the Hartshorne sandstone and has a thickness estimated at from 2,000 to 2,500 feet. It consists principally of shale with some lenticular sandstone and coal beds, of which at least two are of workable thickness. The outcrop of some of the sandstones can be traced for several miles and the beds are of considerable thickness, but none of them can be mapped over sufficient area to permit the formation to be subdivided. The great mass of the formation is of soft clay shale, which shows blue-black color in fresh exposures. The shale areas constitute flat prairie land between the hills and ridges produced by the sandstone ledges. The flat lands are poorly drained and are characterized by big, hummocky mounds which are in great numbers. These mounds are usually less than 100 feet in diameter and stand on the average about 5 feet above the general level of the flats. The sandstones form low ridges. The two workable beds of coal lie about 600 or 700 feet below the top of the formation. They are separated by about 70 feet of shale. As stated above, the upper Hartshorne coal forms the lower limit of the formation.

SAVANNA FORMATION.

The Savanna formation occupies several irregular areas in the southwestern, central, and eastern parts of the county north of Choctaw fault. This formation consists of three sandstone groups separated by shales. The upper division is about 200 feet thick, while the other sandstones are thinner. In all three divisions the beds are more massive toward the top. The shale between the lower and middle sandstone is from 300 to 450 feet, and that between the middle and upper is from 450 to 530 feet thick. The shales are usually more soft than those of the McAlester and Atoka formations. The Savanna outcrops on the slopes of the principal mountains and hills of the area, and in fact, these marked elevations are due to the resistant character of this formation, combined with the structure. The total thickness of the formation varies from 1,000 to 1,500 feet, the thickness increasing from west to east.

BOGGY SHALE.

The boggy shale occupies large areas in the southwestern, central, and northeastern parts of the county. The formation consists of shale with thin beds of sandstone irregularly distributed through it. The total thickness is about 3,000 feet. The sandstones which occur are usually thin-bedded, brown in color, and fine-grained. The common occurrence of sandstone boulders and fragments over the surface and on the slopes where this formation outcrops would indicate that sandstones are more abundant than is evidenced by the actual sections which have been taken in this formation.

Note: The Atoka formation the Hartshorne sandstone and McAlester shale are correlated with the Winslow formation to the northward and the equivalents of these formations are discussed under the heading "Winslow formation" in the description of counties lying to the northeast of Pittsburg County. All of the Pennsylvanian rocks below the Boggy shale occuring in the Muskogee and Tahlequah quadrangle are grouped into the one formation as mentioned. The Winslow as described, however, is much thinner than the rocks to the south, which are taken as the equivalent. The thickness as indicated in the quadrangle above mentioned is only about 1,000 feet, while the combined maximum thickness of the Atoka, Hartshorne and Savanna is about 10,000 feet.

THURMAN SANDSTONE.

The Thurman sandstone occupies a large area in the central-northwestern part of the county. The formation takes its name from the village of Thurman located in the northern part of the county. The Thurman sandstone marks a change in sedimentation. Whereas the older deposits had been fine shale, they are now followed by deposits of coarse, white chert and quartz. Fifty feet of the total 80 to 250 feet is composed of this conglomerate. The sandstone of the upper part becomes thinner and finer in texture to the westward. Some beds of shale are included, and in the Coalgate quadrangle some beds of impure, fossiliferous limestones occur.

For a further description of this formation the reader is referred to "Coal County" and "Hughes County."

STUART SHALE.

The Stuart shale lies next above the Thurman sandstone and is from 100 to 275 feet thick. It consists of thin-bedded shaly sandstones and shales interstratified. The area of its outcrop occurs in the northwestern part of Pittsburg County and is a narrow strip.

SENORA FORMATION.

The Senora formation occupies the extreme northwestern part of the county except such parts as immediately border the Canadian River, where the surface material is composed of Recent and river sands. The thickness is estimated at 500 feet. The formation consists of sandstones and shales interstratified. The sandstones are frequently divided or completely replaced by shale members. Lithologically the shales are bluish clays and brownish sandy shales, while the sandstones are generally fine-grained and gray or reddish-brown in color.

FORMATION SOUTH OF CHOCTAW FAULT.

Along the Choctaw fault zone the Atoka formation, the Wapanucka limestone, and Caney shale occur. Farther to the south the surface rocks consist of the Stringtown shale, Talihina chert, Stanley shale, and Jackfork sandstone. The Jackfork sandstone is the principal mountain-making formation of the region. The Talihina chert also forms many conspicuous hills and ridges.

WAPANUCKA LIMESTONE.

The Wapanucka limestone, which is Pennsylvanian in age, or probably represents the transition series composed of late Mississippian and early Pennsylvanian rocks, is brought to the surface in the northern part of the Ouachita Mountain region by the faulting in the Choctaw fault zone. In this region the Caney shale is conformably overlaid by the Wapanucka limestone. This limestone consists of one or more beds of massive, white to light brown limestone, together with chert, sandstone, and shale. Near Bromide in Coal County a bed of exceptionally fine, massive oolite occurs. In Limestone Ridge the formation is composed of several members of fairly constant occurrence but variable thickness. Near the eastern exposures of the formation the strata are chiefly sandstone. Due to the resistant character of the strata and to the fact that the Wapanucka occurs between two shale formations the outcrops occur as narrow, steep-sided ridges. The formation has a variable thickness of from 100 to 800 feet, the average being about 300 feet.

The Wapanucka limestone as found in the Limestone Ridge area is described by Wallis* as follows

As in the Wapanucka area, the topographic features of this region were produced by the differential erosion of strata of unequal hardness. Here again, there occur narrow, level-crested ridges separated by shale valleys. The general direction of the ridges is east-west, becoming northeast-southwest in the western part of the area. The crests of the ridges lie in the peneplain of Tertiary age, and have a general elevation of 800-85-feet above sea level. The Wapanucka limestone outcrops in several of those ridges, constituting the entire ridge wherever present. If one were to stand on the northermost outcrop of the Wapanucka in the vicinity of Arch Post-Office (7 miles southwest of Hartshorne) he would see to the north the valley formed by the Caney and Atoka shales, the level-crested ridge formed by the Hartshorne sandstone, and still farther other level-crested ridges of later Pennsylvanian age lying in the Sandstone Hills region. Lying to the south, he would see several ridges of Wapnaucka limestone separated by valleys of Caney and Atoka shale and then Pine Mountain, a level-crested sandstone ridge of the Atoka formation rising to a height of 1,000 to 1,200 feet above sea level and forming the northern limit of the Ouachita Range proper. The topography of any one of the ridges composed of Wapnaucka limestone is that of a narrow, steep-sided ridge, rising from 50 to 150 feet above the valley floor. Due to the high dip towards the southeast (usually over 50°) the massive strata stand practically on edge with soft shales occurring above and below, i. e., on each side. Differential erosion has, therefore, produced a ridge with unusually precipitous

*Wallis, B. Franklin, geology and economic value of the Wapanucka limestone of Oklahoma; Okla. Geol. Survey Bull. 23, pp. 51-53, 1915.

CORRELATION TABLE.

System	Series	Generalized Section of North America	Sandstone Hills and Arbuckle Mountain Regions		Ouachita Mountain Region	
Carboniferous.	Pennsylvanian.	Monongahela formation			Undifferentiated in Ouachita Mountain Region.	
		Conemaugh formation.	Seminole conglomerate	50'		
			Holdenville shale	260'		
			Wewoka formation	700'		
			Wetumka shale	120'		
			Calvin sandstone	145-240'		
			Senora formation	140-485'		
			Stuart shale	90-280'		
			Thurman sandstone	80-260'		
		Allegheny formation	Boggy shale	2000' to 2600'		
			Savanna sandstone	1000'		
			Mc. Alester shale	1800' to 2000'		
		Pottsville	Hartshorn sandstone	150'		
			Atoka formation	3100'	Atoka formation	3100'
			Wapanucka limestone	100'	Wapanucka limestone	250-800'
	Mississippian	Chester group	Caney shale	1600'	Caney shale	1000'
		Meramec group			Jackfork sandstone	6000'
		Osage group			Standley shale	6000'
		Kinderhook				
Devonian.		Chemung	Woodford chert	650'	(Wanting)	
		Portage				
		Hamilton	(Wanting)			
		Onondago				
		Oriskany				
		Helderberg	Bois d'Arc limestone Haragan shale	0'-90' 0'-166'		
Silurian.		Cayugan	(Wanting)		Unnamed chert of Upper Silurian age	
		Lockport	Henryhouse shale	0'-223'		
		Clinton	(Wanting)			
		Albion	Chimneyhill limestone Sylvan shale	0'-53' 60'-300'		
		Richmond			?	
Ordovician.		Lorraine	Viola limestone	500' to 700'	Talihina chert	1200'
		Frankfort				
		Utica				
		Trenton				
		Black River	Simpson formation	1200' to 2000'	Stringtown shale	600'+
		Upper Stones River			?	
		Chazy				
		Beekmantown	Arbuckle limestone	4000' to 6000'		
Cambrian		Upper Cambrian				
		Middle Cambrian	Reagan sandstone	0'-500'		

Figure 13.

sides. Where the dip is more gentle, 30°-35°, the southeastern side is not quite so precipitous, but the edges of the massive strata, now being present in the northwestern slope instead of in the crest of the ridge, present a truly perpendicular face. It is thus seen that these ridges would, if unbroken, form practically impassable barriers. The drainage has, however, been imposed upon the strata and has cut water gaps through the ridges at frequent intervals, giving rise to easy routes of travel.

As previously noted, the repetition of outcrop of Wapanucka limestone in this area is due to the presence of folds that have been overturned toward the northwest and broken by strike, thrust faults. The Atoka formation which lies above the Wapanucka limestone and the Caney shale which lies below it, have been included in this folding. This outcrops, therefore, have been repeated also. These facts are clearly brought out in figure 16. 16 E. In this figure it is seen that the ridges are composed of Wapanucka limestone and that the intervening valleys are composed of shale referable to the Atoka and Caney formations. As the Caney and Atoka formations in the valleys are composed of shale with heavy coverings of residual soil, it was impossible to determine the exact positions of the major strike faults. Hence on the large map the fault lines have been drawn, roughly midway between the limestone ridges, or, in cases where intermediate ridges have terminated to the east or west, nearer the south ridge.

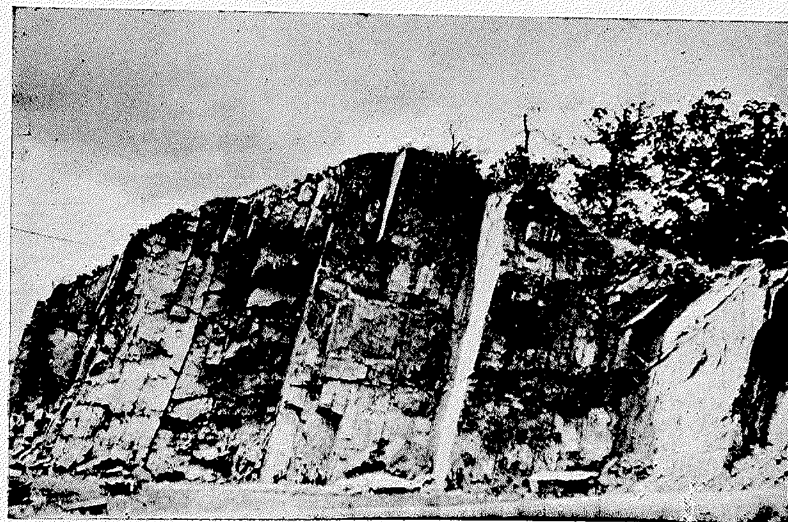
The Atoka may often be distinguished from the Caney, however, by the presence, in the former, of beds of chert and sandstone. These aids were made use of in the field and it is believed that the positions of the faults as shown on the map are approximately correct.

The thickness of the Caney and Atoka strata involved in the folding is not known, first because no determination of the dip could be obtained, and second, because of the difficulty with which the shales in the two formations were differentiated. In regions in which the full thickness of the formations are exposed, the Caney shale has a thickness of 1,500 feet, while that of the Atoka is given as 3,100 feet in the western part of its outcrop. No conclusions may be drawn from this data, however, as it is not known how much of each formation is involved in the folding.

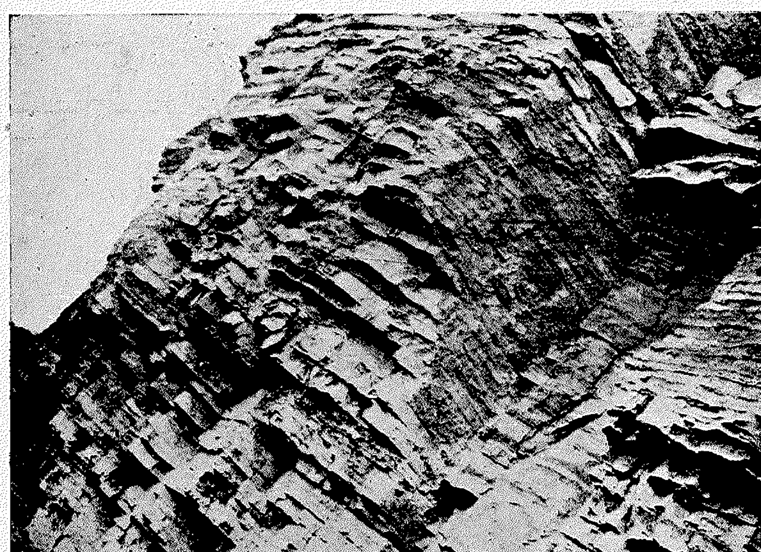
The problem of determining the upper and lower limits of the Wapanucka limestone in this area is not more difficult than in the type area at Wapanucka. The Caney shale below may be recognized by its characteristic blue-black color. The Atoka formation, above, is composed of shale with ferruginous sandstone.

On lithologic grounds, the Wapanucka formation in this area may be divided into eight well defined members. The thickness of these members varies from point to point but they are present either throughut the entire length of the outcrop or a considerable portion of it. A very large number of sections were made during the course of the survey. From the data thus obtained, a diagrammatic section (figure 14) has been drawn parallel to the strike of the rocks (along the ridge) in such a way as to show the persistency of the various members in the western half of the area and the thickness of the strata at any point. This diagram may serve, in a sense,

PLATE XXXVII.



A. VIEW IN QUARRY AT CHOCKIE, SHOWING WELL BEDDED, STEEPLY DIPPING STRATA OF THE WAPANUCKA LIMESTONE.



B. SHOWING STEEPLY DIPPING STRATA IN WAPANUCKA LIMESTONE AT LIMESTONE GAP, 8 MILES SOUTH OF KIOWA.

as a section of the original Wapanucka sedimentation, i. e., a section of the sedimentation before the region was elevated and folded. There may be some distortion in the diagram due to the fact that a datum plane had to be assumed. As the chert and limestone members at the top of the formation have a more constant thickness than lower members, it has been assumed that the top limestone, at least, was deposited on a nearly level surface and that the top of the formation formed a truly level plain.

STRUCTURE.

GENERAL STATEMENT.

There is a very close relation between the structure and topography in Pittsburg County. All of the larger hills or mountains are synclinal and many of the smaller features are also related to structure. Several folds of importance are found in this county. The general course of the folds is in a northeast-southwest direction. The synclines are broader than the anticlines. In most cases the folds are comparatively sharp, the dips ranging from 5 degrees to almost 90 degrees in some of the broken folds, as for instance, in the McAlester anticline north of McAlester. The trend of several of the folds may be determined by following the coal outcrops which occur along the sides of the anticlines, the main body of the coal occupying the synclines.

Since the work was undertaken with a view of determining the probabilities for oil and gas, more attention was paid to determining the axes of the anticlines than those of the synclines. One great difficulty in locating the axes of the anticlines with any great degree of accuracy is that the anticlinal areas are usually located in the valleys which are eroded in the McAlester shale and that in these valleys exposures are rather rare. So while the presence of an anticline is easily determined, the locating of the axis with exactness is often difficult or impossible. The locations given on the map are believed to be sufficiently accurate to be valuable as a guide for prospecting. It is urged, however, that before any locations for drilling be decided on that a thorough examination of the immediate vicinity of the proposed location be made, since a careful search is likely to show small exposures which were overlooked in the comparatively rapid work done in the preparation of this report. Naturally, the greater number of exposures which show reliable dips, the more accurately can the axis of the fold be located.

The principal folds named in order as they occur across the county from north to south are: Canadian anticline, Porum syncline, Enterprise anticline, Cowlington syncline, Kinta anticline, Sansbois syncline, Minor folding north of the McAlester anticline, McAlester anticline, Local folding near Hartshorne, Krebs syncline, Savanna anticline, Kiowa syncline Coalgate anticline, Lehigh syncline, Fault and shear zones, and Choctaw fault zone.

These structures are described on the following pages in the order given.

The descriptions of the McAlester anticline, Minor folding north of

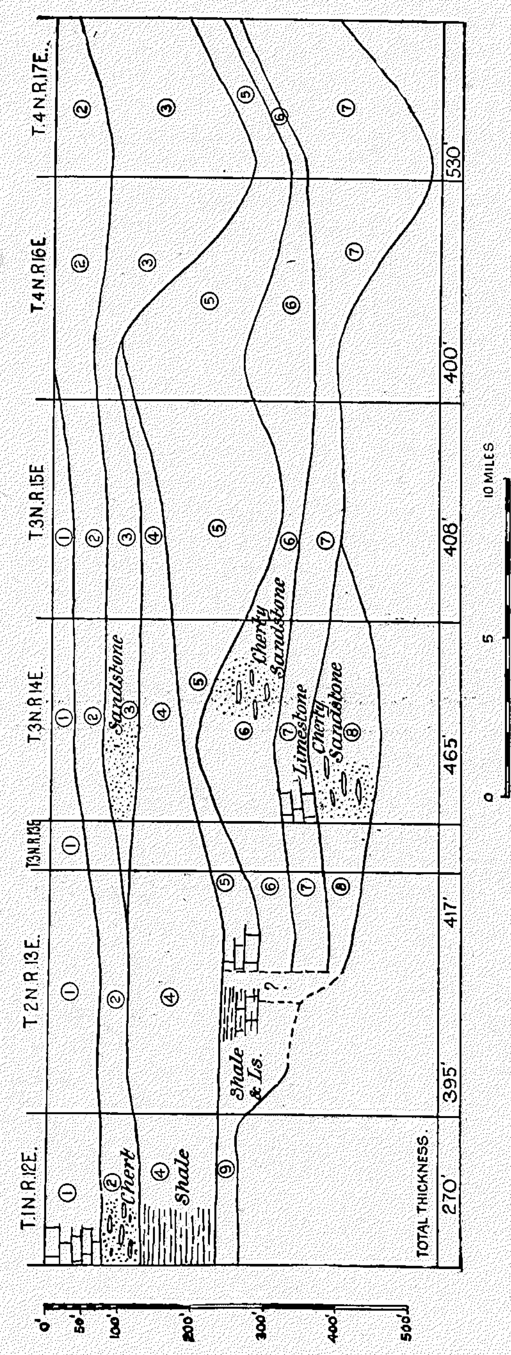


Figure 14. Diagramatic section along the strike of the Wapanucka limestone in the north half of its outcrop.

the McAlester anticline, Local folding near Hartshorne, Krebs syncline, Savanna anticline, Kiowa syncline, and Fault and sheer zones, are quoted from Taff's* report concerning the geology of the McAlester-Lehigh Coal field.

The following paragraphs on the general relations of the structure are as given by Taff in the publication cited.

At the eastern border of the McAlester quadrangle the general strike of the rocks is east and west. This structure continues eastward to the Arkansas line, as shown by Dr. Chance, who examined these rocks and reported upon them in 1890. In Arkansas the same general strike of the rocks prevails from the Arkansas line down the Arkansas River Valley to the Tertiary overlap of the Mississippi embayment, both in the Upper and Lower Coal Measures, as shown by the work of the Arkansas Geological Survey. From the eastern border of the McAlester quadrangle westward the strike of the rocks changes from west to southwest and then south to the Cretaceous border near Atoka, Indian Territory.

From the Chickasaw Nation eastward these rocks have the same general structure, which is that of wide canoe-shaped synclines lapping upon narrow, compressed, and often slightly overturned anticlines. This is also the typical structural character of the Northern Appalachian region. Like the structure in the Appalachian region, again, the folding here becomes less intense toward the north and west, nearer the interior of the coal field. The belt of folded coal-bearing strata varies from 10 to 15 miles in width. North and west of this folded belt the rocks are somewhat crumpled, but maintain a slight downward grade toward the north and west. The structure sections and accompanying map will illustrate the essential features of the rocks of this coal field.

CANADIAN ANTICLINE.

The Canadian anticline is the name applied to local structures which occur along the course of Canadian River in the northern part of the county, and in the vicinity of the town of Canadian.

PORUM SYNCLINE.

The Porum syncline rises in northeastern Pittsburg County and extends across the northwestern part of Haskell County into Muskogee, where it is prominent for a distance of several miles. A more complete description of this syncline is given under the heading of "Structure" in the descriptions of Haskell and Muskogee counties.

ENTERPRISE ANTICLINE.

The Enterprise anticline rises near the east side of Pittsburg County in T. 8 N., R. 17 E., and extends in a northeast direction to Canadian River at Whitefield in Haskell County, and from that point the axis follows along Canadian River to its junction with the Arkansas. At

*Taff, Jos. A., The McAlester-Lehigh Coal Field, Indian Territory; Nineteenth Annual Report, U. S. Geol. Survey, Part III.

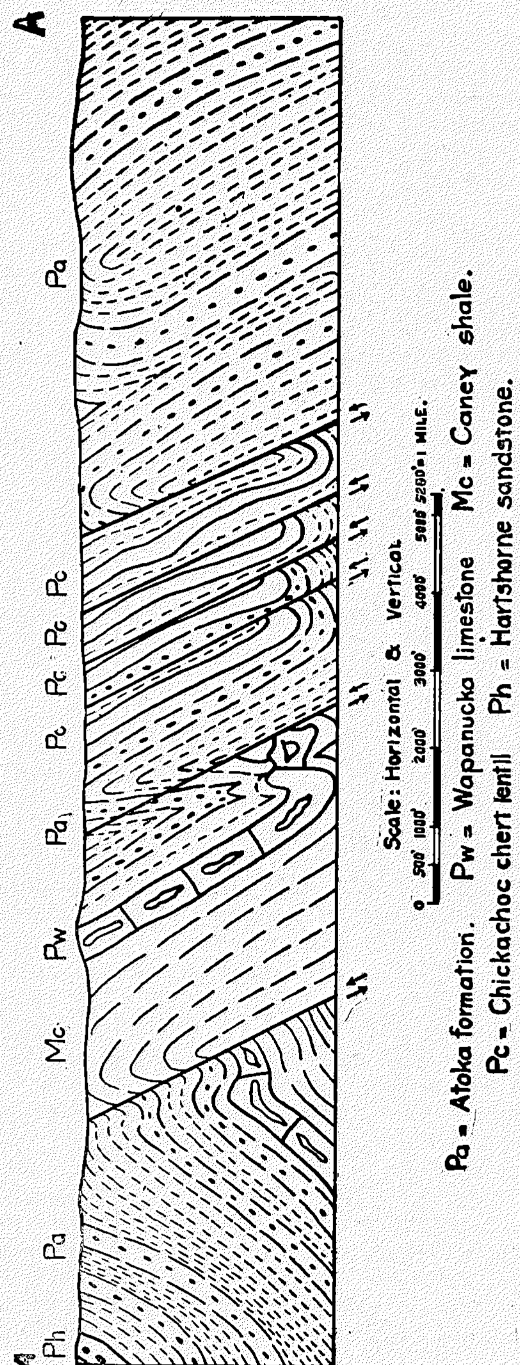


Figure 15. Section showing structure in sec. 22, T. 1 N., R. 12 E.

this point the structure crosses the Arkansas and extends into Sequoyah County for a considerable distance. The name Vian anticline is applied to the structure from near Whitefield to beyond the town of Vian in Sequoyah County. A branch leaving the main fold south of Whitefield and extending past Stigler and Kanima in Haskell County is called the Kanima anticline.

COWLINGTON SYNCLINE.

This fold rises in the hills to the north of Featherston and the axis passes through the ridges north of Quinton, through Beaver Mountain, then to the east and northeast across Sansbois Creek, and along the hilly country northwest of Keota, then curves to the east, passing a short ristance northwest of Cowlington and through Short Mountain, across the Arkansas into Sequoyah County.

KINTA ANTICLINE.

The Kinta anticline enters the area from the west at Featherston and extends eastward in the valley of Sansbois Creek past Quinton to near Kinta, turns somewhat to the north and crosses the Ft. Smith & Western Railroad between Lewisville and Kinta. It then continues to the northeast in a somewhat curved course, passing through Shropshire valley, and dies out opposite the northeastern end of the Siloam syncline near Ironbridge, in the northeastern part of Haskell County. The dips are low, usually less than 5°. Some local disturbances give westward dips near the axis between Quinton and Featherston.

SANSBOIS SYNCLINE.

The Sansbois syncline rises in the central eastern part of Pittsburg County, north of the north fork of the McAlester anticline, and enters Latimer County in sec. 27, T. 6 N., R. 17 E., thus running a distance of about 25 miles across the county. The syncline is broad and the area embraced in the structure is occupied by the Sansbois Mountains.

MINOR FOLDING NORTH OF THE McALESTER ANTICLINE.

Nearly due north of Krebs a narrow and short anticlinal fold extends eastward from the McAlester anticline. Upon the north side the rocks are steeply upturned, while upon the south side the dips are very low. This local anticline is a well-defined structural feature for more than 3 miles from the McAlester anticline. The rocks upon the north side dip at continually lower angles as they are followed eastward. Upon the south side they become horizontal near the axis for 3 or 4 miles, where the anticline becomes simply a swell upon the northern limb of the Krebs syncline and is lost as a structural feature.

An ill-defined shallow basin occurs north of the McAlester anticline west and northwest of McAlester. The axis of this basin lies 2 1-2 to 3 miles north of the McAlester anticlinal axis and is nearly parallel with it. North of the town of McAlester this basin takes a more northerly turn and passes beyond the limits of the quadrangle. Within 6 miles of the western border of the quadrangle the northern limb of this syncline is nearly horizontal, and further west the fold loses character as a structural

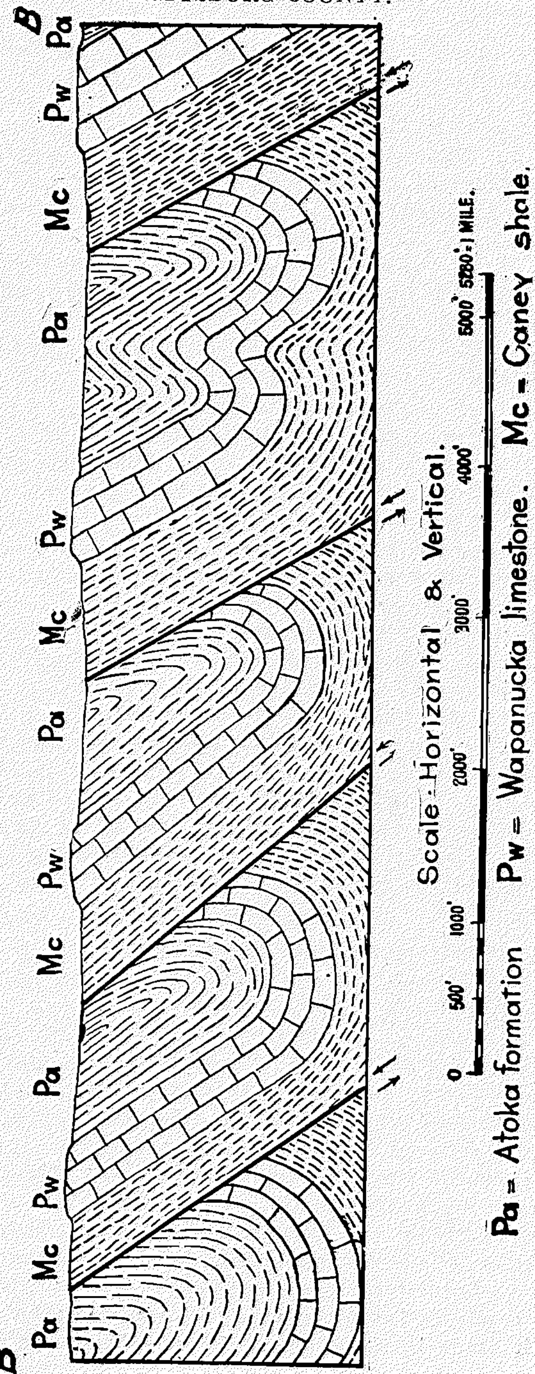


Figure 16, Section showing structure in T. 3 N., R. 15 E.

feature, becoming simply a wide and very shallow depression upon the northern limb of the McAlester anticline.

McALESTER ANTICLINE.

The axis of the McAlester anticline enters the quadrangle upon the east side, in the valley of Gaines Creek, and bears very nearly west for 10 miles, where, at a point between Alderson and Cherryvale, it divides into two folds. One of these divisions of the fold bears southwest by way of Savanna to and beyond the border of the quadrangle. This south division of the anticline is called the Savanna anticline. The other, a more direct continuation of the main fold, bears northwest from Cherryvale for nearly 2 miles and then west to McAlester, where it curves southwest and passes the limits of the quadrangle parallel with the Savanna anticline.

The strata involved in the McAlester anticline from the eastern border of the quadrangle to Cherryvale have been thrust over toward the north, so that the beds upon the north side are on edge in places. At other places, especially south of Cherryvale, the Hartshorne sandstone has been overturned and, it is believed, faulted.

Through its course from Cherryvale eastward the axis of the anticline is almost horizontal. From Cherryvale westward it pitches downward rather abruptly at from 16° to 20°. The Krebs syncline crosses the McAlester arch east of Krebs and depresses it as well as deflects it northward. North of Krebs, however, the McAlester arch regains its normal condition as an unsymmetrical fold, and continues westward, with nearly horizontal axis, to a point about 6 miles southwest of McAlester, where it pitches rapidly for a short space, then becomes a low, wide symmetrical arch, and as such continues to the western limit of the McAlester quadrangle. Upon the south limb of the McAlester anticline, near the axis, the rocks dip usually from 10° to 25°, while upon the north limb, except where the arch is low, and near the western border of the quadrangle, they dip from about 30° to 90°, and in a few places, as noted, are overturned and faulted, dipping southward nearly 90°.

LOCAL FOLDING NEAR HARTSHORNE.

From Hartshorne southwestward for nearly 6 miles the Hartshorne sandstone, with shale, minor sandstone beds, and coal overlying it, is crumpled in an unusual manner. This structure is upon the southern limb of the Kiowa syncline. South and west of Hartshorne the Hartshorne sandstone dips north at 15° to 25°. One-half mile southwest of Hartshorne this sandstone strikes almost due north for nearly 1 mile with dips toward the east, then west for nearly a mile with dips toward the north, and then south nearly a mile with dips toward the west, where it takes a southwest bearing with steep dip toward the northwest. Thus a short and almost square anticlinal fold is indicated with axial trend almost perpendicular to the general structure of the Kiowa syncline. Six miles southwest of Hartshorne the same sandstone turns in strike from southwest to almost directly northwest, and continues for half a mile with dips toward the northeast. At this point it turns in strike nearly 90° and bears again southwest.

Rocks which lie 600 to 1,200 feet above the Hartshorne sandstone show in their outcrop a local syncline and anticline, one lying above the other upon the south limb of the Kiowa syncline, between the structures noted one-half mile and 6 miles, respectively, southwest of Hartshorne. The axes of these folds are parallel with the trend of the Kiowa syncline.

The cause of this buckling of the Hartshorne sandstone and associated rocks may be suggested by the location of the structures in the obtuse angle at the junction of the major east-west and northeast-southwest trends of folding in this district.

KREBS SYNCLINE.

Southwestward from the vicinity of South McAlester, for a distance of nearly 10 miles, the Krebs syncline is a normal canoe basin. Upon the sides and end of the canoe the rocks dip nearly equally—about 15°. Upon the southern side of the syncline farther southwest, opposite Savanna, the dips increase to 45° and from Savanna to the western border of the quadrangle this dip is generally maintained, though it is in places greater. From the southeast side of this basin the dip decreases rapidly toward the northwest from 45° to 10° within the space of a mile. For a wide space the rocks in the central part of this basin are nearly horizontal, and upon the north side of the basin, near the west side of the quadrangle, the beds rise gradually upon the low arch of the McAlester anticline.

The syncline from Krebs eastward across the McAlester anticline can not be easily defined. It is shallow and rises with a gradual upward incline to the axis of the McAlester anticline. From the same point on the McAlester anticline this syncline pitches at a low angle downward toward the east. Northeast of Cherryvale the axis bears northeastward and then east, crossing the side of the quadrangle about 2 miles south of the northeast corner. As is the case in the vicinity of Savanna, the rocks here in the south side of the basin dip steeply toward the north over about 1 mile, and then for a wide space the rocks are nearly horizontal. From the center of the basin northeast of Cherryvale the rocks rise at a low angle to the limit of the quadrangle.

SAVANNA ANTICLINE.

This fold joins the McAlester anticline about 2 miles east of Krebs, and thence bears almost due southwest to the western border of the quadrangle. In the northeastern part of its course it is not a well defined fold. It is little more than a southwestward pitching swell upon the southern limb of the McAlester anticline. South of Craig the ill-defined axis of this fold pitches southwest probably 10°, and south of McAlester it begins to rise. South of Savanna this axis rises rather abruptly at an angle of nearly 20°. From Savanna it continues southwestward almost level to a point northwest of Kiowa, where it begins to pitch downward, and so continues beyond the limit of the McAlester quadrangle.

Northeast from Savanna the rocks dip gradually away toward the northwest and southeast from the axis of the fold. South and southwest of Savanna the fold near the axis becomes sharply contracted and elevated, so that the rocks dip northwest 40° to 60° and southeast 55° to 90°. This fold between Savanna and Kiowa may be compared to an inverted and narrowly contracted canoe. The south side of this inverted canoe is so crushed near the northeast end that the rocks are vertical, while at the end near by the dip will not exceed 20°. The same is true near the southeast end, northwest of Kiowa, except that there has been greater compression upon the northwest side of the fold.

KIOWA SYNCLINE.

The Hartshorne sandstone is at the base of the Productive Coal Measures of this coal field. South of Hartshorne this sandstone is a ridge maker and is usually exposed at its crop, where it dips to the north at about 80°. The dip decreases northward, and is horizontal at the center of the basin, 3 miles distant, where the sandstone lies not more than 600 feet beneath the surface. At Gowen, 3 miles still farther north it comes up on the north side of the basin, forming a prominent ridge. From Hartshorne it strikes westward and then southwestward to the limits of the quadrangle, with dips varying from 40° to 80° toward the north and northwest. From Gowen, on the north limb of the syncline, the rocks bear a little north of west to the vicinity of Alderson, where they turn toward the north and pass across the axis of the McAlester anticline. The axis of this syncline, as in a typical canoe basin, pitches abruptly westward at the east end, northeast of Hartshorne, for a short space, and then becomes nearly horizontal north of Hartshorne. Sandstones which cap the flat topped mesa of Belle Starr Mountain appear at the same elevation in the ridge northwest of Hartshorne, pitching 6° toward the west. From the vicinity of Hartshorne southwest this syncline becomes rapidly broader and deeper for 6 to 8 miles, and then grows narrow, with a gradually rising axis to the vicinity of Kiowa. Opposite Kiowa this synclinal basin is about 4 miles wide. From Kiowa toward the southwest the basin grows gradually broader to the limit of the McAlester quadrangle, where it divides into two synclines separated by a peculiar anticline; one of these extends nearly due south, ending in the Lehigh basin, while the other bears southwestward into the southern part of the Coalgate quadrangle, where it becomes broad and flat.

The contraction of the Kiowa syncline near Kiowa appears to be due to a northwestward movement of the strata from the south side of the basin. The northwestward overthrust of the older rocks southeast of Kiowa corresponds in strike and movement with those of the coal-bearing beds on the south side of Kiowa basin.

COALGATE ANTICLINE.

The Coalgate anticline extends through Coal County in a southwest-northeast direction, then across the northwest corner of northern Atoka County, and dies out near the southern edge of Pittsburg County, a short distance west of Reynolds. This anticline is discussed under "Structure" in the descriptions of Atoka and Coal counties.

LEHIGH SYNCLINE.

The Lehigh syncline first becomes prominent a few miles northwest of Atoka, and extends in a north-northeast direction through the corner of Coal County, then across northern Atoka County, and dies out near the Pittsburg County line, in the vicinity of Reynolds. This synclinal basin is discussed under the heading of "Structure" in the descriptions of Atoka and Coal counties.

FAULTS AND SHEAR ZONES.

The faulting in this coal field is of minor importance and local extent. The sandstone beds, which are exposed in ridges, curve back and forth across the field, so that faults of much magnitude may be easily detected. A fault that may be called the Cherryvale fault occurs on the north limb of the McAlester anticline with strike parallel to the folding. Its location could not be determined with precision, but it occurs between the mines in Cherryvale and the crest of the ridge about one-fourth of a mile south of the town. The fault is an overthrust from the south. It is believed to extend not far from Cherryvale toward the east, and but a few miles toward the west.

The local faulting occurs in the sandstone ridge in the town of South McAlester, as may be seen in the railroad cut north of the station. It is of small extent and does not displace the sandstone which forms the ridge to more than barely appreciable extent.

In the vicinity of Kiowa, where the beds in the south side of the Kiowa basin have been deflected toward the northwest, the sandstone beds have been broken by cross faults or zones of shearing in a number of places. This structure is especially prominent in the limestone ridge, below the coal-bearing beds, immediately south of Kiowa, where it has been thrust strongly over toward the northwest. Near the south side of sec. 25, T. 3 N., R. 13 E., the Hartshorne sandstone is broken and displaced laterally 200 feet. The sandstone on the east side is thrust toward the north with respect to the sandstone on the west side. This sandstone is inclosed in several hundred feet of shale, so that it is not possible to trace the displacement farther than the limit of the sandstone. Near the middle of section 3 and the north side of section 10, T. 2 N., R. 13 E., other shear zones or cross faults occur in the Hartshorne sandstone. In the first instance the sandstone on the southwest side of the break is thrust northward and overturned, while that on the other side remains with normal northwest dip. In section 10 the displacement is in the opposite direction.

These features of structure are not of great importance of themselves, but a knowledge of their occurrence and character will be of much value to the prospector and miner who operate coal in their vicinity.

CHOCTAW FAULT ZONE.

The southeastern part of the county, as above indicated, lies to the south of the Choctaw fault, and the entire area is much folded and faulted. Most of the stream valleys are anticlinal, and the rough, mountainous regions consist of massive sandstone comprising the syncline areas. The dip of the rocks is in most cases sharp, and most of the folds are not symmetrical, and in many cases the folds have been broken by overthrust folding. In addition to being sharply folded and faulted the formations are badly broken throughout the entire region. The character of the structure in the northern part of the area, which contains the limestone ridges, is shown in the accompanying figures. (See figures.)

The numerous occurrences of asphalt indicate that at some time oil was present in these formations, but the presence of the asphalt is also proof that that the lighter oils have escaped, leaving behind the asphaltic base. It is probable that on account of the great thickness of shales some of the oil may have been sealed in. However, the chances for successful development are very slight.

DEVELOPMENT.

Structural features are very pronounced in Pittsburg County, but until recently very little consideration has been given the area in oil and gas prospecting. Prior to 1914 only five or six wells had been drilled in the county, or in the immediately adjacent territory. In the southern part of the county several diamond drill holes had been made in previous years, but these were too shallow to be of much value from the standpoint of oil and gas production, and most of the locations were in synclines, as the primary purpose was to test out the depths and thicknesses of the coal beds at distances somewhat removed from the outcrops Since the coal beds outcrop along the sides of the anticlines and dip away from the crests, the main body of the coal beds lies either in the synclines or well down the sides of the anticlines. However, the fact that none of the early holes drilled in the county showed anything of value in the way of oil and gas production, and since the structures are very steep. prospecting has not received the attention in the county that should be warranted by the geologic and structural conditions. Some parts of the structure are no doubt too steep in the anticlinal folds, and the rocks are too badly broken to permit proper accumulation of oil and gas, while in the less steeply tilted areas good gas deposits are likely to be found in parts which have not yet been developed, and the more gently folded parts of the major structure may be productive of oil. No doubt there are numerous low folds in the areas between some of the larger folds. and these would be more likely to be productive than the principal lines of structure.

At the present writing (February, 1917) there are in Pittsburg County four gas-producing areas. One of these is located south of Ashland, in the extreme southwestern corner of the county, on the Savanna anticline. The seven producing wells are all gas wells, with no showing of oil whatever, and are located as follows:

Nn the SE. 1/4 NW. 1/4 sec. 19, T. 3 N., R. 12 E.
In the SW. 1/4 NE. 1/4 sec. 19, T. 3 N., R. 12 E.
In the NE. 1/4 SW. 1/4 sec. 19, T. 3 N., R. 12 E.
In the NW. 1/4 SE. 1/4 sec. 19, T. 3 N., R. 12 E.
In the SW. 1/4 SE. 1/4 sec. 19, T. 3 N., R. 12 E.
In the SW. 1/4 SW. 1/4 sec. 17, T. 3 N., R. 12 E.
In the NW. 1/4 NE. 1/4 sec. 24, T. 3 N., R. 11 E. (Coal Co.)

Dry holes have been drilled as follows:

In the SW. 1/4 SE. 1/4 sec. 18, T. 3 N., R. 12 E.
In the NW. 1/4 NW. 1/4 sec. 30, T. 3 N., R. 12 E.
In the NW. 1/4 NE. 1/4 sec. 26, T. 3 N., R. 12 E.
In the SW. 1/4 SW. 1/4 sec. 33, T. 4 N., R. 12 E.
In the NW. 1/4 NW. 1/4 sec. 24, T. 3 N., R. 11 E. (Coal Co.)
In the NW. 1/4 SE. 1/4 sec. 23, T. 3 N., R. 11 E. (Coal Co.)
In the SE. 1/4 NW. 1/4 sec. 4, T. 2 N., R 11 E. (Coal Co.)
In the NE. 1/4 SW. 1/4 sec. 17, T. 2 N., R. 11 E. (Coal Co.)
In the SE. 1/4 NW. 1/4 sec. 12, T. 2 N., R. 11 E. (Coal Co.)
In the SE. 1/4 SE. 1/4 sec. 24, T. 2 N., R. 11 E. (Coal Co.)

A second field of operations is that south of Quinton, in the extreme northeastern corner of the county. Four producing wells have been secured here, located as follows:

In the SW. 1/4 NE. 1/4 sec. 1, T. 7 N., R. 18 E.
In the NW. 1/4 SW. 1/4 sec. 1, T. 7 N., R. 18 E.
In the NE. 1/4 SW. 1/4 sec. 1, T. 7 N., R. 18 E.
In the SE. 1/4 SE. 1/4 sec. 2, T. 7 N., R. 18 E., and one dry hole drilled in the NW. 1/4 of SE. 1/4 sec. 1, T. 7 N., R. 18 E.

The largest well of the four producers yields 20,000,000 cubic feet of gas, with a pressure of from 400 to 700 pounds. Arrangements are being made to pipe a part of the gas to McAlester. A large zinc smelter located at Quinton will reserve probably as much as one-fourth of the supply for fuel in connection with the zinc smelting. A pressure of 150 pounds is maintained at the smelter at the present time.

This field is located on the Kinta anticline, and has bright prospects for a great future. To the east on this same structure, but in Haskell County, are four other producing gas wells. They are located as follows:

In the NW. 1/4 NW. 1/4 sec. 4, T. 7 N., R. 19 E.; 6,000,000 cubic feet of gas at 933-935 feet; depth of hole 1,525 feet; owned by Gladys Belle Oil Company.

In the SW. 1/4 NE. 1/4 sec. 4, T. 7 N., R. 19 E.; production and depth not known.

In the SW. 1/4 NW. 1/4 sec. 4, T. 7 N., R. 19 E.; production and depth not konwn.

In the NE. 1/4 NW. 1/4 sec. 28, T. 8 N., R. 20 E., near Kinta; depth about 1,200 feet; production not known.

A dry hole in the NW. 1/4 SW. 1/4 sec. 27, T. 8 N., R. 20 E., near Kinta.

Of the ten holes drilled in the Quinton-Kinta field it will be observed that all but two are producing wells. The gas here, as everywhere in the entire county and surrounding region, is very dry and nowhere has any oil been found. It appears therefore that no oil will be encountered i this field, unless at much greater depths. All the wells in this field have a depth varying from 1,800 to 2,300 feet, and with sands varying from a few inches to over 100 feet in thickness.

The logs of the three wells south of Quinton follow:

Log of well No. 1, drilled by Quinton Oil & Gas Co., in SW. ¼ of the NW. ¼ sec. 1, T. 7 N., R. 18 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface soil	16	16	Shale	23	924
Lime	6	22	Shale	27	951
Shale	38	60	Sand	10	961
Lime	2	62	Shale	39	1,000
Shale	49	111	Sand	20	1,020
Asphalt	8	119	Shale	5	1,025
Water sand	21	140	Sand	15	1,040
Shale	130	270	Shale	10	1,050
Shale	30	300	Sand	15	1,065
Lime	4	304	Sand	35	1,100
Sand	6	310	Shale	310	1,410
Hard shell	91	401	Shale	30	1,440
Shale	39	440	Gas sand	20	1,460
Shale	52	492	Slate	20	1,480
Brown slate	18	510	Gas sand	40	1,520
Coal	6	516	Shale	85	1,605
Blue shale	84	600	Gas sand	20	1,625
Lime	10	610	Slate	155	1,780
Light shale	280	890	Slate	100	1,880
Hard shell	1	891	Gas sand	20	1,900
Trenton rock	10	901	Black shale	383	2,283

Log of well No. 2, drilled by Quinton Oil & Gas Co., in NW. ¼ of the SW. ¼ sec. 1, T. 7, N., R. 18 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface soil	6	6	Light shale	55	440
Hard rock	8	14	Shale and shells	25	465
Shale	16	30	Sandy shale & gas	10	475
Shell and water	2	32	Light shale	50	525
Shale	35	67	Shale and shells	15	540
Sandy shale & water	10	77	Black lime	10	550
Shale	28	105	Dark shale	30	580
Sand and lime shells cased 16 in. pipe	45	150	Light shale	40	620
			Lime	20	640
Broken shale—shells	15	165	Dark shale	50	690
Dark and light shale	35	200	Hard lime	5	695
Shell	5	205	Hard sand gas	20	715
Hard shale	15	220	Trenton rock	10	725
Dark shale	20	240	Dark shale	30	755
Sand showing oil	10	250	Shell	5	760
Shale and shells	30	280	Light shale	15	775
Hard lime	10	290	Sand and lime, gas	63	838
Shale	40	330	Salt, sand, water	22	860
Hard shell	5	335	Lime	5	865
Sandy shale	25	360	Sand and lime	110	975
Hard shale	20	380	Break	3	978
Shell	5	385	Sand and lime	22	1,000

Log of well No. 2, drilled by Quinton Oil & Gas Co., in NW. 1/4 of the SW. 1/4 sec. 1, T. 7, N., 18 E.—Continued.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Salt, sand, water	20	1,020	Sand	35	1,135
Black shale, soft	15	1,035	Shale	5	1,140
Broken lime and shale	15	1,050	Shale	200	1,340
Shell	5	1,055	Oil sand	60	1,400
Dark shale	10	1,065	Shale	15	1,415
Shell	5	1,070	Gas sand	112	1,527
Sand	5	1,075	Black shale	148	1,675
Sandy shale	25	1,100			

Log of well No. 3, Quinton Oil & Gas Co., in SE. 1/4 of the SE. 1/4 of sec. 2, T. 7 N., R. 18 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface, quicksand, water	31	31	Dark sand	6	845
Hard shell	10	41	Shale	13	858
Shale	34	75	Black shale, caving badly, salt water	8	866
Coal	8	83	Set 10 in. casing	2	868
Shale	32	115	Oil sand and water	10	878
Hard shell, much water	2	117	Dark shale	45	923
Shale	43	160	Oil sand	45	968
Hard shale	5	165	Gray water sand	40	1,008
Lime	60	225	Oil sand	15	1,023
Shale	75	300	Lime	20	1,043
Lime	6	306	Water sand	25	1,068
Coal	4	310	Shale; cased with 6 5-8	145	1,213
Shale	65	375	Shale	120	1,333
Hard shell	5	380	Oil sand	15	1,348
Hard gray sand	18	398	Shale	133	1,481
Shale	80	478	Dark sand	83	1,564
Hard gray lime	3	481	Light sand	24	1,588
Shale	14	495	Shale	10	1,598
Dark sand	5	500	Gas sand	22	1,620
Shale Black (caved in)	287	787	Shale	101	1,721
Oil sand	20	807	Hard shell	8	1,729
Salt, sand, water	22	829	Shale	262	1,991
Shale	10	839	Shale	285	2,276

Development is taking place likewise at Blocker, on the westward extension of the Kinta anticline, which constitutes the third field of operations in this county. At the present time (February, 1917) the producing wells are two in number and are located in the NE. 1/4 SE. 1/4 sec. 19, T. 7 N., R. 17 E. and in the SE. 1/4 NE. 1/4 sec. 20, T. 7 N., R. 17 E. One dry hole has been drilled between these two wells, in the NW. 1/4 SW. 1/4 sec. 20, T. 7 N., R. 17 E., and another in sec. 23 of the same township and range. Other locations for drilling operations have been selected, however, and preparations are being made for further production. The producing wells are owned by the Choctaw Natural Gas Company of McAlester and yield 3,500,000 and 1,000,000 cubic feet respectively.

The larger producer is 2,490 feet and the smaller one 3,400 feet in depth.

The fourth field of operations is at Canadian, on the westward extension of the Enterprise anticline. The Choctaw Natural Gas Company has leased 5,000 acres in this vicinity and has begun drilling. No production has been secured as yet in this region.

A number of widely scattered "wildcat" holes have been drilled in Pittsburg County aside from the locations already mentioned. Some of these are as follows:

A dry hole 3,100 feet deep in the NW. 1/4 SW. 1/4 sec. 30, T. 6 N., R. 13 E., and another 2,300 feet in sec. 36 of the same township and range.

The deepest well drilled so far in the State is that of the Gypsy Oil Company in the NW. 1/4 sec. 6, T. 6 N., R. 14 E. This well was abanoned at a depth of 4,303 feet. About 2,000,000 cubic feet of gas was encountered at a depth of 600 feet in a 55-foot sand. The log of this well is as follows:

Gypsy Oil Co. well No. 1, SE. cor. NW. 1/4 sec. 6 T. 6 N., R. 14 E.

Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*
Soil	0	4
Sand	38	42
Slate	18	60
Sand	20	80
Slate	84	164
Sand	6	170
Slate	40	210
Sand	30	240
Brown shale	20	260
Slate	20	280
Black shale	85	365
Black slate, hard shells	1	366
Sandy shale, gray	69	435
Sand, hard	10	445
Soft white sand	10	455
Slate	25	480
Black shale	20	500
Slate, white	20	520
Sand	15	535
Slate, white	15	550
Slate, black	50	600
Sand (2M gas 665)	55	655
Broken sand and slate	30	685
Slate	15	700
Lime	20	720
Slate	5	725
Sand	45	770
Slate, dark	230	1,000
Slate, white	22	1,022
Shell, lime	8	1,030
Slate, black	10	1,040
Sand	30	1,070
Slate, white	150	1,220
Slate, black	5	1,225
Shell	10	1,235
Slate	8	1,243
Lime shell	3	1,246
Slate, white	18	1,264
Lime shell	3	1,267
Slate and shells	65	1,332
Sand	28	1,360
Slate, black (caving 1385-1400 ft.)	40	1,400
Coal	2	1,402
Slate, black	18	1,420
Slate, white	30	1,450
Shale, brown	40	1,490
Shale, black	41	1,531
Slate	17	1,548
Sand	12	1,560
Slate, blue	20	1,580
Shale, black	85	1,665
Coal	3	1,668
Shale, black	32	1,700
Sand, soft, broken	15	1,715
Sand	13	1,728
Slate, white	50	1,778
Slate, black	172	1,950
Sandy lime	5	1,955
Slate, black	241	2,196
Sand, broken	21	2,217
Shale, black	40	2,257
Sand, little gas	33	2,290
Slate, black	313	2,603
Coal (1-2 boiler water)	7	2,610
Slate, black, soft	20	2,630
Sand	115	2,745
Sandy shale	155	2,900
Shale, brown	140	3,040
Shale, black brown, and bluish black	1,263	4,303

A gas well yielding 250,000 cubic feet of gas daily is located in the SE. 1/4 NE. 1/4 sec. 1, T. 6 N., R. 15 E. Gas was encountered at 1,900 feet. The hole, however, was deepened to 2,100 feet. It is owned by the Choctaw Natural Gas Company but was formerly a Gladys Belle Oil & Gas Company well.

A local company drilled a dry hole in the NW. 1/4 NW. 1/4 sec. 18. T. 8 N., R. 16 E. The depth was about 3,000 feet.

Near and about the town of Crowder in northern Pittsburg County a local company composed of C. M. Smith and others drilled during 1907 three dry holes, two of which were 1,200 feet and the third 1,500 feet deep. Twenty-two feet of sand were encountered in the deepest test. but no oil or gas was found.

At a later date the Gladys Belle Oil & Gas Company drilled a dry hole in sec. 35, T. 8 N., R. 18 E., (Haskell Co.) The depth of this hole is not known.

SUMMARY.

Pittsburg County, with the exception of the southeastern part, is in probable oil and gas territory. The rocks of the entire region north of Choctaw fault are sandstones and shales of the Pennsylvanian system, and are the same general age and character as the oil and gas bearing rocks in the main field farther to the north. The rocks are folded into structures suitable for accumulation and the sandstones are of such nature as to afford good reservoirs. The shales with which the sandstones are interstratified are dense enough to furnish good cap rocks. In some parts of the region the structure is sharp, the rocks having been thrown into very steep folds, and in some places faulted. In the vicinity of the steeper folds and faults it is probable that the rocks have been broken to such an extent that oil or gas contained in them could have found a means of escape to the surface. Such close folding would also indicate that the belt for the accumulation of oil or gas is probably narrow and the chances are not so favorable as on the more gentle folds. The chief rocks exposed in the region in which oil and gas have been found, or are most likely to be found, are the Boggy shale, Savanna sandstone, McAlester shale, Hartshorne sandstone, and Atoka formations. These rocks, however, have so far proved to be chiefly productive of gas, only very small amount of oil having been found in drilling. The Hartshorne sandstone is the horizon in which gas has been found in Leflore County, and the production near Wardville in Coal and Pittsburg counties is either in the Hartshorne sandstone or sandstones closely associated with it in the McAlester shale. Gas has also been found at about the same horizon north of Redoak and at Kinta. Several wells have been drilled and came in as good gas producers in the vicinity of Featherston and Quinton, but the producing horizon has not been definitely correlated with that of other sections. The Atoka formation produced gas near Mansfield and Ft. Smith, Ark., and it is very probable that in the great thickness of this formation varying from 3,000 to 7,000 feet there are several sandstones which would be good reservoirs for the accumulation of oil and gas, and as this formation is found in several of the principal structures it is to be considered of special importance.

It is very probable that oil will not be found in paying quantities in any of the steeper structures, but in the more gentle folds conditions are favorable. Hence, further prospecting for both oil and gas is advisable.

The southeastern part of the county, which is in the Quachita Mountain region, cannot be considered as favorable oil and gas territory, although it is possible that some deposits of small extent may be found in that region. Some oil and gas were reported from a drilling near Rennen in northeastern Atoka County but not in sufficient quantity to be of value.

The work which has been done in Pittsburg County in prospecting and mining the coal has aided materially in the location of structure folds and faults, and the data thus collected should prove of considerable value in future prospecting for oil and gas in this county.

PONTOTOC COUNTY.

LOCATION.

Pontotoc County is in the south-central part of the State. Its northern boundary is the Canadian River. It extends from T. 1 N. to T. 6 N. inclusive, and from R. 4 E. to R. 8 E. inclusive. The county contains 17 whole townships and parts of 6 others. The total area is 716 square miles.

TOPOGRAPHY.

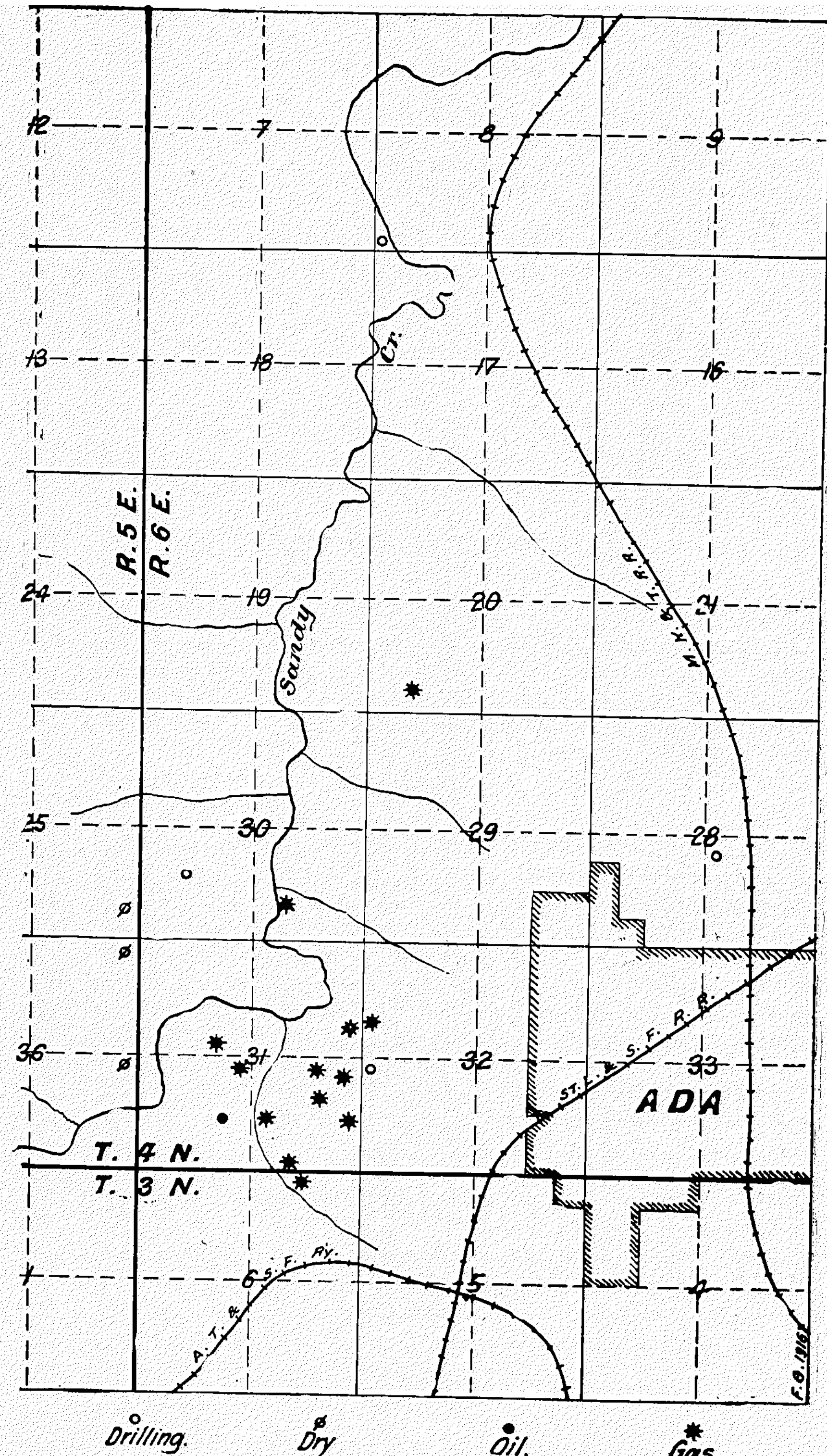
Most of the county lies within the Sandstone Hills region. The extreme southern part lies within the Arbuckle Mountain region. The topography of the northern part of the county is the result of weathering alternating sandstones and shales that have rather low dips. More or less parallel escarpments follow each other at great distances. These escarpments have been dissected by streams, giving to the whole surface a broken appearance. Most of the northern part of the county is wooded. Farther south limestones predominate, and flat or rolling prairie is the type of topography.

Canadian River forms the north boundary of the county, and together with its tributaries drains approximately the northern half of the county. Blue River and Boggy Creek drain the south half of the county.

The elevation of the surface in Pontotoc County ranges from 645 feet to 1,300 feet. The lowest elevation is found where Clear Boggy Creek crosses the east county line, in sec. 25, T. 2 N., R. 7 E. The highest elevation is found near the northeast corner of sec. 18, T. 2 N., R. 4 E., about 1½ miles north of Dolberg.

GEOLOGY.

A detailed geological survey has not yet been made of Pontotoc



12
7
8
9
13
18
17
16
Cr.
R. 5 E.
R. 6 E.
24
19
20
21
Sandy
M. K. & T. R. R.
25
30
29
28
36
31
32
33
ST. L. & S. F. R. R.
ADA
T. 4 N.
T. 3 N.
1
6
5
4
A. T. & S. F. Ry.
F. G. 1916
Drilling.
Dry
Oil.
Gas

Figure 17

County. However, a general reconnaissance, together with the detailed geological survey of bordering territory, makes possible a few general statements. Silurian, Devonian, and Pennsylvanian rocks are exposed in the county.

The Silurian rocks are found in the southern part of the county. They consist of thin and thick-bedded limestones, shales, and sandstones. The Devonian, found in the southeastern part of the county, consists of black flint chert and shale. The Pennsylvanian, found in the central north and eastern parts of the county, consists of conglomerates, shales, and sandstones. Capping some of the hills are found some unconsolidated silt, sand and gravel of probable Neocene age. Along the rivers and streams are found fine, yellow sand and alluvium which are Quaternary. A general idea of the underground rocks may be had from the following logs, one from the Ada gas field and the other from the Allen oil field:

MacThwaite Oil and Gas Co. No. 2, in NE. cor. of SW. ¼ sec. 31, T. 4 N., R. 6 E. Elevation 905 feet.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	60	60	Blue shale	20	625
Sand	6	66	Black shale	115	740
Blue shale	164	230	Hard lime	25	765
Sand and water	20	250	White sand—(salt water)	19	784
Blue shale	10	260	Black shale	22	806
Sand and water	25	285	Limestone	4	810
White shale	30	315	Black shale	32	842
Red shale	69	384	Gray lime	16	858
Sand	16	400	Black shale	42	900
Red bed	60	460	Sand—upper gas sand	6	906
Gray sand	40	500	Black shale	74	980
Blue shale	44	544	Hard lime shell	5	985
Lime cave	24	568	Gas sand	15	1,000
Blue shale	30	598			
Water, sand, shale	7	605			

Lower part of the log of the Kansas City Oil Company's well located 200 feet north and 200 feet west of the S. ¼ corner sec. 23, T. 4 N., R. 8 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Blue shale	45	270	Slate	10	575
Black shale	30	300	Water sand	20	595
Red rock	10	310	White slate	95	690
Sand	50	360	Blue shale	10	700
Red rock	45	405	Black slate	20	720
White sand	25	430	Blue slate	14	734
White shale	21	451	White and pink slate	11	745
Water sand	74	525	Red rock	3	748
White shale	15	540	White solid slate turning to sand	15	763
Blue slate	15	555	Oil sand	18	781
White lime	10	565			

ALLEN OIL FIELD.

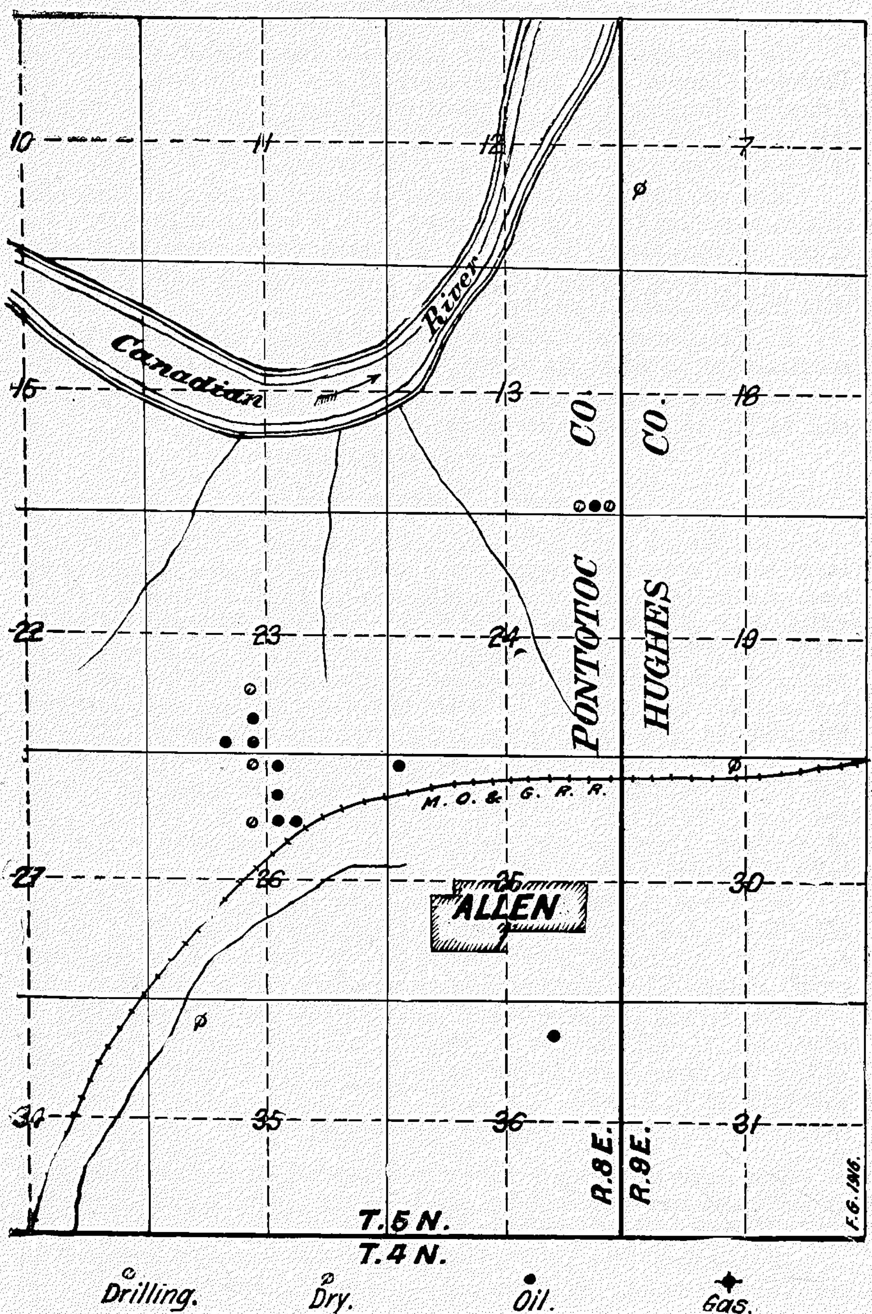


Figure 18

STRUCTURE.

No work has been done to determine the detailed structure of Pontotoc County. The southern part of the county belongs to the Arbuckle Mountain uplift. Normal and block faulting are found in this part of the county. The Pennsylvanian rocks to the north belong to a monoclinal fold which dips at a low angle to the northwest.

Detail of logs of wells and surface outcrops indicate a terrace-like structure running from the center of sec. 6, T. 3 N., R. 6 E., a little north of east through sec. 31, T. 4 N. R. 6 E., to the center of sec. 20, T. 4 N., R. 6 E. Considerable gas and "shows" of oil have been found associated with this terrace-like structure.

In the absence of sufficient data the relation of structure to the accumulation of oil in the Allen field cannot be determined.

Detailed work will no doubt show up considerable folding favorable to the accumulation of oil or gas.

DEVELOPMENT.

THE ADA GAS FIELD.

The Ada gas field was discovered in 1914 in a region which had been looked upon as a region more or less unfavorable because of its close proximity to the older Paleozoic rocks which are exposed a few miles south of Ada. The initial well in the Ada field was drilled by MacThwaite Oil & Gas Company in sec. 31, T. 4 N., R. 6 E., and produced about 2,000,000 cubic feet of gas from a 50-foot sand, the top of which was found at 1,050 feet below the surface. Since drilling this well the same company has put down in sec. 31, T. 4 N., R. 6 E. 7 other wells. One well located in the NW. 1/4 of the SE. 1/4 of the SW. 1/4 of sec. 31 had a show of oil at a depth of 1,070 feet. They are now (May, 1916) drilling in sec. 28, T. 4 N., R. 6 E. In most of the wells there are two gas sands, one at approximately 900 feet below the surface, and the other at 1,000 feet.

Skelly and Sankee have one gas well in sec. 32, T. 4 N., R. 6 E., offsetting a well of the MacThwaite Oil & Gas Company, and one in sec. 31, on a small lease surrounded by MacThwaite Oil & Gas Company's leases. They are now drilling an offset well in sec. 32.

The Rex Oil Company No. 3 has an oil and gas well in the SW. 1/4 of the SE. 1/4 sec. 30, T. 4 N., R. 6 E., and a gas well in the SW. 1/4 of sec. 20, same township and range. They are drilling in the SW. corner of sec. 8, T. 4 N., R. 6 E.

THE ALLEN FIELD.

The Allen oil and gas field was discovered during the latter part of 1913, and on account of the nature of the production has been slow in developing. The field lies in T. 5 N., R. 8 E.

The Kansas City Oil Company has three producing wells, all in the SW. 1/4 sec. 23. They are now drilling the fourth well.

The total initial production for these three wells is reported to have been 70 barrels, or an average of 23 barrels per well. The Central State Oil Company has two producing wells, both in the SW. 1/4 of the NE. 1/4 sec. 26, T. 5 N., R. 8 E. The total initial production for the two wells was 105 barrels, an average of 52 barrels per well. This company is now drilling two other wells, one in the SE. 1/4 of the NW. 1/4 of sec. 26, and the other in the NE. corner of the NW. 1/4 of sec. 26.

The Gypsy Oil Company has two producing wells, both in the NW. 1/4 sec. 26. The total initial production was 12 barrels. The Hub Oil Company has one producing well with an initial production of 3 barrels. It is located in the SE. 1/4 of the SE. 1/4 of sec. 13. They are now drilling, and have another location in the same quarter of section 13. The Cummings Oil Company has a 5 barrel well on the NW. 1/4 of the NW. 1/4 sec. 10. Burton and Stabb are reported to have had a 5 barrel well in the NE. 1/4 of the SE. 1/4 sec. 24. Its initial production was 3 barrels natural. The Bell Lawrence Gas Company has a gas well in the NE. 1/4 of the NW. 1/4 of sec. 27.

All the production in the Allen field was found at a depth that will average 800 feet. The productive sand averages 28 feet in thickness in sec. 26, and from 19 to 24 feet in sec. 23.

MISCELLANEOUS DEVELOPMENT.

Some development work has been done in T. 4 N., R. 8 E. The Cummings Oil Company has an 8 barrel well in the SW. 1/4 of the SE. 1/4 sec. 17. The same company has a 25,000,000 cubic feet gas well in the NW. 1/4 of the NW. 1/4 sec. 21. Kurtz, Taubach, and Pope have an 8 barrel well on the NW. 1/4 of the NE. 1/4 sec. 2. Twenty feet of productive sand is reported at a depth of 620 feet.

In T. 5 N., R. 6 E., the Oklahoma Texas Syndicate has a 15,000 000 cubic feet gas well in the SE. 1/4 sec. 36. The Tidewater Company is drilling in the same quarter section and has been reported as having a show of oil.

Drilling is now going on in sec. 34, T. 5 N., R. 7 E., 2 miles east of Francis. Reports say that encouraging material has been encountered.

In sec. 3, T. 4 N., R. 7 W., Mascho et al. report having struck an oil sand into which they drilled 36 feet at a depth of 1,200 feet. The reported production was 300 barrels daily. The quarter section in which this well is located sold for $100,000.

Several dry holes have been drilled in Pontotoc County. In T. 5 N., R. 8 E., Burton and Stabb drilled a dry hole in the NW. 1/4 sec. 35. In T. 5 N., R. 9 E., in the SW. 1/4 sec. 7, the Dumm well was drilled to a depth of 1,026 feet and was dry. Burton and Stabb drilled a dry hole to a depth of 1,190 feet in the NW. 1/4 sec. 30. In T. 4 N., R. 5 E., the Stewart well drilled to a depth of 1,600 feet in the SE. 1/4 sec. 25 was dry. The Caney well in the NE. 1/4 of sec. 36 was drilled to a depth of 1,800 feet and was dry. In T. 4 N., R. 8 E. Cornish and Patton had a dry hole at a depth of 1,200 feet in the SW. 1/4 of sec. 19. The Cummings Oil Company's well in the SW. 1/4 of the SW. 1/4 sec. 17 was dry. In T. 4 N., R. 9 E. Burton and Stabb had a dry hole 1,900 feet deep in the NW. 1/4 sec. 12.

SUMMARY.

The northern part of Pontotoc County is in proved oil and gas territory. While the production has not been large it has been encouraging. The next year will see considerable activity in this field.

POTTAWATOMIE COUNTY.

LOCATION.

Pottawatomie County lies just southeast of the center of the State. It extends from T. 5 N. to T. 11 N. inclusive, and from R. 2 E. to R. 6 E. inclusive. It includes 16 whole townships and parts of 13 others. The total area is approximately 819 square miles.

TOPOGRAPHY.

The northeastern part of the county is in the Redbeds Plains region and the remainder of the county is in the Sandstone Hills region. The Redbeds Plains region is a gently rolling prairie plain. The topography in the Sandstone Hills region is the result of weathering of alternating sandstone and shale formations which dip at a low angle. There are more or less parallel sandstone escarpments at rather great distances apart. These escarpments have been dissected by the streams, thus giving a broken appearance to the surface. The sandstone hills are usually covered with black-jack timber.

Pottawatomie County is drained by Canadian River, North Fork of Canadian River, and their tributaries.

GEOLOGY.

Pennsylvanian and Permian rocks are found at the surface in Pottawatomie County. J. W. Beede* shows the approximate contact between the Pennsylvanian and Permian to run in a northeast-southwest direction through Tecumseh. The Pennsylvanian is made up of sandstones, conglomerates, and shales, with the shales predominating, though the sandstones are quite numerous. A good many of these Pennsylvanian rocks are red and they are not easily distinguished from the red Permian. Mr. Beede* has mapped the Pennsylvanian-Permian contact on paleontological grounds. The Permian consists, for the most part, of red sandstones and shales.

*Beede, J. W., Bull. Okla. Geol. Survey, No. 21, 1914, Fig. 1, p. 22.

The following log will give an idea of the underground formations:

Log of well near Tecumseh, on Spencer farm, T. 9 N., R. 3 E.

Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*
Soil	1	1
Sand	8	9
Red clay shale	20	29
Gravel (with fine water)	4	33
Red clay shale	117	150
Sand rock	6	156
Red clay shale	119	275
Red sand shale	8	283
Sand shale	29	312
Sand (with water)	5	317
Red clay shale	5	322
Sand	5	327
Sand rock (water)	15	342
Red clay shale	23	365
Sandy shale	9	374
Gray clay shale	82	456
Sandy shale	5	461
Sand rock (hard)	2	463
Red clay shale	24	487
Sand rock	4	491
Red clay shale	5	496
Sand rock (water)	10	506
Sandy shale	40	546
Red clay shale	14	560
Sand rock (red cast)	18	578
Red clay shale	12	590
Sand rock	7	597
Red clay shale	17	614
Sand rock	8	622
Red clay shale	8	630
Sand rock	16	646
Limestone	24	670
Blue sky shale	9	679
Limestone	8	687
Red and blue shale	37	724
Blue clay shale	7	731
Red clay shale	6	737
Blue clay shale	25	762
Red clay shale	17	779
Hard pan	5	784
Red clay shale	8	792
Hard pan	16	808
Red clay shale	2	810
Hard pan	17	827
Blue clay shale	6	833
Red clay shale	34	867
Gray clay shale	27	894
Red and green clay shale	15	909
Red clay shale	3	912
Sand	7	919
Red clay shale	5	924
Gray sand	3	927
Red clay shale	4	931
Limestone (mixed with sand)	7	938
Sand rock (gray)	3	941
Red clay shale	24	965
Gray clay shale (also shell)	6	971
Red and gray clay shale	30	1,001
Red clay shale	19	1,020
Red and gray clay shale	15	1,035
Limestone	11	1,046
Sand rock (salt water)	24	1,070
Red clay shale	9	1,079
Red clay shale	20	1,099
Gray clay shale	21	1,120
Blue clay shale	3	1,123
Limestone	3	1,126
Red clay shale	3	1,129
Gray clay shale (lime)	3	1,132
Red clay shale	28	1,160
Sand rock (salt water)	16	1,176
Red clay shale (shells)	15	1,191
Red clay shale	13	1,204
Gray clay shale	5	1,209
Red clay shale	21	1,230
Sand rock (salt water)	16	1,246
Gray clay shale	24	1,270
Red clay shale	8	1,278
Gray clay shale	24	1,302
Red clay shale	2	1,304
Sand shale (little water)	8	1,312
Red clay shale	22	1,334
Gray clay shale	26	1,360
Red clay shale	90	1,450
Gray sand	11	1,461
Gray clay shale	2	1,463
Red clay shale	19	1,482
Red clay shale with limestone	4	1,486
Red clay shale	8	1,494
Gray sand	10	1,504
Sandy shale	10	1,514
Red clay shale	30	1,544
Gray clay shale	9	1,553
Gray lime	2	1,555
Red clay shale (with lime shale)	5	1,560
Sand rock	15	1,575
Gray clay shale	6	1,581

Log of well near Tecumseh, on Spencer farm, T 9 N., R. 3 E.—Continued.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Red clay shale	2	1,583	Blue clay shale	6	1,804
Gray sand rock	15	1,598	Red clay shale	7	1,811
Red clay shale	7	1,605	Blue clay shale	8	1,819
Red clay shale	4	1,609	Gray sand	6	1,825
Limestone	20	1,629	Red clay shale	8	1,833
Blue clay shale	6	1,635	Gray clay shale	2	1,835
Gray clay shale	10	1,645	Gray sandy shale	10	1,845
Red clay shale	10	1,655	Gray sand (with salt water)	17	1,862
Sand rock	44	1,699	Sandy rock	14	1,876
Gray clay shale	2	1,701	Gray shale	5	1,881
Limestone	12	1,713	Red clay shale	8	1,889
Gray clay shale	10	1,723	Red shale	5	1,894
Red clay shale	5	1,728	Sandy shale	12	1,906
Sandy shale	8	1,736	Sand rock	15	1,921
Red clay shale	7	1,743	Gray shale (shells of ss.)	26	1,947
Gray clay shale	20	1,763	Sand rock	7	1,954
Limestone (hard)	9	1,772	Red clay shale	2	1,956
Impure limestone (sandy)	9	1,781			
Limestone	17	1,798			

DEVELOPMENT.

Within the past year or so Pottawatomie County has seen considerable exploration, some of which has been encouraging. The Shawnee Oil & Gas Company is reported to have drilled a dry hole in sec. 26, T. 11 N., R. 3 E. A well was put down some years ago on the Spencer farm in T. 9 N., R. 3 E., which proved to be a dry hole (See log page 453). The Maud Oil & Gas Company put down a well to a depth of 2,925 feet in sec. 18, T. 7 N., R. 5 E. The well is reported as producing 3,000,000 cubic feet of gas and 50 barrels of oil daily.

The Wanetta Development Co. drilled a well in sec. 5, T. 6 N., R. 2 E. to a depth of about 3,000 feet. A showing of heavy asphaltic oil was reported at that depth. The Prairie Oil & Gas Co. have taken over the well and will continue drilling to 3,500 feet. The productive sand in the Maud Oil & Gas Co.'s well near the town of Maud, if continuous to this area, would probably be encountered at a depth less than 3,500 feet.

The Vindicator Oil Co. are drilling a well in sec. 34, T. 8 N., R. 5 E. A good showing of gas is reported to have been encountered. The Prairie Oil & Gas Co. are drilling several wells in this county, and are located in sec. 34, T. 8 N., R. 5 E., half a mile north of the original Maud discovery well, in sec. 1, T. 6 N., R. 4 E., near Sacred Heart, and in sec. 28, T. 10 N., R. 2 E., about 10 miles west of Shawnee. The Oklahoma Star Oil Co. are drilling in sec. 8, T. 9 N., R. 5 E., near Earlsboro. Van Kinkle *et al.* are drilling near Remus. The W. B. Wilson Co. have made a location in sec. 28, T. 10 N., R. 4 E., about 2 miles southeast of Shawnee.

SUMMARY.

The discovery of oil by the Maud Oil & Gas Company in sec. 8, T. 7 N., R. 5 E., has placed the extreme eastern part of Pottawatomie County in proved oil and gas territory. The oil and gas-bearing sands probably underlie the entire county but in the western part are very deep. The expense of exploring is so great that this part of the county will not for the present, receive much development.

PUSHMATAHA COUNTY.

LOCATION.

In general terms, Pushmataha County extends from T. 2 N. to T. 4 S. inclusive, and from R. 15 E. to R. 22 E. inclusive. It is bounded on the north by Pittsburg, Latimer, and Leflore counties, on the east by Leflore and McCurtain, on the south by McCurtain and Choctaw, and on the west by Atoka and Pittsburg counties. The total area is 1,422 square miles.

TOPOGRAPHY.

Pushmataha County lies almost wholly within the Ouachita Mountains region and has a topography which is, therefore, for the most part, rough and rugged.

The Ouachita Mountains, together with the Arbuckles and Wichita mountains, constitute the Ouachita system, which extends from western Oklahoma into western Arkansas, and to the Mississippi embayment of the Gulf Coastal Plain. The system as a whole is a narrow line of old mountains, whose elevation nowhere exceeds 3,000 feet.

The Ouachita Mountains themselves consist of elongated ridges of crumpled sandstones and shales with a few limestones, mostly of Carboniferous age. They extend in an east-west direction from Atoka in Atoka County into the State of Arkansas and have an average width of about 50 miles. The range has been deeply dissected in the past but the numerous elongated ridges are now reduced to more moderate slopes and in some cases cut into isolated mountains or rounded hills by a well developed drainage system.

Many of the streams, particularly the larger ones such as Kiamichi and Little rivers, have reached a state of late maturity in some parts of the region and are now meandering about in broad valleys between the hills. These two rivers have broad deep channels and can be forded at but few points. They are not at present eroding very rapidly. The smaller streams and the creeks have mostly V-shaped valleys but near their source headward erosion is in progress and the hills are everywhere being cut away and gradually reduced in elevation. The most prominent ridges are Pine Mountain and Limestone Ridge in Atoka and Pittsburg counties; Jackfork Mountain in Pittsburg County;

Winding Stair and Buffalo Mountain in Latimer County; Kiamichi Mountain, extending from central Pushmataha County to the eastern side of Leflore County, where it terminates in Round Mountain on the Oklahoma-Kansas line; and Winding Stair Mountain, Black Fork Mountain, Rich Mountain, Pine Mountain, and Poteau Mountain lying in part in Leflore County and in part in the State of Arkansas. In Arkansas other equally important ridges form the eastern end of the Ouachitas.

The highest elevations in the Ouachita Mountains in Oklahoma are: 2,850 feet on the west end of Rich Mountain in sec. 6, T. 2 N., R. 26 E., in Leflore County; and 2,428 feet in sec. 33, T. 4 N., R. 23 E., also in Leflore County. The majority of the hills range from 750 to 1,200 or 1,500 feet in elevation; the relief varies from 200 to 1,200 feet.

The southward continuation of these mountains was planed off by the transgressing sea of Cretaceous times, and their roots buried beneath the derived sediments. These Cretaceous sediments are everywhere present south of the Ouachita and Arbuckle mountains from Love County east into Arkansas and south to the Gulf of Mexico. This entire prairie is almost flat and is in marked contrast to the country to the north.

Pushmataha County, with the exception of a small area in the southwest part, lies in the rougher region of the Ouachita Mountains. In the southewstern corner of the county, along a line northwest and southeast from the town of Antlers, a marked change in the topography occurs, for it is here, in this county, that the horizontal Cretaceous strata abruptly end against the up-turned Paleozoic strata of the mountains. This small corner is almost flat and is drained to the east by two sluggish streams, Beaver and Dumpling creeks, which discharge their waters into Kiamichi River.

The area covered by this county is very sparsely settled and the roads are generally poor and entirely lacking in some townships.

Certain small areas are barren of trees but in general the county is well timbered and the lands may be said to be valued chiefly for their timber.

GEOLOGY.

Very little is known regarding the geology of the Ouachita Mountains, more than that they are a series of sharply folded shales and sandstones, with a few limestones.

The axes of the folds bear generally east-west and are more or less parallel—a typical Appalachian type of structure. The individual members of the formations have, however, not been differentiated nor the minor structures studied. See "geology under Latimer, Leflore, and Pittsburg Counties.

DEVELOPMENT.

Two wells have been drilled in Pushmataha County near the town of Jumbo in T. 1 S., R. 15 E. A small amount of asphalt is reported to have been found in one of the wells but no oil is reported from either. However, a well drilled near Redden in Atoka County, just northwest of the location above mentioned, showed some oil.

SUMMARY.

A geologic structure involving sharply folded and broken strata is not favorable for the accumulation and preservation of petroleum and natural gas. Anticlines, during the process of being folded, become weak and are often shattered and broken along the crests if the folding is carried to an extreme, thus allowing the oil and gas to escape along these openings, where otherwise the hydrocarbons would accumulate.

If the porous, oil-bearing sands are deep in the earth the oil and gas in them might remain sealed in for a time but erosion would take place more rapidly on the shattered crests of the anticlines than in the tightly compressed troughs of the synclines and rivers, when thus started on the weaker, fractured materials would continue there and eventually cut their way into the deeper rocks.

ROGERS COUNTY.

LOCATION.

Rogers County is located in the northeastern part of the State. It extends from T. 19 N. to T. 24 N. inclusive, and from R. 14 E. to R. 18 E. inclusive. It includes 18 whole townships and parts of 5 others. The total area is approximately 751 square miles.

TOPOGRAPHY.

The eastern part of the county is hilly, while the western part is generally a rolling prairie, except along the wooded valleys of the streams. The most striking feature of the topography is the hills that rise from the west bank of Verdigris River, west of Claremore. North of Claremore there are a number of small hills or mounds from 150 to 200 feet high. The range in elevation in the county is about 430 feet, the highest point being 960 feet in the extreme northeastern corner of the county, and the lowest along Verdigris River in the southeastern part of the county.

Verdigris River and its tributaries drain the county. Caney River and Bird Creek are the two most important tributaries to Verdigris River. Dog Creek drains the eastern part of the county.

GEOLOGY.

The surface rocks consist of sandstones, shales, and limestones of Pennsylvanian age. The subdivisions of the Pennsylvanian exposed in this county are the Cherokee formation, farther south known as Winslow formation, Fort Scott formation, Labette shale, Oolagah formation, Nowata shale, Lenapah limestone, and Curl formation.

The Cherokee formation outcrops in the northeastern corner of the county and the western limit extends in a southwest direction to the vicinity of Catoosa. The formation consists of a series of shales, limestones, and coal beds. In the vicinity of Claremore it is 960 feet thick. It is the chief productive horizon in the northern and northeastern fields of Oklahoma.

The Fort Scott formation succeeds the Cherokee formation and outcrops to the west of and parallels the latter. The Fort Scott, or Claremore* formation, consists of three ledges of limestone, separated by shale. The thickness is about 48 feet near Claremore. The Labette shales outcrop to the west of and succeed the Fort Scott formation. They are exposed along Verdigris River. The total thickness in the vicinity of Claremore is about 137 feet.

The Oolagah formation lies above the Labette shales and outcrops to the west of them. The Oolagah consists of several ledges of limestone separated by shale. The lower limestone members are commonly called the "Big Lime" by drillers. It is more than 100 feet thick.

The Nowata shales lie above the Oolagah formation and outcrop in the northwestern corner of the county. In this locality the Nowata shales are on the average about 200 feet thick.

Above the Nowata shales lie the Lenapah limestone and Curl formation, the latter lying above the former. They outcrop across the northwestern corner of the county. The Lenapah is about 30 inches thick, while the Curl formation, which consists of shales and sandstones, is about 300 feet thick.

The following log is characteristic of the formations encountered:

Lucinda Johnson No. 1, in NE. 1/4 sec. 30, T. 22 N., R. 15 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	18	18	Broken sand	10	680
Blue shale water	132	150	Shale	175	855
Lime	30	180	Sand	6	861
Black shale	5	185	Broken sand, gas	5	866
Lime	12	197	Broken sand	5	871
Shale	40	237	B. Shale	50	921
Lime	8	245	Lime	10	931
Shale	175	420	Black shale	45	976
Lime	25	445	Lime	45	1,021
White shale	40	485	Shale	10	1,031
Sand, gas	15	500	Lime	40	1,071
Shale	100	600	Shale	9	1,080
Sand, gas	15	615	Sand	10	1,090
Black shale	5	620	Lime	7	1,097
Lime	5	625	Sand	5	1,102
Broken sand	5	630	White sand (water)	30	1,137
Shale	40	670			

*Ohern, D. W., Stratigraphy of the older Pennsylvanian rocks of northeastern Oklahoma: Research Bull. No. 4, Univ. of Oklahoma, 1910.

STRUCTURE.

The structure in Rogers County is in general that of a westward-dipping monocline, except where interrupted by reversal dips to the east. The average dip is about 30 feet per mile to the west.

DEVELOPMENT.

GENERAL STATEMENT.

Development in Rogers County began at an early date and on account of the shallow production it has had much drilling. Within the county the following fields have been developed: Inola, Catoosa, Claremore, Chelsea, Collinsville, and Talala.

INOLA FIELD.

GENERAL STATEMENT.

The Inola field is located in Rogers and Wagoner counties about 22 miles east of Tulsa and 7 miles west of Inola, along the Verdigris River, in Tps. 19 and 20 N., R. 16 E. There are no available data at hand concerning the opening wells in this field. Some of the early wells were good producers and were sufficient to stimulate much activity in developing the territory. A test in the SE. ¼ sec. 31, T. 20 N., R. 16 E., was reported to have produced about 12 barrels per hour on initial flow from the 670-foot sand. As a general average, the better wells made from 170 to 270 barrels per day initial production.

Late 1914 developments were out of the ordinary and stamped the field as a very rich discovery. Three wells in sec. 9, T. 19 N., R. 16 E. were reported at 1,200, 1,000, and 600 barrels respectively, initial production. Other good wells ranging from 50 to 400 barrels have been completed in secs. 3, 4, and 10, T. 19 N., R. 19 E. All of this production was reported to be from the 500-foot sand, which is probably the Tucker sand. No completions worthy of note have been reported for 1915. The following log is characteristic of this field.

Freedland Lewis well, in sec. 20, T. 19 N., R. 17 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil and gravel	25	25	Oil sand, taste and smell	5	375
Blue shale	25	50	Water sand	10	385
White sand (water)	30	80	Black shale	30	415
Blue shale	160	240	Lime	10	425
Sand	5	245	Black shale	73	498
Blue shale	75	320	Lime	82	580
Sand	10	330	Black shale	19	599
Blue shale	20	350	Sand oil taste and Smell	47	646
Lime	15	365	Lime	17	663
Shale	5	370			

CATOOSA FIELD.

GENERAL STATEMENT.

Most of the development near Catoosa is centered in T. 19 N., R. 15 E. In general the area may be classed as a gas rather than an oil field. Most of the gas wells average about 3,000,000 cubic feet initial volume. Wells have been completed in secs. 7, 10, 15, 16, and 33. T. 19 N., R. 15 E. and in secs. 8, 18, 20, and 28, T. 20 N., R. 15 E. The largest gas wells were in sec. 20, T. 20 N., R. 15 E., drilled by the Kansas Natural Gas Company and having an initial volume of 10,000,000 cubic feet per day, and in sec. 16, T. 19 N., R. 15 E. drilled by Frank Tack and reported to have had an initial volume of 15,000,000 cubic feet per day. The productive gas is usually encountered at about 900 feet, and is probably near the top of the "Mississippi lime."

CLAREMORE FIELD.

GENERAL STATEMENT.

This field was opened up by the completion of several good gas wells in 1914, and is located in T. 21 N., R. 16 E. southwest of Claremore. The wells range in initial volume from 1,000,000 to 7,000,000 cubic feet and had an average initial rock pressure of 400 pounds to the square inch. The productive gas sand is encountered from 810 to 825 feet and is probably near the "Mississippi lime."

CHELSEA FIELD.

GENERAL STATEMENT.

The Chelsea field, located just west of Chelsea, is an extension of the Coody's Bluff-Alluwe pool and will be discussed under that heading under Nowata County.

MISCELLANEOUS DEVELOPMENT.

At Talala, in sec. 5, T. 23 N., R. 16 E., the Verdigris River Oil & Gas Company completed a 3,000,000 cubic foot gas well at a depth of 800 feet. This is the fifth productive well drilled in this field.

Other wells have been completed between the Claremore gas field and Sequoyah in T. 21 N., R. 15 E. The first well was completed in sec. 24 and if the report was true, produced about 25 barrels of light green oil from a sand at a depth of 960 feet. Several other wells have been drilled in the same section.

The development in the vicinity of Collinsville will be discussed under Collinsville-Owasso-Dawson pool, Tulsa County. A number of scattering wells are being drilled throughout the county.

SUMMARY.

All of Rogers County may be considered as favorable territory. The production is very shallow, which, together with the high market price of oil, are stimulants for the renewal of development.

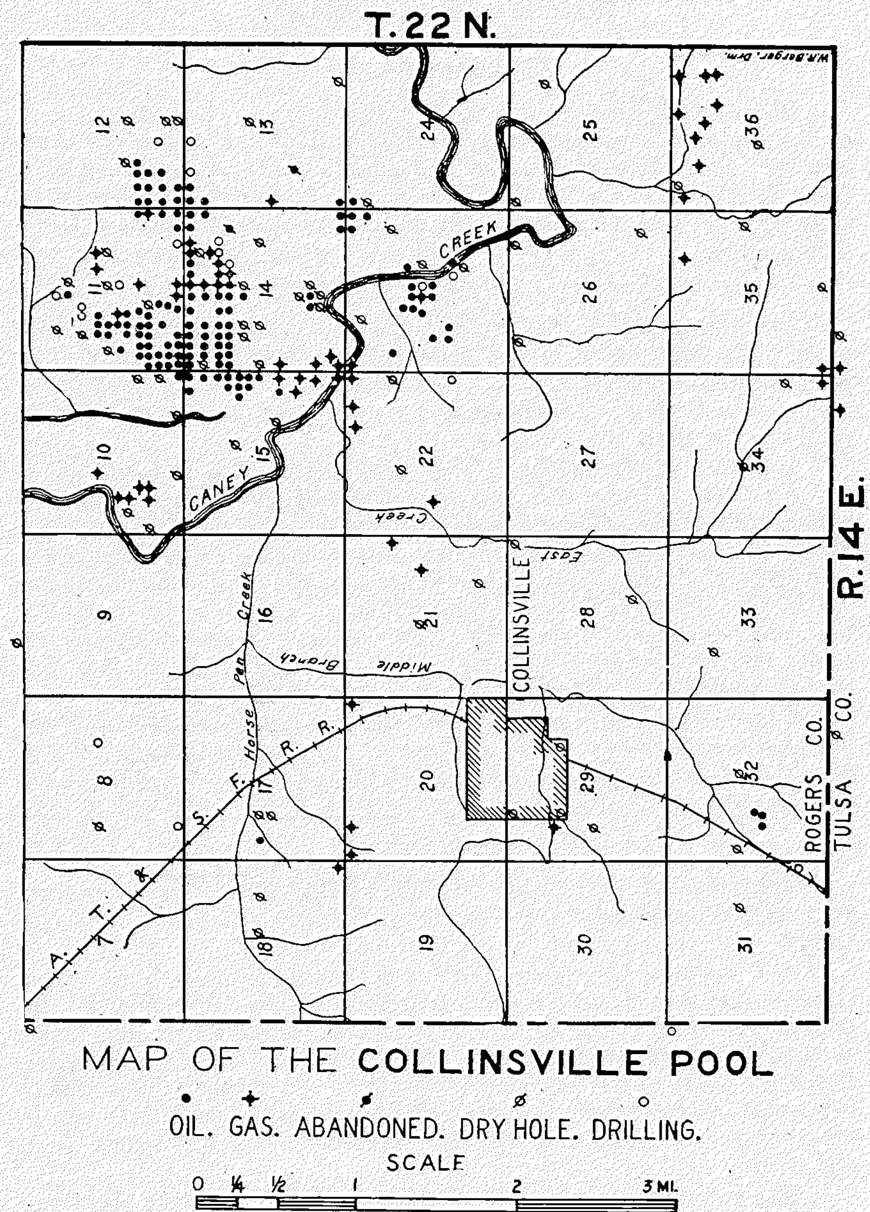

T. 22 N.
R. 14 E.
W.R. Berger, Drm.
CANEY CREEK
East Creek
Middle Branch
Pen Creek
Horse
COLLINSVILLE
A. T. & S. F. R. R.
ROGERS CO.
TULSA CO.
MAP OF THE COLLINSVILLE POOL
OIL. GAS. ABANDONED. DRY HOLE. DRILLING.
SCALE
0 1/4 1/2 1 2 3 MI.

Figure 19

ROGER MILLS COUNTY.

LOCATION.

Roger Mills County is located in the extreme west-central part of the State. Its western boundary is a part of the Texas-Oklahoma boundary line. It extends from T. 11 N. to T. 18 N., inclusive, and from R. 21 W. to R. 26 W. inclusive. It includes 25 entire townships and parts of 16 others. The entire area is approximately 1,160 square miles.

TOPOGRAPHY.

The topography of Roger Mills County may be divided into two parts. The topography in the eastern two-thirds of the county is a plain broken by low-lying red sandstone hills. The topography of the western third of the county is that of a level sand plain sloping gently to the west.

Marked topographic features of this area are the Antelope Hills and the Twin Hills, which are 75 to 100 feet above the surrounding plains. The Twin Hills are located in the southern part of T. 16 N., R. 25 W. They consist of two flat-topped buttes, one of which is partially divided. The capping consists of a silicious limestone 15 to 20 feet in thickness. The Antelope Hills are a few miles to the northwest of the Twin Hills. They consist of several flat-topped buttes and are presumably held up by the same kind of material that caps Twin Hills.

The northern part of the county is drained by Canadian River and streams tributary to it; the central part of the county by the Washita River and streams tributary to it; and the extreme southern part by streams tributary to the North Fork of Red River.

GEOLOGY.

The rocks at the surface in Roger Mills County are Permian, younger rocks which have not yet been definitely classified, and Quaternary.

The Permian formations, Greer and Quartermaster, outcrop. The Greer occupies an area of about 40 square miles in the extreme northeastern part of the county. It consists of red clays, shales, and sandstones interbedded with gypsum and dolomite. The Quartermaster formation occupies an area of approximately 650 square miles, extending from the east county line west, about two-thirds the distance across the county. It consists of soft red sandstones, and arenaceous clays and shales.

The rocks younger than the Permian, but of uncertain classification, occupy an area of approximately 350 square miles in the northwestern and southwestern parts of the county. These rocks consist of sand and some definitely bedded calcareous sandstones.

The Quaternary consists of alluvium, and is found along the valleys of Canadian and Washita rivers.

STRUCTURE.

The general attitude of the rocks in Roger Mills County is supposedly flat or perhaps with a slight dip to the west. The strata of the Woodward formation show steep dips, but in all directions. These erratic dips may be due to original bedding or slumping. The slumping may be due to the effect of gravity on rocks on steep hill slopes, or to cave-ins of gypsum caves and underground streams below the surface. It is difficult to determine the general dip of the Woodward formation. Any folding which may occur in the underground rocks is concealed by the erratic dips of the Woodward formation. The area of rocks younger than the Permian in northwestern and southwestern parts of the county is mostly sand with a few thin-bedded calcareous sandstones. The general attitude of the rocks in this area is hard to determine. In fact, the only continuously bedded strata in this area are those of the ledge capping Twin Hills and Antelope Hills. Readings made on the ledge capping Twin Hills show a slight west dip.

SUMMARY.

Productive oil and gas sands may underlie Roger Mills County, though at considerable depths. No production is expected in the Permian, which is barren of carbonaceous material. The approximate thickness of the Permian in Roger Mills County is 2,600 feet. The drill would have to penetrate this depth before Pennsylvanian rocks are reached. Considerable production has been found in Oklahoma at or near the contact between the Permian and Pennsylvanian. Good showings have been encountered in sands found in the upper Pennsylvanian though the greatest production has been found well toward the base of this formation. To make a complete test it would be necessary to drill entirely through the Pennsylvanian rocks, a distance of approximately 3,000 feet, making the depth of a complete test in Roger Mills County about 5,600 feet, with chances for production at shallower depth, but probably below 2,600 feet.

SEMINOLE COUNTY.

LOCATION.

Seminole County is located a little south and east of the center of the State. It extends from T. 5 N. to T. 11 N. inclusive, and from the center of R. 5 E. to 4 miles east of R. 7 E. inclusive. It contains 10 whole townships and parts of 18 others. The total area is approximately 626 square miles. The north boundary line of the county is North Fork of Canadian River, while Canadian River is the southern boundary.

TOPOGRAPHY.

Seminole County lies entirely within the Sandstone Hills region.

The topography is the result of weathering of alternating sandstone and shale that have low dips. There are more or less parallel escarpments of sandstone at rather great distances apart. These have been dissected by streams, giving to the surface a broken appearance.

Seminole County is drained by Canadian River and North Fork of Canadian River, and their tributaries. The largest tributary to Canadian River is Little River, which flows diagonally in a southeast direction across the southern part of the county.

The surface ranges in elevation from 750 to 1,200 feet, a difference of 450 feet. The lowest point in the county is where the east county line intersects Canadian River in sec. 18, T. 5 N., R. 8 E. The highest point is in sec. 1, T. 9 N., R. 7 E., about 3 miles southeast of Cheyarha.

GEOLOGY.

Pennsylvanian rocks are found at the surface in Seminole County. They consist of sandstones, shales, conglomerates, and a few limestones. The shales predominate. The following log will give a general idea of the underground formations:

Wewoka Trading and Realty Co., No. 4, in sec. 19, T. 8 N., R. 8 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Light clay	25	25	White shale (soft, caves badly)	10	1,115
Blue shale (sticky)	32	57	Hard limestone	5	1,120
Hard light limestone	4	61	Sandstone (medium hard)	22	1,142
Dark blue shale	49	110	Brown shale	16	1,158
Light sand (water 115 feet)	17	127	Hard white sandstone	12	1,170
Shale	7	134	Dark shale	140	1,310
Sandstone (broken formation)	28	162	Black shale	13	1,323
Blue shale, sand shells about 170 feet	108	270	Hard limestone	2	1,325
Red shale	5	275	White shale (caving)	20	1,345
Soft, light sand, full of water	10	285	Soft, white sand	44	1,389
Hard dark sand	10	295	White shale	61	1,450
Shale	35	330	Dark shale, show of oil at 1,460 feet	25	1,475
Dark limestone	30	360	White shale, sand and lime shells	58	1,533
Dark shale	35	395	Hard white sandstone	8	1,541
Hard limestone	10	405	White shale, top of sand; gas when struck	54	1,595
Light shale	81	486	Gray sandstone, flows oil and water	2	1,597
Black shale	24	510	White, soft sand, salt water	14	1,611
Red shale	105	615	Hard white sandstone, hole full of salt water	2	1,613
Dark and light shale	150	765	White sandstone	15	1,628
Limestone	3	768	Sandstone	10	1,638
White shale	21	789	Blue sandstone	16	1,654
White sand, much salt water, big oil show	42	831	Soft white sand	4	1,658
Light shale	4	835	Close formation	11	1,669
Shale	103	938			
Sandstone, good show of green oil 931 feet	10	948			
Light shale	132	1,080			
Black shale	25	1,105			

STRUCTURE.

The formations in Seminole County lie in a monoclinal fold which dips at a low angle to the west. This monoclinal fold is associated with the Ouachita Mountain uplift. Occasionally the general dip of the formations to the west is interrupted by gentle folds. As no detailed work has been done in this county, exact location of folds cannot be pointed out.

DEVELOPMENT.

Oil was discovered in Seminole County just east of Wewoka in 1908. The Wewoka Trading & Realty Company had a well which in a pumping test showed 144 barrels per day over a period of 60 days. There was little development between 1908 and 1912. A well drilled in Lot 12, Block 38, by the Wewoka Oil & Gas Company had a reported initial production of 10 barrels. A well drilled by the Oklahoma-Tennessee Oil & Gas Company in sec. 1, T. 7 N., R. 7 E. was a dry hole. The Sasakwa Oil & Gas Company had a dry hole in sec. 36, T. 6 N., R. 7 E.

The Weowna Oil & Gas Company had two showings of oil in their well in sec. 29, T. 6 N., R. 6 E., one showing at 820 feet, and a yield of 5 barrels at 2,500 feet.

SUMMARY.

Seminole County is within proved oil and gas territory. The results of drilling to date have been disappointing. More detailed work for surface indication of underground structure may help to locate more favorable territory.

SEQUOYAH COUNTY.

LOCATION.

The east county line of Sequoyah County coincides with the Oklahoma-Arkansas line and lies near the center of the eastern boundary line of the State of Oklahoma. It extends from T. 9 N. to T. 13 N. inclusive, and from R. 21 E. to R. 27 E. inclusive. It includes 14 entire townships and parts of 13 others. The entire area is approximately 734 square miles.

TOPOGRAPHY.

Sequoyah County lies almost entirely within the Sandstone Hills. A very small portion in the north-central part lies in the Ozark Plateau. As a whole the topography of the county is quite rough, though the northern part is rougher than the southern part. The hills are capped with massive sandstones. A good many of the valleys are anticlinal and the hills synclinal. The surface ranges in elevation from 410 feet to 1,500 feet, a distance of 1,090 feet. The lowest point is located in the southeastern part of the county where the Arkansas River leaves

Oklahoma. The highest point is near the SE. cor. of sec. 2, T. 13 N., R. 24 E. in the Brushy Mountains.

Some of the prominent topographic features are Brushy Mountains, which are in the north-central part of the county and which are 900 feet above the valleys at their base; Badger Mountain, which is 3 miles northwest of Sallisaw and which is 300 feet above the surrounding country; and Wild Horse Mountain, which is 4 miles south of Sallisaw and which is 300 feet above the surrounding country.

The county is drained by Arkansas River and streams tributary to it.

GEOLOGY.

Most of the rocks at the surface in Sequoyah County are Pennsylvanian. The rocks in a small area in the north-central part of the county are Silurian and Mississippian. The sands and gravels along the large stream valleys are Recent.

The Pennsylvanian rocks consist of shales, sandstones, and some coal. In a general way the shales conform to the valleys and the sandstones to the hills. The following logs will give a general idea of the underground strata.

Well No. 1, Nigger Creek Oil & Gas Co., Vian, Oklahoma.

Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*
Earth and mud	32	32
Black lime	20	52
Black shale	63	115
Lime	5	120
Gravel	3	123
Black shale	27	150
Lime rock	10	160
Shell rock	30	190
Lime rock	10	200
Flint shell	10	210
Shale	155	365
Hard sand rock	15	380
Brown shale	20	400
Lime shell	5	405
Black shale	95	500
Lime, very hard	50	550
Shale	80	630
Gray granite	5	635
Shale	25	660
Sand rock	15	675
Shale	80	755
Lime rock	65	820
White lime	30	850
Blue shale	60	910
Black shale	40	950
Sand rock	20	970
Lime rock	30	1,000
Granite, very hard	5	1,005
Shale	15	1,020
White lime	110	1,130
Sand rock	15	1,145
Black shale	25	1,170
White lime	15	1,185
Brown shale	5	1,190
Hard lime	20	1,210
Shale	2	1,212
Lime rock	13	1,225
Sand rock	25	1,250
Lime rock	20	1,270
Hard blue lime	50	1,320
Hard white lime	75	1,395
Brown shale	45	1,440
White lime	10	1,450
Water sand	58	1,508
Sandy white lime	12	1,520
White lime	180	1,700
Gray lime, hard	30	1,730
Blue lime	7	1,737
Blue shale	23	1,760
Blue lime	40	1,800
Water sand	35	1,835
Green lime	12	1,847
Water sand	10	1,857
Green lime	18	1,875
Water sand	10	1,885
Green lime	18	1,903
Red sand rock	5	1,908
Blue shale	5	1,913
Green lime	5	1,918
Gray lime, hard	4	1,922
Water sand	17	1,939
Sand	6	1,945

Log of the lower portion of the Sallisaw well, in SW. ¼ SE. ¼ NE. ¼ sec. 5, T. 11 N., R. 24 E.

Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*
Black shale		1,905
Sand	8	1,913
Coarse hard sand	3	1,916
Loose sand	6	1,922
Hard blue lime	2	1,924
Blue lime, extra hard	4	1,928
Hard blue lime	4	1,932
Sand	8	1,940
Blue shale and sand	3	1,943
Sand stone and shale	5	1,948
Hard black shale	31	1,979
Good sand	10	1,989
Blue shale	232	2,221
Lime shell and gray sand stone	45	2,266
Blue shale and occasional shell	85	2,351
Gray sand stone, lime shells	46	2,397
Hard blue shale mixed with grit	37	2,434
Hard gray lime	30	2,464
Blue shale with occasional shell	113	2,577
Hard blue lime without break	23	2,600
Good coarse sand showing oil	19	2,619
Blue shale and sand	18	2,637
Hard lime shell	6	2,643
Blue shale	34	2,877
Hard blue lime without break	46	2,923
Sand, gray	24	2,947
Blue shale	43	2,990
Sand	3	2,993
Blue shale	37	3,030

STRUCTURE.

In general, the Pennsylvania strata lie in a rather low, northwest-dipping monocline. Locally there are variations in this general northwest dip. The axis of an anticline extends from a point near the center of sec. 34, T. 12 N., R. 23 E., almost due east to the E. ¼ cor. sec. 36, T. 12 N., R. 23 E., a distance of 2½ miles. The strata on the south limb of this anticline dip at angles from 10° to 15°. The strata on the north limb of this anticline dip at angles from 8° to 10°.

The axis of an anticline extends from the center of the NE. ¼ of sec. 33, T. 12 N., R. 24 E., northeast to the center of sec. 27, T. 12 N., R. 24 E., where it swings to almost due east and extends to the center of the NE. ¼ of sec. 29, T. 12 N., R. 25 E. The linear extent of the axis of this anticline is approximately 5 miles. The strata on the south limb of the anticline dip at angles from 8° to 10°; those on the north limb from 3° to 5°.

There is a small anticline in T. 11 N., R. 25 E., whose axis extends from a point near the center of the SE. ¼ of sec. 32, northeast to a point near the center of sec. 27, a distance of 2 miles.

The axis of an anticline extends from a point near the W. ¼ cor. of sec. 26, T. 11 N., R. 25 E., northeast to a point about one-fourth mile north of the NE. cor. of sec. 20, T. 11 N., R. 26 E., a distance of 4 miles. The strata on the south limb of this anticline dip from 7° to 20°; those on the north limb from 5° to 12°.

It is noteworthy that in all the above anticlines the steeper dips are found on the south limb of the anticline in each case. Also the strata of the axes of the anticlines are parallel and also are parallel to the general strike of the strata. There may be other anticlinal folds, but the short time given for field work in Sequoyah County permitted the mapping of only those noted above.

A fault enters Sequoyah County from Cherokee County at the NE. cor. of T. 13 N., R. 23 E., and extends southwest to a point near the center of T. 12 N., R. 22 E., a distance of approximately 15 miles. This fault has brought Silurian, and Mississippian strata in contact with Pennsylvanian.

DEVELOPMENT.

There has been some drilling near the town of Vian on the Vian anticline. Gas was found.

A few years ago a well was drilled near Sallisaw in the SW. 1/4 of SE. 1/4 of NE. 1/4 sec: 5, T. 11 N., R. 24 E. This well proved to be dry. Recent reports show that about 4,000,000 cubic feet of gas was encountered in a well near Upson Switch.

A well was drilled in sec. 19, T. 11 N., R. 12 E., just east of Muldrow. This well was located on the axis of an anticline which runs east-west through Muldrow. A gas sand was encountered at a depth of 1,200 feet. The production was estimated to be 500,000 cubic feet daily.

SUMMARY.

All the production to date in Sequoyah County has been gas. found in the north and western parts of the county. This puts the county in proved gas territory. There are known anticlines in the county, but the fact that there is faulting within the county, and that the Pennsylvanian rocks may be of comparatively small vertical section has caused some hesitancy in drilling in otherwise favorable looking structures

STEPHENS COUNTY.

LOCATION.

Stephens County is located in the south-central part of the State. It extends from the middle of T. 3 S. to T. 2 N. inclusive, and from R. 4 W. to the middle of R. 9 W. inclusive. It includes 20 whole townships and parts of 10 others. The county is rectangular in shape, being 33 miles in an east-west direction and 47 miles in a north-south direction, with a total area of 891 square miles.

TOPOGRAPHY.

Stephens County lies in the Redbeds Plains region. The surface varies from level or gently rolling to hilly. The highest elevations are in the northern part of the county, where a maximum height above sea level is about 1,400 feet. The average elevation in the northern part of the county is about 1,100 feet. In the southern part of the county the average elevation is between 950 and 1,000 feet. The lowest elevation is 875 feet. The entire drainage of the county is to the south and southeast. Wildhorse Creek and its tributaries drain the eastern and northeastern parts into Washita River. The southern and western parts are drained by Big Beaver Creek and Mud Creek and tributaries into Red River.

GEOLOGY.

The surface rocks of Stephens County are classified as Permian Redbeds. However, these rocks exposed have not been in all cases fully correlated or differentiated and in the general construction of the geology of this region the rocks are termed as Redbeds of uncertain relationship. On the geological map of western Oklahoma, which accompanies this report (Pl. III), the area embraced in Stephens County is classed in the area of undifferentiated Redbeds. However, recent investtigations which have been made have aided materially in correlating certain formations, and maps to be prepared in the near future will show considerable areas of known formations extending through Stephens County. For instance, one of the most prominent sandstones which outcrops in the county is now definitely thought to be the Whitehorse sandstone, which lies near the top of the Woodward formation. In places this sandstone is capped by a dolomitic limestone which is also characteristic of the top of the Woodward formation to the northward. These occurrences of the Whitehorse sandstone in the area where it has not been mapped prior to this time is of special interest from both a geographical and structural standpoint. It is probable that some Cretaceous and Tertiary deposits also occur in the eastern and southern parts of the county. Detailed mapping of similar formations to the eastward in Carter County and to the south in Jefferson County has indicated that at least isolated areas of these rocks may be found.

The general geology of the county is discussed in the reports given on the following pages dealing with the Cruce and Loco gas fields.

The Whitehorse sandstone mentioned above may be described briefly as follows, both as to its occurrence in Stephens County and in counties to the northwest, where it is typically developed.

The Whitehorse sandstone lies at or near the top of the Woodward formation. It consists of 100 to 200 feet of light red sandstones and shales. Generally, it is regularly stratified and in some cases considerably inclined, the cross-bedding often giving at first glance the impression of dips and structural features. In most of the areas of its outcrop the Whitehorse sandstone weathers locally into conspicuous buttes and mesas. It derives its name from the Whitehorse Springs in Woods County, and from this point running southward it forms a line of conspicuous buttes which bear the local names of Lone Butte, Potato Hill, Watersign Hill, Wildcat Butte, Red Hill, and Caddo County Buttes. On to the southward this sandstone is exposed along the Washita from near Chickasha south and westward into the vicinity of Anadarko, where it forms bold bluffs both north and south of the river and extends as far west as Mountain View. It is also prominent in the vicinity of Cement, Rush Springs, and the Cruce gas field. Ledges of the sandstone occurring farther south into Stephens County and to the westward and outcropping north of the Wichita Mountains in the vicinity of Hobart and Harrison possibly belong to the same general horizon. As above stated, the local occurrence of dolomitic limestones on the top of the sandstone buttes is another means of correlating the sandstone outcrops with the Whitehorse.

The following log shows in general the character of the subsurface formations.

F. H. Marley well No. 1, in SE. 1/4 SW. 1/4 sec. 1, T. 4 S., R. 9 W.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Red bed, soft	185	185	Blue shale	10	1,635
Water sand	5	190	Red beds	15	1,650
Red beds	140	330	Blue shale	10	1,660
Water sand	5	335	Red beds	40	1,700
Red beds	290	625	Water sand	10	1,710
Water sand	10	635	Red beds	75	1,785
Red beds	200	835	White slate	5	1,790
Water sand	5	840	Water sand	8	1,798
Red beds	33	873	Red beds	25	1,823
Gas sand	10	883	Blue shale	32	1,855
Red beds	17	900	Water sand	40	1,895
Brown shale	35	935	Blue shale	10	1,905
Red beds	55	990	Red beds	10	1,915
Gray slate	40	1,030	Blue shale	10	1,925
Red beds	355	1,385	Black shale	25	1,950
White shale	25	1,410	Lime rock, fossils (?)	3	1,953
Water sand	22	1,432	Black sand	5	1,958
White slate	8	1,440	Blue shale	17	1,975
Brown slate	38	1,478	Red beds	15	1,990
Water sand	27	1,505	Lime shell	15	2,005
Blue shale	25	1,530	Blue shale	20	2,025
Brown shale	30	1,560	Red beds	25	2,050
Blue shale	12	1,572	Blue slate	95	2,145
Brown shale	8	1,580	Lime shell, hard	10	2,155
Blue shale	25	1,605	Blue shale	10	2,165
Red beds	20	1,625	Red rock	20	2,185

STRUCTURE.

In a general way the structure is related to the topography. All of the principal streams are synclinal along all or a part of their courses, and in general the divides are anticlinal. However, there are local variations in these conditions, and it is necessary to work out in detail every particular area in which prospecting is to be carried on. These conditions have proved true in the Loco, Fox, and Cruce development. In working out structural features in Stephens County, especially in the western and northern parts, it is necessary to take into consideration the extent of the synclinal basin which is formed as the rocks dip away from the Wichita Mountain uplift. The extent of this basin has not been fully determined, but it is very probable that it is a comparatively wide basin and covers a considerable area in southern Caddo, northeastern Comanche, and northwestern Stephens counties. On the other hand, it appears that the divides in northeastern Stephens County and the higher topographic features between Wooley and Comanche in the central-southern part of the county, and along the divides between the forks of Beaver Creek in the western part offer favorable localities for detailed investigation and prospecting for oil and gas. A well now being drilled near Kilgore in sec. 2, T. 2 N., R. 5 W. is reported to have encountered some gas. However, the well has not been completed and the actual results of the drilling are not known.

Two special areas have been mapped in detail and reports published concerning the investigations. These areas were mapped and the reports prepared under a cooperative agreement between the United States Geological Survey and the Oklahoma Geological Survey in 1913-14. The field work was in charge of Carroll H. Wegemann and R. W. Howell of the United States Geological Survey. The two reports are on the Loco gas field and the Duncan (Cruce) gas field. These reports are given in full in the following pages.

DETAILED SURVEYS OF SPECIAL AREAS.

THE LOCO GAS FIELD.

INTRODUCTION.

The Loco gas field is on the line between Stephens and Jefferson counties, Okla., about 3 miles southwest of the village of Loco and 10 miles northwest of the Healdton oil field. It is 18 miles east of the line of the Chicago, Rock Island & Pacific Railway. For many years asphalt deposits have been known to exist in this vicinity, but deep drilling for oil and gas was not begun until 1912. The first gas well was struck in the spring of 1913, about six months before the Healdton pool was discovered. Six other gas wells of capacities ranging from 6,000,000 to 20,000,000 cubic feet a day have been drilled, but no pipe line has yet been laid to the field and the wells are capped.

The field work on which the following report is based was done in November, 1913, the writer being assisted by Mr. R. W. Howell, of whose aid, both in the field and in the office, he desires to express his appreciation. The report has been prepared under a cooperative agreement between the United States Geological Survey and the Oklahoma Geological Survey, according to which each organization furnished a part of the funds necessary for the work.

Thanks are due to the Oklahoma Diamond Oil & Gas Co., the Washita Gas & Fuel Co., and Messrs. McQueen Bros. for logs of their respective wells; also to Mr. M. M. Hightower, Mr. W. J. Collier, and other residents of the district, who supplied valuable information and extended courtesies during the prosecution of the field work.

HISTORY OF DEVELOPMENT.

For many years asphalt seeps have been known to exist along a belt of territory lying southwest of the town of Loco, in Stephens County, Okla., and extending in a general northwesterly direction. In 1903 an unsuccessful attempt at development of the asphalt deposits was made by the Tar Springs Refining Co., whose works were built just south of the center of sec. 25, T. 3 S., R. 5 W. The refinery burned down soon after operations were begun, and current report states that owing to the lack of transportation facilities the venture would not in any event have been profitable. The same company drilled a well 1,000 feet northeast of the pit from which the asphalt-bearing sandstone was obtained, but apparently met with no success. It is reported that the well is not more than 600 or 700 feet deep.

R. V. LeGrande, of the Tar Springs Refining Co., after the burning or the asphalt plant, opened mines on grahamite deposits in sec. 6, T. 2 S., R. 4 W., 6 miles north of Loco, which for a time were worked with profit. He was also instrumental in putting down a dug well in search of oil near the south quarter corner of sec. 10, T. 3 S., R. 5 W., about a quarter of a mile north of a water well in which asphalt was encountered. The well was 142 feet in depth and by bailing twice daily would produce about 3 barrels of dark, heavy oil every 24 hours. The product was used in the vicinity as lubricating oil.

Deep drilling in the Loco field was begun by the Oklahoma Diamond Oil & Gas Co. in October, 1912. The first well was drilled in sec. 6, T. 3 S., R. 5 W., and encountered traces of oil and gas, but not in quantities sufficient to warrant development. Four other wells were drilled by the same company in the spring of 1913 in secs. 10 and 15, T. 3 S., R. 5 W. All obtained gas under heavy pressure, the estimated capacity of the wells ranging from 6,000,000 to 20,000,000 cubic feet a day. About the same time the Washita Oil & Gas Co. drilled a well in sec. 15 which had a daily capacity of 15,000,000 cubic feet. McQueen Bros. drilled in the SW. ¼ sec. 3 of the same township but obtained only a showing of oil. The Oklahoma Diamond Oil & Gas Co. drilled during the winter of 1913-14 a well in the NW. ¼ SW. ¼ sec. 14, T. 3 S., R. 5 W., which obtained a little heavy oil, but no gas in commercial quantity. During 1914 the same company drilled a dry hole in NE. ¼ NE. ¼ sec. 10, T. 3 S., R. 5 W., a gas well, in the NW. ¼ NW. ¼ sec. 15, T. 3 S., R. 5 W. and an oil well near the middle of sec. 9, T. 3 S., R. 5 W. This last-named well is reported to yield about 25 barrels of heavy petroleum daily, as well as gas in considerable quantity.

The Nippon Oil Co. is at the time of writing (April, 1915) drilling a well in the NE. ¼ SE. ¼ sec. 26, T. 3 S., R. 5 W.

TOPOGRAPHY.

Loco is on the southwest edge of a belt of sandy wooded country which borders the Arbuckle Mountains. The territory is rather more rolling than that of the treeless plains farther west, but the relief does not exceed 150 feet. The drainage of the Loco field is effected by branches of Mud Creek, a tributary of Red River.

STRATIGRAPHY.

The rocks exposed in the Loco field are of Permian age and consist of sandstone, shale, and fine conglomerate. The rocks lie stratigraphically lower than the beds that are exposed on the surface of the plains region a few miles farther west and are considerably more sandy. The following section of the lowest rocks exposed in the Loco field, which was measured near the crest of the anticline in the SW. 1/4 sec. 24, T. 3 S., R. 5 W., will give a general idea of the nature of the rocks exposed, particularly the asphalt-bearing beds.

Section of rocks exposed in the SW. 1/4 sec. 24, T. 3 S., R. 5 W.

Top.	Feet.
Sandstone, coarse, buff, or brown, composed of quartz, feldspar, zircon, and a highly altered manganese (?) mineral. Cement brown to opaque; some grains well rounded, others angular. Average diameter of grains, 0.303 millimeter	15
Shale, blue	3
Shale, red (poorly exposed); about 3 feet above the base fragments of very dark ferruginous sandstone lying on the surface of outcrop	35
Shale (?); near the top are great numbers of round and irregular-shaped pebbles resembling concretions apparently derived from a bed of shale conglomerate similar to those described by various authors as occurring in the Wichita formation.*	5
Sandstone, impregnated with asphalt; weathers white	3
Sandstone, calcareous, mottled gray and brown; weathers into large rounded forms, black on surface. Consists of quartz with apatite and rutile inclusions, zircon, and plagioclase; quartz grains somewhat separated from one another, subangular. Cement calcite, parts of which are very impure, giving rise to the mottled appearance	5
Sandstone, greenish white, thin bedded, fine grained. Cement calcite. Some of the layers carry a little asphalt	5
Shale, red and gray	3
Sandstone, cross-bedded, greenish white to black, according to the nature of the cement, which in some layers is calcite and in others entirely asphalt. Consists of quartz, with apatite and rutile inclusions, zircon in comparatively large amount, muscovite and hornblende (?). The quartz grains are in some specimens separated from one another as if forced apart by the crystallization of the calcite forming the cement between them	5
Shale conglomerate containing pebbles which resemble concretions, bluish gray	1 1-6
Shale, red.	

Overlying the rocks described in the above section are those which form the surface in the timbered belt northeast of the Loco anticline.

*Udden, J. A., and Phillips, D. McN., A reconnaissance report on the geology of the oil and gas fields of Wichita and Clay counties, Tex.: Texas Univ. Bull. 246, Austin, 1912.

These consist of alternating beds of shale and sandstone in about equal amounts. The sandstone beds are for the most part white, bluish white, or gray, but in some places red. The rock is comparatively coarse grained, some thin beds being conglomeratic and the individual grains being well rounded. The cement is calcareous. The character of the beds is shown by the following stratigraphic section, which was measured in a deep valley between the old grahamite mines in sec. 6, T. 2 S., R. 4 W., 6 miles north of Loco.

Section of rocks exposed near grahamite mines in sec. 6, *T.* 2 *S.*, *R.* 4 *W.*

Top.	Feet.
Sandstone, white, with brown ferruginous layers	15
Sandstone, white, flecked with brown. Under the microscope shows quartz with rutile and apatite inclusions, altered feldspar, zircon, and tourmaline	15
Cement calcite. Brown specks, probably manganese. Average size of grain 0.126 millimeter	10
Covered; near top 2 to 4 feet of brown ferruginous sandstone, forming ledge	22
Sandstone, buff	2
Covered	20
Sandstone, white; upper part calcareous	6
Sandstone, bluish black, coarse. Contains small round concretions the size of buckshot, which weather out on surface, apparently of same material as mass of the rock. On extraction with chloroform, yields asphaltic oil in considerable amount	12
Sandstone, dark brown, coarse. Color probably due in part to content of manganese oxide. Upper part of bed cream-color streaked with dark brown	9
Conglomerate, pebbles of blue shale, cemented by calcite, hard, dolomite	½
Sandstone, brown and black	3
Shale, blue	18
Sandstone, white, buff, and brown, hard; calcite cement; contains round pyrite concretions as much as 2 inches in diameter. The basal layers are irregularly impregnated in streaks and patches with petroleum of which the rock smells strongly. The upper layers of the ledge are shaly and cross-bedded. The bed resembles in many respects the lower asphalt-bearing sandstone exposed in sec. 24, T. 3 S., R. 5 W.	10
Conglomerate, pebbles of blue shale cemented by calcite; a shade of red in some layers	2
Shale, blue, sandy, blotched with red. Base not exposed.	

The sand series is about 300 feet thick and forms a marked feature of the Permian over a considerable area. It constitutes the surface rock in the wooded country northeast of the Healdton field as well as the high divide in the vicinity of the grahamite mines. This divide may be traced northwestward to the "base line road" 5 miles southeast of the Duncan gas field, and it is probable that the low hills that partly encircle the Lawton oil and gas field, 50 miles farther west, are formed by this same sandy series.

Fossil plants have been collected in the vicinity of Dixie, 6 miles east of Loco, from the red shale and fine-grained sandstone within or below the sandy series just described and have been determined by David White as probably of Permian age.

Knowledge of the strata underlying the surface in the Loco field is furnished by the logs of the deep wells. The beds consist of alternating shale and sandstone to a depth of about 800 feet. The red shale extends to depths ranging from 500 to 700 feet, the shale below being prevailingly blue or gray. The sandstone beds in the series just described appear to be fairly continuous over the area and by means of them the logs of the various wells may be correlated. Below this series, which is believed to be of the Permian age, lie thick beds of blue or black shale alternating with beds of limestone. The rocks include also beds of sandstone, but the section as recorded in the logs of three include also beds of sandstone, but the section as recorded in the logs of three of the deeper wells varies greatly, as if different parts of a rock series were penetrated in different wells. This series is believed to be of Pennsylvanian age, which is indicated by certain fossils obtained in the drill cuttings in some of the deeper wells, and is supposed to lie unconformably below the Permian strata. If the Pennsylvanian beds here dip at a considerable angle it is evident that wells put down at different localities will not encounter equivalent beds, and that the variations noted in the well logs are thus easily accounted for. The precise line of demarcation between the Pennsylvanian and the overlying Permian can not be determined, but it probably lies within 200 feet of the sand that in the productive wells is the principal gas horizon. In well No. 6 of the Oklahoma Diamond Oil & Gas Co. for example, it would appear to lie somewhere between 650 and 850 feet below the surface, possibly just above the 25 feet of limestone recorded at 860 feet. In wll No. 7 of the same company which is about a mile northwest of well No. 6, this limestone is not recorded, and in well No. 1 of the Oklahoma Diamond Oil & Gas Co. which is 3 miles northwest of No. 7, the beds between 1,086 and 1,461 feet are for the most part limestone.

The unconformity noted in the wells of the Loco field may be well observed along the west end of the Arbuckle Mountains, about 15 miles northeast of the field. Here the horizontal Permian beds lie unconformably on steeply dipping strata ranging in age from Ordovician to Carboniferous, and the same general condition may be seen along the Wichita Mountains, which lie 50 miles northwest of the Arbuckle Mountains. This unconformity between the Pennsylvanian and the Permian appears to have been only local in extent, for in north-central Texas, where the same rocks are exposed at the surface, the Cisco formation, the highest division of the Pennsylvanian, appears to be perfectly conformable with the overlying Permian beds. Somewhere between the Arbuckle-Wichita uplift and the Texas area the unconformity which exists along the mountains must disappear, but the Loco field is evidently well within the area affected by it. A tentative correlation between certain well logs of the Loco and Healdton fields seems to show that the gas-bearing sands at Loco lie within 200 feet of the surface on the crest of the Healdton dome. As most of the oil at Healdton is found in Permian strata at a depth of 800 or more feet below the surface it is evident that the Permian beds at Healdton are lower than any represented at Loco and that the Permian in the Healdton field as originally deposited was somewhat thicker than in the Loco area. The surface on which the Permian beds were deposited appears to have been one of considerable relief, and variations in the thickness of the Permian are probably due to the irregularities of the old land surface.

STRUCTURE.

Rock structure, as shown on the accompanying map, has been worked out from a comparison of the logs of the several wells and from observations on an asphalt-bearing sandstone which outcrops at many places in the Loco field and which lies about 600 feet stratigraphically above the principal gas-bearing horizon. This asphaltic sandstone, or rather series of sandstones, for the different beds are separated by thin beds of shale, is about 20 feet thick. At some places in the exposures it is possible to distinguish the relation of the particular bed on which observations are taken to the other beds in the series. The asphalt-bearing beds are thus great aid in an accurate determination of the structure, for by calculating the altitude of the base of the series throughout the field, the nature of the rock folds becomes apparent. The asphalt-bearing sandstones in this area are so uniformly impregnated with asphalt as to make it seem probable that they represent former oil sands which have been brought to the surface by erosion, the petroleum in them being oxidized to asphalt.

The largest exposures of the bed of asphaltic sandstone lie in secs. 23, 24, 25, and 26, T. 3 S., R. 5 W., and outline in cross section an anticline, the axis of which trends in a northwesterly direction. The crest of the dome in this vicinity lies in the middle of the SW. ¼ sec. 24, the base of the asphaltic sandstone layer here being at an altitude of 930 feet. From the crest the bed dips to the northeast and to the southwest. To the northeast it may be traced for a quarter of a mile, being well exposed in the SE. ¼ NW. ¼ sec. 24, where, however, the rock is entirely free from asphalt and consists of a hard, compact, dirty-white calcareous sandstone. This rock appears to be identical with certain thin beds that alternate with the asphaltic sandstone beds farther southwest. The base is at an altitude of 894 feet, showing a dip of 36 feet to the northeast between this exposure and the one above described. The bed northeast of this point appears to be practically horizontal for at least half a mile, as the base of what is believed to be the same bed exposed 1,300 feet west of the northeast corner of sec. 24 is at an altitude of 899 feet.

In the SE. ¼ sec. 18, T. 3 S. R. 4 W., are exposed two beds of asphalt-bearing sandstone, the stratigraphic distance between the bases of which is 40 feet. These two sandstone beds are believed to represent the asphalt-bearing sandstone together with the highest bed in the exposure on the wooded knoll at the crest of the dome in the SW. ¼ sec. 24, T. 3 S., R. 5 W. If this correlation is correct the lower bed in the SE. ¼ sec. 18, T. 3 S., R. 4 W., lies 41 feet higher than the same stratum a mile to the west, and in the NE. ¼ sec. 24 there is a shallow syncline, on each side of which are showings of asphalt. The axis of this syncline plunges to the north.

Southwest of the crest of the anticline, in the SW. ¼ sec. 24, T. 3 S., R. 5 W., the asphalt-bearing stratum dips to the southwest. Its base is at an altitude of 913 feet in the NE. ¼ SE. ¼ sec. 23 and at 889 feet one-third of a mile farther west. In the SE. ¼ NW. ¼ sec. 26 the same stratum is at an altitude of 890 feet, or 40 feet lower than it is on the crest of the dome a mile to the northeast. The same bed is exposed in the NE. ¼ NW. ¼ sec. 25, T. 3 S., R. 5 W., at an altitude of 915 feet, and at the old asphalt works just south of the center of the section it lies at an altitude of 918 feet. It is reported that asphalt was struck in a well 48 feet in depth in the NE. ¼ NW. ¼ sec. 35, T. 3 S., R. 5 W. The altitude of the surface at this well is 865 feet. The shape of the crest of the fold is indicated in sec. 25, T. 3 S., R. 5 W., and sec. 30, T. 3 S., R. 4 W., by altitudes on the bed of sandstone already mentioned as lying about 40 feet above the asphalt-bearing bed. The base of a sandstone believed to represent this higher bed lies at an altitude of 978 feet in the NW. ¼ NW ¼ sec. 30, T. 3 S., R. 4 W. In the SE. ¼ NE. ¼ sec. 25, T. 3 S., R. 5 W., it is at an altitude of 980 feet, the bed being therefore practically flat between the two places. From the latter point, however, the dip is to the southwest, the base of the bed lying at an altitude of 945 feet in the SE. ¼ SW. ¼ sec. 25, T. 3 S., R. 5 W. What is believed to be the same bed is exposed in the NW. ¼ NW. ¼ sec. 36, where its base is at an altitude of 936 feet.

The extension of the Loco anticline to the southeast is indicated at several places in the southwestern part of T. 3 S., R. 4 W., by the presence of the lower asphalt-bearing sandstone. In the NW. ¼ SE. ¼ sec. 31 the bed is exposed at an elevation of 920 feet above sea level. A few hundred feet northwest of this locality sulphur water was encountered in a dug well. In the SE. ¼ SW. ¼ of the same section water carrying the taste of petroleum was found in a well at a depth of 43 feet, or about 930 feet above sea level. The upper sandstone is here exposed at the surface, its base being at an altitude of 967 feet, and it is probable that the water in the well comes from the top of the lower or asphalt-bearing bed, which is about 21 feet thick. The base of this bed is therefore at an altitude of 909 feet at this locality. The water in the well belonging to E. A. Burton, in the SE. ¼ SE. ¼ sec. 30, T. 3 S., R. 4 W., is highly impregnated with asphalt, which coats the bucket in which the water is drawn. The altitude of the mouth of the well is 962 feet, and the well is reported to be 54 feet in depth, so that the asphalt bearing sandstone probably lies at an altitude of about 908 feet. In the NW. ¼ NW. ¼ sec. 32, T. 3 S., R. 4 W., salt water was encountered in a well, and in the NE. ¼ NW. ¼ of the same section the asphalt-bearing sandstone outcrops at an altitude of 912 feet. Asphalt is reported in a well in the SE. ¼ NE. ¼ sec. 32, T. 3 S., R. 4 W., which is said to be 40 feet in depth. The altitude of the mouth of the well is 919 feet. A test well 2,100 feet in depth has been drilled in the SW. ¼ NE. ¼ sec. 32, on the Boles farm, which did not encounter oil or gas in paying quantity. Sulphur water is found in a well in the SE. ¼ SW. ¼ sec. 33, in the same township, and salt water is found in a well belonging to Julia Long in the NW. ¼ NE. ¼ sec. 3, T. 4 S., R. 4 W. There are no surface indications of asphalt or petroleum in this vicinity nor to the east as far as the wells in the SE. ¼ sec. 36, T. 3 S., R. 4 W. at the northwest end of the Healdton field. In the NW. ¼ NW. ¼ sec. 29, T. 3 S., R. 4 W., asphalt is reported in an old well, and in the SE. ¼ SW. ¼ sec. 21 of the same township the water in a well on the Sessum farm tastes slightly of petroleum. The well is reported to be 119 feet in depth, and the altitude of its mouth is 861 feet.

Northwest of the outcrops in secs. 23 and 24, T. 3 S., R. 5 W., above described, the lower or asphalt-bearing sandstone is exposed in the NW. ¼ SE. ¼ sec. 14 at an altitude of 898 feet. A mile southwest of this locality a sandstone which is believed to represent the highest bed exposed in the SW. ¼ sec. 24, T. 3 S., R. 5 W., is exposed, its base being at an altitude of 908 feet. In the NE. ¼ NW. ¼ sec. 27 an asphalt seep known as the Tar Spring occurs in what is believed to be the lower or asphalt bed, the base of the asphalt stratum being at an altitude of 862 feet.

Along the stream valley in the NE. ¼ sec. 11 a bed of sandstone is exposed continuously for about half a mile. Altitudes taken at several places along the bed indicate a rather pronounced dip north-northeastward. In the N. ½ sec. 4, T. 3 S., R. 5 W., three different beds of sandstone are exposed, which have a pronounced dip to the northeast. Their relation to the beds thus far described could not be determined. Just north of the township line road, in the SE. ¼ SW. ¼ sec. 31, T. 2 S., R. 5 W., the lower or asphalt-bearing sandstone is exposed, the asphalt stratum being at an altitude of 955 feet. About 600 feet farther east the hill is capped by the upper sandstone, the base of which is at an altitude of 997 feet. The asphalt-bearing bed is exposed in the SW. ¼ SW. ¼ sec. 31, where it lies at an altitude of 936 feet. There is therefore in this locality a dip to the west of 19 feet in about one-third of a mile, and the anticlinal axis lies farther east, its crest being perhaps coincident with that of the wooded hill, part of which lies in the NE. ¼ sec. 6, T. 3 S., R. 5 W.

The structure in the vicinity of the gas wells has been worked out principally by means of the information afforded by the well logs, but as it is often difficult to make exact correlations between the logs of different wells conclusions based upon them must be taken as more or less conjectural. The gas wells in the NE. ¼ sec. 15, T. 3 S., R. 5 W., appear to be on the point of an anticline which extends in a northwest direction. North of the wells in the east part of section 10 there is a rather steep dip to the northeast, which is present also in the NE. ¼ sec. 11, T. 3 S., R. 5 W., as is shown by the exposures of a bed of sandstone in this locality. South of the wells in the south half of sec. 15 there is a dip to the southwest. Under these conditions the end of the anticline in the NE. ¼ sec. 15 constitutes a most favorable location for the accumulation of gas.

In the SW. 1/4 sec. 24, T. 3 S., R. 5 W., there is a second end or "nose" of an anticline which might be tested by a well located at the south end of the small wooded knoll at this locality. The dips on the flanks of this fold are not, however, as steep as are those on the flank of the similar structure noted in sec. 15. If the well in the SE. 1/4 SW. 1/4 sec. 24 were successful the area to the south should be tested, particularly the NE. 1/4 sec. 25, T. 3 S., R. 5 W., the southwestern part of sec. 30, T. 3 S., R. 4 W., and the northeastern part of sec. 31, T. 3 S., R 4 W. The well of the Nippon Oil Co., in the NE. 1/4 SE. 1/4 sec. 26, T. 3 S., R. 5 W., is on the flank rather than on the crest of the anticline.

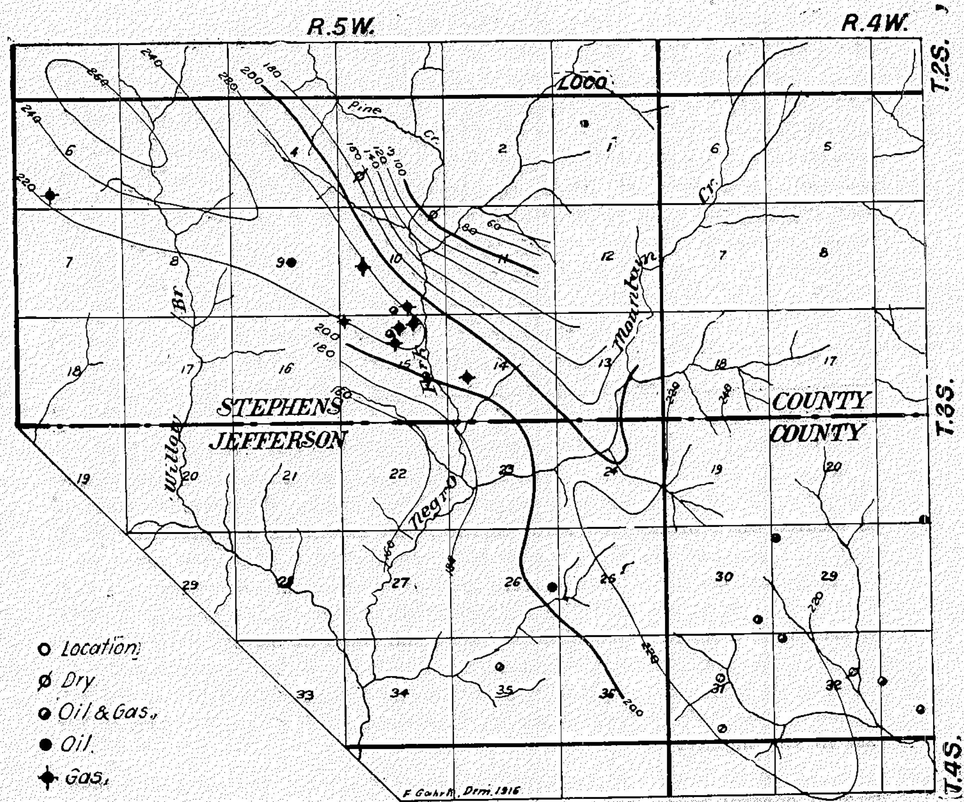
If the lower of the two asphaltic sandstone beds exposed in the SE. 1/4 sec. 18, T. 3 S., R. 4 W., is the same as the bed exposed in secs. 24 and 25, T. 3 S., R. 5 W., it is evident that the strata are higher in this locality than they are farther to the west, and a test well might be drilled near the southeast corner of sec. 18, T. 3 S., R. 4 W.

The well drilled by the Oklahoma Diamond Oil & Gas Co. near the center of sec. 9, T. 3 S., R. 5 W., on the Ida Billy farm, obtained dark and rather heavy oil with a production as reported of 25 barrels. This well appears to be located on a broad structural terrace, and as far as our present knowledge goes most of the N. 1/2 sec. 9, with the exception of a small area near the northeast corner, should be territory as good as that on which the well is situated. Well No. 1 of the Oklahoma Oil & Gas Co., in the SE. 1/4 SW. 1/4 sec. 6, T. 3 S., R. 5 W., obtained only showings of oil and gas. The location of the anticlinal axis in this locality is somewhat uncertain; it appears to lie about three-quarters of a mile northeast of well No. 1. A well drilled in the NE. 1/4 NE. 1/4 sec. 6, T. 3 S., R. 5 W., should prove a fair test of the locality.

The above suggestions in regard to prospecting the field are made after a careful consideration of all the data available. The reader should bear in mind, however, that rock outcrops in parts of this area are very few and that a slight error in correlation between beds in surface exposures or in well logs might change materially the apparent shape of the structure. If the information concerning the area is meager, the predictions in regard to the location of oil and gas pools in it must be either meager or more or less conjectural. The writer in his work has endeavored to go as far as possible in his predictions, trusting to his reader to interpret his remarks in the spirit in which they are written.

ORIGIN OF THE OIL AND GAS.

Oil and gas in the Loco field occur in small quantities in many of the Permian sandstone beds, but the principal gas-bearing zone consists of one or more beds of sandstone occurring within 250 feet of the base of the Permian at depths ranging in the various wells from 650 to 750 feet below the surface. In certain of the deeper wells showings of oil and gas have been obtained in the strata which underlie the Permian and which are probably Pennsylvanian in age. From the fact that in the great oil fields of northern Oklahoma the oil is obtained from beds of Pennsylvanian age, as well as from the nature of the sedimentary rocks themselves (the



LOCO GAS FIELD.

STRUCTURAL WORK DONE IN COOPERATION WITH U.S.G.S. By C.H. Wegemann

Figure 20.

rocks of the Pennsylvanian containing more organic matter than do those of the Permian, it seems probable that the oil which is found in Permian beds is derived from the underlying older rocks. In the Loco field these rocks are shown to be of Carboniferous age by the crinoid stems and small pelecypods which have been obtained from the cuttings of wells Nos. 1 and 5 of the Oklahoma Diamond Oil & Gas Co. As the oil and gas appear to have accumulated in the Permian strata near the crests of folds, it is evident that the oil must have accumulated since the folding occurred. That the folding occurred in comparatively recent geologic time is indicated by the fact that along Red River southwest of the Loco field the smaller drainage shows a minute adjustment to the structure, which would not be the case had the folding taken place at a very remote period.[1]

[1] Wegemann, C. H., Anticlinal structure in parts of Cotton and Jefferson counties, Okla.: U. S. Geol. Survey Bull. 602, p. 34, 1915.

Many theories have been advanced to account for the origin and accumulation of oil, but none have met with universal acceptance. To the writer it seems most probable that oil and gas have been derived from organic matter contained in shale or limestone which has been distilled under conditions of heat and pressure produced by earth movement. The oil may have been impelled through the rock pores to its place of accumulation by water under the forces of capillarity and gravity, or it may have migrated through the rocks in the form of gas which afterward condensed into oil.

THE DUNCAN GAS FIELD, STEPHENS COUNTY, OKLAHOMA.

By C. H. Wegemann.

INTRODUCTION.

The Duncan gas field, sometimes known as the Hope field, lies in Stephens County, Okla., near the post office of Cruce, about 10 miles northeast of the town of Duncan.

The first well in the field was drilled about 1907, in the NW. ¼ SE. ¼ sec. 12, T. 1 N., R. 6 W., and is reported to have obtained some gas and oil but was abandoned. The Skelly Drilling Co. a few years later drilled three wells in the E. ½ sec. 12, T. 1 N., R. 6 W., and two dry holes, one a few rods west of the center of the same section and another in the NW. ¼ sec. 7, T. 1 N., R. 5 W. It is understood that these wells have since been taken over by the Wichita Gas & Fuel Co., which itself began drilling in the field on March 20, 1912. The company's first well, which was a "gasser," was drilled in the NW. ¼ SE. ¼ sec. 12 T. 1 N., R. 6 W. The company has drilled one other well in the same quarter section and two dry holes, one in the SW. ¼ SE. ¼ sec. 12, T. 1 N., R. 6 W., and one near the middle of sec. 1, T. 1 N., R. 6 W.

The principal flow of gas in the wells is obtained at about 850 feet, and the wells vary in production from 3,000,000 to almost 18,000,000 cubic feet a day. A pipe line has been laid from the field to Duncan and supplies that town with gas.

The present report has been prepared by the United States Geological Survey under a cooperative agreement with the Oklahoma Geological Survey, acording to which agreement each organization furnished a part of the funds necessary for the work.

The field work for the report was done in September, 1914, the writer being assisted by Mr. Ralph W. Howell, of whose careful work he desires to express his appreciation. Thanks are due to Mr. B. A. Barnes, a resident of Duncan, for much information in regard to the field; also to the Wichita Gas & Fuel Co., the Stephens County Oil & Development Co., and Mr. W. G. Skelly, for logs of wells drilled in the field.

DRAINAGE AND TOPOGRAPHY.

The Duncan field lies just south of the divide between Wild Horse and Brush creeks, both of which are branches of Washita River. The relief in the field is not over 250 feet, the most prominent topographic feature being an escarpment formed by a bed of sandstone which partially encircles the field. The region is for the most part covered with post-oak timber.

STRATIGRAPHY.

The surface rocks in the Duncan field are red beds of Permian age. They consist of shale, sandstone, calcareous sandstone and shale conglomerate. The shale is red or bluish gray in color. The sandstone is predominantly white or buff but is in some places red. The cement of the sandstone is calcareous and in some beds the lime content increases in amount until the rock is a calcareous sandstone. At the bases of certain of the sandstone strata, or embedded in them, are thin beds of conglomerate, the pebbles of which consist of fragments of shale. The fragments are more or less angular and do not appear to have been transported far from their place of origin, being of the same material as the ordinary Permian shale.

The most important bed or group of beds in the Duncan field structurally and stratigraphically is a series of sandstones and interbedded shale about 40 feet in thickness, which forms an escarpment that partly encircles the field. The surface of the bed is in most places timber-covered, and the line of wooded hills produced by its outcrop is a conspicuous topographic feature. The individual beds of the group are variable in thickness and extent but the group as a whole covers a broad area and has been traced for about 60 miles from a point north of Foster, a small settlement 18 miles east of the Duncan field, to the north flank of the Wichita Mountains. The sandstone in the Duncan field is white, but that in part of the adjoining area is pink or red, and there are places where the change from pink to red may be observed in a single outcrop. This sandstone group forms the best horizon marker in the region and it is by means of it that a considerable part of the structure in the Duncan field has been determined.

Below the sandstone lies about 100 feet of shale containing near its middle one or more thin beds of white sandstone, which are inconspicuous in outcrop. The shale is underlaid by beds of sandstone interstratified with shale, the whole being about 300 feet thick. Where the sandstone beds reach the surface they form rounded knolls or ridges, which, however, are inconspicuous as compared with the escarpment of the higher group of sandstone beds. Below the soft sandstone and shale beds, or about 400 to 500 feet below the base of the escarpment-forming sandstone, is a group of beds in which sandstone predominates and which, where it reaches the surface, produces hills and ridges of considerable height. The soil formed by this group of sandstone supports a thick growth of post oak like that of the higher escarpment-forming sandstone.

The nature of the strata which underlie the Duncan field is shown by the logs of the gas wells, the deepest of which is in the SE. ¼ NW. ¼ with thinner beds of white sandstone to a depth of 1,825 feet but below sec. 12, T. 1 N., R. 6 W. In this well red, brown, and bluish shale alternate this depth the shale is prevailingly blue. At 1,900 feet a 20-foot bed of limestone is recorded. From observations in adjacent fields, it is believed that the red color in this region is confined to the Permian and that thick beds of limestone are not found in that formation. It therefore

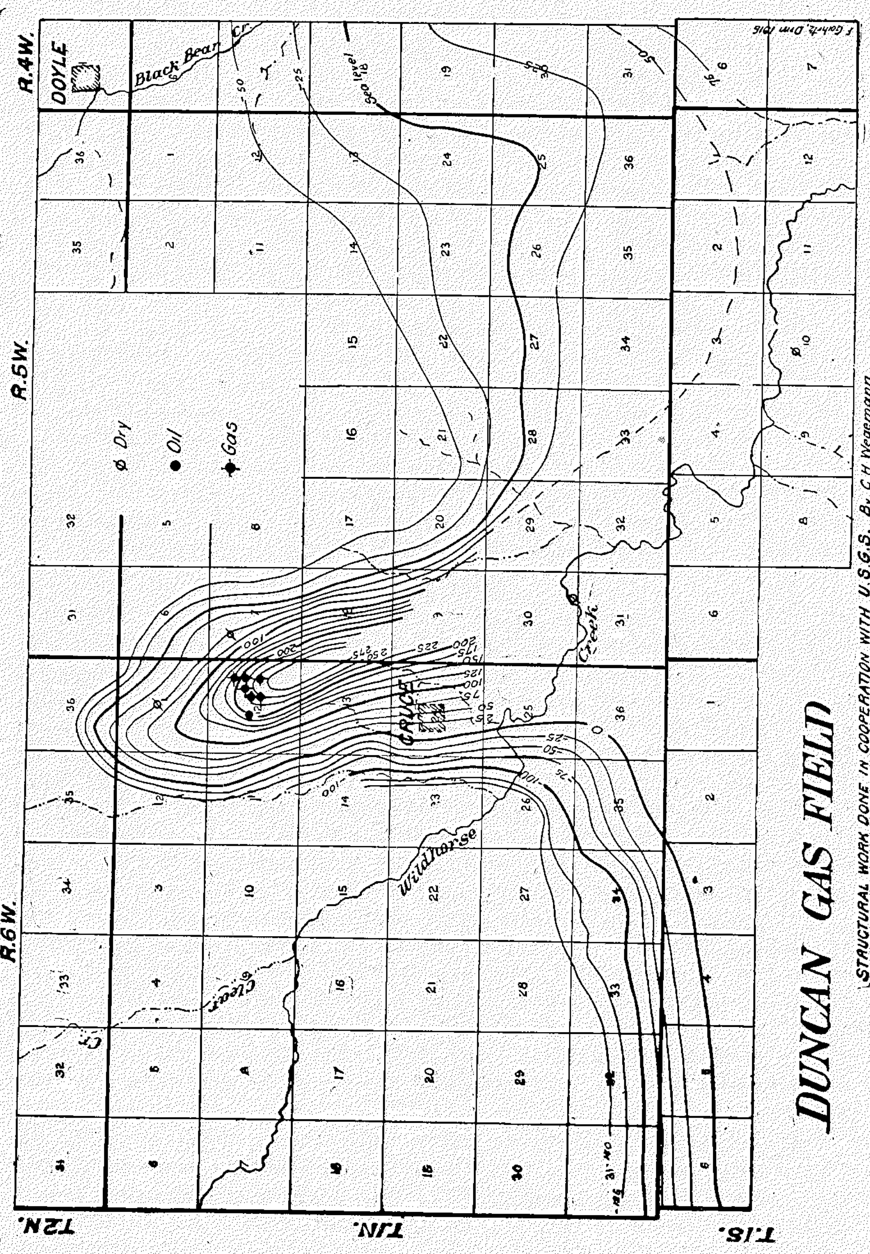

DUNCAN GAS FIELD
STRUCTURAL WORK DONE IN COOPERATION WITH U.S.G.S. By C H Wegemann
R.4W.
R.5W.
R.6W.
T.2N.
T.1N.
T.1S.
DOYLE
Black Bear Cr.
Wildhorse
Creek
Ø Dry
● Oil
Gas
Sea level

Figure 21

seems probable that the unconformity between the Permian and the underlying Pennsylvanian lies in the well mentioned above, between the red shale and the limestone, probably at the base of the 25-foot bed of "yellow quicksand' recorded at 1,825 feet. As none of the other wells in the field reached this depth it is impossible to demonstrate the presence of the unconformity by a comparison of logs. Its presence can be shown, however, in the Healdton and Loco fields, and the unconformity may be observed in surface exposures along the west end of the Arbuckle Mountains. Here the unconformity between the Permian and the underlying Carboniferous is well exposed east of the town of Pooleville, where steeply dipping Paleozoic beds, ranging in age from Ordovician to Pennsylvanian, are overlaid unconformably by flat-lying deposits of Permian age.

Fossils are comparatively rare in the Permian. About 25 miles southwest of the Duncan field, in Cotton County, the bones of primitive amphibians have been found, and fossil leaves of Permian age have been collected in the Healdton field and near Dixie and Pooleville, southeast of the Duncan field. In the field itself certain of the sandstone beds bear the marks of plant stems, but the impressions are so indistinct that the nature of the plants can not be determined. They are perhaps algae. Some of the thin beds of calcareous sandstone contain also very much broken fragments of shells, among which bits of crinoid stem were recognized.

STRUCTURE.

The Duncan anticline proper is about 2 miles broad by five miles long, its axis trending a few degrees west of north. About 15 miles south by southeast of this fold, in line with its axis, lies the Loco gas field, which is 10 miles northwest of the great Healdton field of Carter County. Roughly speaking the three fields lie on a curve which partially encircles the west end of the Arbuckle Mountains. The mountains lie 25 miles east by south of the Duncan field. About 30 miles west of the Duncan field is the Lawton field, at the eastern extremity of the Wichita Mountains, and between the Wichita and Arbuckle uplifts there is a low arch, the north flank of which is outlined by the escarpment which is so prominent in the Duncan field. This escarpment may be traced from a point in sec. 23, T. 2 N., R. 3 W., north of Foster post office, southwestward to and around the Duncan gas field and thence to an exposure on the north side of sec. 32, T. 1 N,. R. 7 W., 1 mile north of the town of Duncan. From this place it may be traced northwestward in a straight line to the NE. ¼ sec. 24, T. 4 N., R. 11 W., northeast of the Wichita Mountains. It doubtless extends farther northwest along the mountain flank. The dips along this escarpment are comparatively low, not exceeding 1°, except in the vicinity of the Duncan field.

The southern limb of the low fold between the two mountain uplifts can not be defined because of lack of exposures, and hence the exact position of the axis of this fold is unknown. The cross fold which forms the Duncan anticline lies north of the axis and the domes of Loco and Healdton lie south of it. The three fields are in no sense along the axis of a continuous cross fold. They are in fact distinct structures but are so situated with reference to the Arbuckle uplift that they appear to have been originally formed at the same time by stresses acting between the rigid mass of the mountains and the strata of the plains. The Duncan field does not, however, like the fields south of the mountain axis, give evidence of two periods of folding. Its structure is more regular than that of the other oil or gas fields mentioned. The axis lies midway between the sandstone escarpments on either side, and the beds dip from the axis at angles of about 3°. The anticline plunges rather steeply at its north end, and at its south end the escarpments formed by the outcropping edges of the sandstone beds diverge in a direction almost at right angles to the axis of the fold, the structure itself appearing to merge into that of the low arch above mentioned, connecting the two mountain uplifts. In the E. ½ sec. 6 and in sec. 5, T. 1 S., R. 5 W., a line of timbered hills is formed by the lowest group of sandstone beds exposed in the vicinity of the field. This line of hills may be traced southeastward to sec. 6, T. 2 S., R. 4 W., at which place grahamite deposits have been mined in the sandstone strata which form the ridge. As this ridge lies in approximate alignment with the axis of the Duncan field, it may be to a certain extent anticlinal, although observations in the neighborhood of the grahamite mines, as well as in sec. 6, T. 1 S., R. 5 W., indicate that the beds in these two localities are horizontal. In sec. 32, T. 1 S., R.4 W., about 1½ miles west of the town of Alma, sandstone beds exposed in a gulch north of the road appear to dip northward with the grade of the stream. This dip may in fact be to the northeast, away from the possible anticlinal axis on which the grahamite mines are situated. Because of the lack of definite beds which can be traced from place to place in this region, the exact nature of the structure is very difficult to determine.

OIL AND GAS.

The principal gas horizon in the Duncan field, a sand from 7 to 19 feet thick, lies at a depth of 800 to 900 feet below the surface and about 900 feet above the base of the Permian as the formation is here developed. Showings of gas and heavy oil in small quantity are obtained in some of the wells in shallower sands, and it is reported that the gas sand on the limbs of the anticline below the gas pool in one well (in the SE. ¼ NW. ¼ sec. 12, T. 1 N., R. 6 W.) carries heavy oil in small amount.

None of the wells in the productive area in the Duncan pool extend far below the principal gas horizon, and hence the sands in the 900 feet of Permian beds which underlie this horizon have not been tested in the best part of the field. The deep well already mentioned, in the SE. ¼ NW. ¼ sec. 12, T. 1 N., R. 6 W., encountered showings of gas at a depth of 1,300 feet and a "rainbow" of oil at 1,625 feet, but whether or not these two beds would be productive on the crest of the anticline it is impossible to say in advance of drilling.

From a comparison of well logs, as well as from studies of the surface rocks in the Duncan, Lawton, Loco, and Healdton fields, the following tentative correlations of the oil and gas sands may be made: The principal gas sand at Duncan is probably the same as the "400-foot sand" in the Lawton field, in which case the sand with showings of gas struck at 1,335 feet in the deep test well in the NW. 1/4 sec. 12, T. 1 N., R. 6 W., of the Duncan field is the probable equivalent of the "800-foot sand" in the Lawton field. The gas sands at Loco probably lie at or a little above the same horizon, and the productive sands of Healdton some 300 or 400 feet lower, corresponding in a general way to the sand carrying showings of oil which was struck in the deep well at Duncan at 1,625 feet.

The extent of the gas pool to the southeast and the possible presence of oil in commercial quantity in the Duncan field are subjects on which no positive statements can be made. It appears probable that the axis of the anticline for at least a mile southeast of the gas wells should prove good gas territory. The well of the Stephens County Oil & Development Co. in the SW. 1/4 sec. 20, T. 1 N., R. 5 W., was drilled too far east to test the possibilities of the anticline in this locality. The dry hole, however, in the SE. 1/4 sec. 30, T. 1 N., R. 5 W., is in a good location. Its log was not obtained, but if it reached a depth of 1,000 feet without encountering oil or gas in commercial quantity it is probable that the anticline is barren in this part of the field, at least as regards the sands now producing in the Duncan field.

As the sandstones exposed in sec. 5 and the E. 1/2 sec. 6, T. 1 S., R. 5 W., are lower than any of the beds exposed in the vicinity of the gas wells, it is evident that the gas sand must be nearer the surface and hence the structure higher in secs. 5 and 6, T. 1 S., R. 5 W., than farther to the north. The dips in this locality are, however, very small, and so little is known of the exact shape of the fold that it is impossible to make predictions in regard to it. The well in NW. 1/4 sec. 10, T. 1 S., R. 5 W., appears to have been drilled too far east to have been a fair test. The plunging end of an anticline like that on which the gas wells are situated is always a very favorable place for the accumulation of oil or gas, but it may be questioned whether in the more gentle folds, such as the fold which appears to be indicated by the sandstone ridge above mentioned in secs. 5 and 6, T. 1 S., R. 5 W., oil or gas is as likely to accumulate, even if the beds on the crest of the fold are in reality higher than those on the point of the anticline.

Prospecting for gas in the Duncan field should be carried on along the crest of the anticline as indicated on figure 21, the first well being placed about half a mile south of the present productive wells. If the first well is successful other wells may be drilled at intervals of about half a mile along the axis to the southeast until the limit of the pool in this direction is reached.

The gas probably extends also about half a mile northwestward along the axis from the present productive wells.

The chances for obtaining oil in large quantity in the immediate vicinity of the gas wells would appear to be poor, inasmuch as the deep well in the SE. 1/4 NW. 1/4 sec. 12, T. 1 N., R. 6 W., was unproductive. Oil may possibly be found beyond the limits of the gas pool to the southeast along the anticlinal axis as indicated on figure 21, but this possibility can be tested only by systematic exploration of the gas pool in that direction as indicated above.

As the base-bearing sand now known in the Duncan field lies 900 feet above the base of the Permian, and as lower Permian sands produce oil and gas in neighboring fields, the field can not be considered as thoroughly tested until the base of the Permian on the crest of the anticline is reached by the drill.

If the Permian sands below the gas sand be found unproductive in the most favorable part of the Duncan anticline—that is, in the vicinity of the wells already drilled or just southeast of them—they will probably be barren in other parts of the field. If, however, they are found to carry oil or gas in paying quantity test wells in other parts of the field should reach them.

SUMMARY.

The development which has taken place in Stephens County proves that the entire area is in probable oil and gas territory. While very little oil has been encountered in any of the wells drilled, the finding of the gas and oil near Loco, the gas at Cruce, the very recent discovery of gas in the extreme northeastern part of Cotton County, just west of Stephens County, the oil and gas in the Lawton field, just to the northwest of this county, and the oil and gas in the vicinity of Fox. near the southeastern part of this county, demonstrate that the entire county is to be considered as lying in favorable territory. Several miscellaneous wells have been drilled in parts of the county where production has not been encountered, but these wells have not been sufficient tests to determine the value of the area in which they were drilled.

In the discussion under the heading of "Structure," several areas are designated as being favorable for prospecting. In doing structural work in the northwestern part of Stephens County, the influence of the Wichita Mountain uplift must be taken into consideration. Detailed structural work in this county will no doubt reveal the presence of folds which have not been tested and may also lead to the discovery of oil as well as good yields of gas.

This county has not received the amount of investigation and prospecting during the past few years that would be expected in consideration of the extensive development in the Healdton field and other miscellaneous drilling in surrounding areas.

TEXAS COUNTY.

LOCATION.

Texas County is the middle of the three counties comprising the western extension of Oklahoma known as the "Panhandle." The area was formerly included in "old" Beaver County. The county is rectangular in shape and includes all of 50 townships and 4 miles off of the northern tier of 10 townships. The territory embraces Tps. 1 to 5, inclusive, and 4 miles of T. 6, from the base line on the 36° 30' line of north latitude, Rs. 10 to 19 inclusive, east from the Cimarron Meridian. The north boundary of the county is the Oklahoma-Kansas line and the southern line is the Oklahoma-Texas line. The area is 2,065 square miles.

TOPOGRAPHY.

This region is a typical part of the high plains and is apparently flat and level, but slopes gradually from the west to the east, having an elevation of over 3,700 feet at the northwest corner and decreasing to about 2,900 feet at the eastern border of the county. Beaver Creek and its tributaries carry the drainage from west to east through the county. Along the main course of Beaver Creek the valley is on an average a mile in width and from 40 to 70 feet in depth. During much of the year there is very little water in the streams except from such tributaries as lie in Tertiary springs. The northeastern one-third of the county is high upland, practically without drainage lines.

GEOLOGY.

The surface rocks of the county are chiefly Tertiary sands and clay. In some places these surface rocks reach a thickness of 500 feet. The Tertiary is underlaid by the Redbeds which are exposed along the streams and canyons. Some sand hills occur as a result of the weathering of the Tertiary rocks. The character of the Tertiary rocks are shown by the log of the Optima well which is given below. The location is near the center of the county. This well was drilled as a water well but was dry at a depth of 498 feet, a rather rare occurrence at so great a depth in the high plains. It appears that the formations passed through are all Tertiary, but the drilling was stopped near the contact between the Tertiary and the Redbeds as in many places the contact is characterized by a sandy and gravelly material.

Log of the Optima well, Texas County.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Sandy clay	100	100	Yellow sand	15	388
Reddish clay	15	115	Dry sand	10	398
Sandy clay	114	229	Brown sand	5	403
Red clay	64	293	Sandy clay	3	406
Dark clay	56	349	Blue shale	80	486
Blue clay	4	353	Sandy gravel & shale	12	498
Yellow clay	20	373			

SUMMARY.

The Tertiary rocks which cover the surface of most of the county have a thickness varying from a few feet to about 500 feet. The Redbeds attain very great thickness, at least 2,000 to 2,500 feet. Any drilling passing through the Redbeds would be almost prohibitive, and there is little indication that production would be found at a shallower depth.

TILLMAN COUNTY.

LOCATION.

Tillman County is located in the southwestern part of the State in the tier of counties north of Red River and bordering on Texas. It extends approximately from T. 5 S., to T. 1 N., inclusive, and from R. 14 W. to R. 19 W., inclusive. It includes 18 whole townships and parts of 12 others. The total area is approximately 862 square miles.

TOPOGRAPHY.

Tillman County lies entirely within the Redbeds Plains region. In general the county is a level rolling prairie plain. In some places the streams have eroded this plain, giving rise locally to a bad land type of topography. The whole region is drained by Red River. The eastern and northeastern parts of the county are drained by Deep Red Run, a tributary to Red River. The extreme western part of the county is drained by North Fork of Red River and small tributaries to Red River. The topography of the southeastern part of the county is discussed in full in the report on the Grandfield district, by Munn, under "Cotton County."

Burt Switch No. 1, in NE. ¼ sec. 28, T. 2 S., R. 18 W.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Sand shale		10	Red shell	20	1,320
Water sand	19	29	Slate and shells	80	1,400
Red rock	9	38	Black slate	22	1,422
Red rock	891	900	Red rock	8	-,430
Red sand	16	916	Top salt sand	5	1,435
Red rock	142	1,058	Bottom salt sand	45	1,480
Lignite	2	1,060	Black slate	5	1,485
Red rock	40	1,100	Red rock	5	1,490
Lime shell	5	1,105	Blue shale	80	1,570
Red rock	26	1,131	Black shale	45	1,615
Lime shell	5	1,136	Slate and shells	25	1,640
Red rock	14	1,150	Red rock	5	1,645
Black slate	5	1,155	Blue shale	30	1,675
Red rock	35	1,190	Shells	20	1,695
Black slate	10	1,200	Brown shale	5	1,700
Red rock	20	1,220	Lime	20	1,720
Red sand	40	1,260	Red rock	20	1,740
Lime rock	5	1,265	Blue shale	50	1,790
Black slate	5	1,270	Brown shale	50	1,840
Red sand	5	1,275	Red rock	45	1,885
Black slate	5	1,280	Brown peppery sand	15	1,900
Red rock	20	1,300			

GEOLOGY.

The surface rocks in Tillman County are Permian Redbeds, probable Tertiary or Quaternary conglomerate, and Recent deposits of sand and alluvium. The Permian Redbeds consist of sandstones, shales, and conglomerates. Most of the northern part of the county is covered with red clay shale, sandstone outcrops being scarce. The sandstone are usually cross-bedded and lenticular. The western part of the county near North Fork of Red River is covered with dune sand. The geology of the southeastern part of the county is discussed by Munn in his report on the Grandfield district, included under "Cotton County."

STRUCTURE.

The general dip of the Permian rocks in this county is to the southwest away from the Wichita Mountains. No detailed work has been done in this county outside of the Grandfield district. A report on this area is included under "Cotton County."

DEVELOPMENT.

A well was drilled some years ago in sec. 9 T. 3 S., R. 13 W. at Loveland. This well is located in the Deep Red syncline, and was abandoned without finding oil or gas. Another well was drilled in the SW. 1/4 sec. 9, T. 4 S., R. 14 W., southeast of Grandfield. A showing of oil was reported at a depth of about 1,000 feet. The Grandfield Oil & Gas Company abandoned their well in sec. 9, T. 3, S., R. 15 W., at a depth of about 2,400 feet. This well was located on a dome on the Devol anticline, and should be a favorable location. The sands encountered in this well were in most cases dry. If there had been an abundance of salt water in the sands then the area in that vicinity would be regarded as improbable territory, but since such was not the case, the lower domes or secondary anticlines may contain oil. This test, however, should not be regarded as final. A test, to be thorough, should be drilled to a depth of at least 3,000 feet.

A location has been made in the NE. 1/4 sec. 35, T. 3 S., R. 16 W. near the Quanah townsite.

Another location is reported to have bee nmade in sec. 29, T. 1 N., R. 16 W., northeast of Manitou.

The Princess Oil Company is drilling a well in sec. 34, T. 3 S., R. 14 W., northeast of Grandfield. Several showings of gas have been encountered. This well is located near the axis of the Devol anticline.

SUMMARY.

Tillman County lies in probable oil and gas territory. The surface rocks are Permian Redbeds, with the exception of Tertiary or Quaternary gravel and conglomerate, and Recent deposits. Detailed work has revealed favorable structure in the vicinity of Apheatone, and the area covered by the Devol anticline. Several wells have been drilled on this anticline without finding oil or gas in commercial quantities. This may be due to several things: (1) The sands on the high points of the structure may be hard and compact; (2) the tests are not to be considered thorough, on account of shallow drilling, and should not be abandoned at a depth less than 3,000 feet.

Munn* says: "If, however, the domes prove to contain no oil or gas and carry salt water under considerable head in the various sands down to 3,000 feet, the prospect of finding gas or oil in the district as a whole is unfavorable. If, on the other hand, the higher domes carry no salt water, oil, or gas in any sand, the lower domes and secondary anticlines should be tested, especially those nearest the Burkburnett field. The fact that these beds carry oil in the Burkburnett field suggests that the lower domes and secondary anticlines in the eastern part of the district bring the oil sands up to about the right elevation for accumulations, in which case the higher domes to the west may carry gas almost exclusively. At all times it must be remembered that the three favorable factors to get in combination are (1) an anticline, (2) a good open sand, and (3) the right height on the anticline with reference to salt water in the porous sand. It is evident that in wildcat tests only one of these factors—structure—can be determined in advance of the drill, but, having it given, the chances are increased at least one-third. Once the combination of all three is found the test for an oil or gas pool, whether successful or not, is at least complete for that vicinity."

TULSA COUNTY.

LOCATION.

Tulsa County is located in the central part of the northeastern part of the State. It extends from T. 16 N. to T. 22 N. inclusive, and from R. 10 E. to R. 14 E. inclusive. It consists of 12 entire townships and parts of 10 others. The area is approximately 555 square miles.

TOPOGRAPHY.

Tulsa County lies within the Sandstone Hills region. That part of the county lying north and east of the Arkansas River is for the most part a level prairie plain broken by low escarpments. That part of the county south and west of Arkansas River is also a prairie plain, but upon this plain are found rugged sandstone-capped hills, which are covered with blackjack oaks. These sandstone-capped hills reach their maximum relief near Red Fork in T. 19 N., R. 12 E., where they are as much as 200 feet above the surrounding plain.

The highest point in the county is near the center of sec. 21, T. 19 N., R. 10 E., where the sea level elevation is 1,017 feet. The lowest point is near the SE. cor. sec. 25, T. 17 N., R. 14 E., where

*Munn, M. J., U. S. Geol. Survey Bull. No. 547, 1914.

Arkansas River crosses the east county line. The sea level elevation is approximately 550 feet. This shows a range in relief of approximately 467 feet.

The southern part of the county is drained by Arkansas River and streams tributary to it. The northern part is drained by streams tributary to Verdigris River. The streams entering the north bank of Arkansas River are very short. In fact, in some places the divide between the Arkansas River drainage and the Verdigris River drainage is only a mile or so north of Arkansas River.

The largest tributary to Verdigris River is Bird Creek, which drains the greater part of northern Tulsa County.

GEOLOGY.

The rocks at the surface in Tulsa County are Pennsylvanian.

The Pennsylvanian in this part of the State is divided into two general areas, i. e., Pennsylvanian north of Arkansas River and Pennsylvanian south of Arkansas River. The rocks north of the Arkansas are shales, limestones, and sandstones, with the limestones predominating over the sandstones. The rocks south of Arkansas River are slates, sandstones, and limestones, the sandstones predominating over the limestones.

In Tulsa County north of Arkansas River the following Pennsylvanian formations in order from youngest to oldest outcrop: (6) Formations mapped but not named, (5) Nowata shale, (4) Oologah formation, (3) Labette shale, (2) Fort Scott formation, and (1) Winslow formation.

The *Winslow formation* occupies an area of approximately 10 square miles in the eastern part of the county. This formation consists of shales and sandstones. The shales vary from laminated blue clay shales to black carbonaceous shales. The sandstones vary in texture from fine-grained to coarse-grained, and the degree of hardness varies.

The *Fort Scott formation* occupies an area of approximately 10 square miles, running in a northeast-southwest direction, and immediately west of the Winslow formation outcrop. The Fort Scott formation consists of a lower limestone approximately 10 feet thick, a shale parting of 8 feet, and an upper limestone approximately 20 feet thick.

The *Labette shale* occupies an area of approximately 30 square miles and lies in a narrow northeast-southwest belt immediately northwest of the Fort Scott. It consists of a great mass of shales, with occasional heavy sandstones.

The *Oologah formation* occupies an area of about 40 square miles in Tulsa County. Its outcrop is a narrow belt extending in a northeast-southwest direction and lies immediately northwest of the Labette shale. The Oologah formation consists of limestones and shales, the limestones predominating.

The *Nowata shale* occupies an area of approximately 700 square miles in Tulsa County. Its outcrop occupies a belt approximately 6 miles wide, extending in a northeast-southwest direction and lies immediately northwest of the Oologah formation.

In the region just to the north of Arkansas River and west of the Nowata shale outcrop in Tulsa County there is an area of approximately 80 square miles, where the outcropping rocks have not been named. These rocks consist of limestones, shales, and sandstones.

South of Arkansas River the Pennsylvanian formations outcropping in Tulsa County named in order from youngest to oldest are: (3) Unnamed formations, (2) Wetumka shale, and (1) Calvin sandstone.

The *Calvin sandstone* occupies in Tulsa County an area of approximately 30 square miles in the southeastern part of the county. It consists of thin-bedded sandstones with some shale. In the lower part of the formation the sandstones are massive and rather soft. In the upper part of the formation the shales predominate, the sandstones becoming thinner-bedded.

The *Wetumka shale* occupies an area of approximately 65 square miles and occupies a belt approximately 9 miles wide and extending in a northeast-southwest direction immediately west of the Calvin sandstone. This formation consists of friable, laminated clay shales, with some thin shaly sandstones near the middle of the formation.

In the western part of the county and south of Arkansas River there is an area of unnamed rocks which consist of shales and sandstones.

STRUCTURE.

The general attitude of the rocks in Tulsa County is that of a northeast-dipping monocline whose average dip is 30 feet to the mile. There are local variations in this general northeast dip. These variations will be discussed in connection with various pools under "Development" in Tulsa County.

DEVELOPMENT.

GENERAL STATEMENT.

Most of Tulsa County was developed early and the present activities are intensive rather than extensive. Some small new pools have been opened from time to time.

The line between Tps. 19 and 20 marks the division of the two principal areas of development in Tulsa County. There is a geological reason for the division between these two main groups. Dip and strike readings taken south of Arkansas River in T. 19 N., R. 12 E., together with the general grouping of productive wells, both north and south of Arkansas River, indicate a synclinal fold in T. 19 N., R. 12 E., whose axis extends in a general east-west direction.

The northern group consists of several small pools which connect up with each other. A study of logs and dip and strike readings observed in various parts of Tulsa County, together with the general grouping of productive wells, indicate that all the production in Tulsa County north of the north line of T. 19 is associated with a broad anticlinal fold upon which are local variations in structure. For this reason all this production could be grouped in one pool and discussed as such. Since, however, it has been usual to discuss the Dawson pool and the Collinsville-Owasso as separate pools, and since the production of these pools is largely gas, they will be discussed together as one pool called the Collinsville-Owasso-Dawson pool. For the remainder of the production the old name, Bird Creek-Flat Rock pool, will be used.

The main production in Tulsa County south of the north line of T. 19 is associated with the Glenn pool structure. Since, however, there is considerable production in Tulsa County it will be discussed briefly under the general head Red Fork-Jenks pool.

The remainder of the production in Tulsa County is small and scattered. It will be discussed by townships.

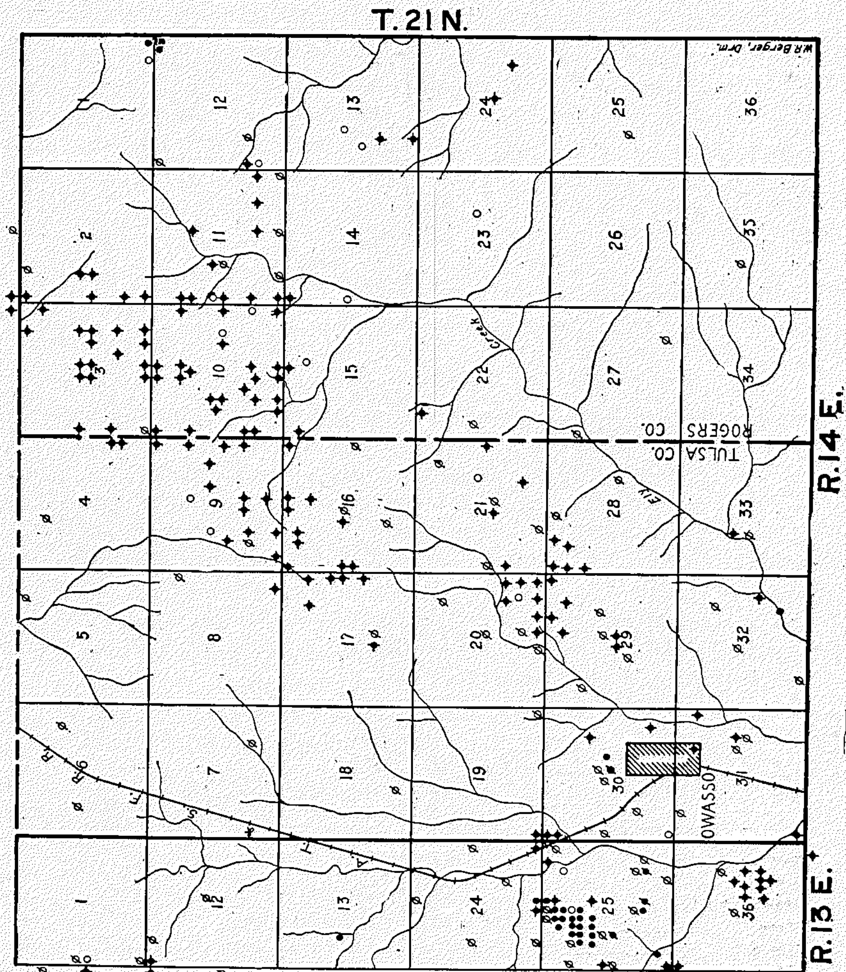
BIRD CREEK—FLAT ROCK POOL.

The Bird Creek-Flat Rock pool extends from Skiatook in sec. 23, T. 22 N., R. 12 E. in a southeastern direction to sec. 29, T. 20 N., R. 13 E., a distance of approximately 15 miles. It has an average width of approximately 5 miles. This pool was one of the earliest developments in the Cherokee Nation and has been productive of many large wells. The limits of the separate pools comprising this large pool have been pretty well defined.

The productive sands in this pool are found at depths varying from 1,000 to 2,000 feet. The following logs give a general idea of the underground conditions.

Log of well located on center location of south line of E. ½ of SE. ¼ sec. 8, T. 21 N., R. 13 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	3	3	Lime	10	705
Clay	7	10	White slate	65	770
Blue mud	25	35	Sand	30	800
White slate	105	140	Brown shale	100	900
Brown shale	45	185	Shell	5	905
Sand	65	250	White slate	10	915
Gray shale	10	260	Shell	5	920
Sand	50	310	Brown shale	45	965
Brown slate	85	395	White slate	55	1,020
Lime	125	520	Brown shale	15	1,035
Brown shale	50	570	Sand	35	1,070
Oswego lime (water at 610—gas in top)	60	630	Blue slate	10	1,080
			Sand	66	1,146
Brown shale	20	650	Oil sand—production 20 barrels	22	1,168
Sand	45	695			



MAP OF THE **OWASSO POOL**

OIL. GAS. ABANDONED. DRY HOLE. DRILLING.

SCALE

0 ¼ ½ 1 2 3 MI.

Figure 22.

Sag-la-hoc No. 2, in sec. 3, T. 20 N., R. 12 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	15	15	Slate, black	75	641
Lime	10	25	Lime	35	676
Shale	50	75	Slate	120	796
Lime	15	90	Lime (gas)	45	841
Shale	60	150	Sand	25	866
Lime (water)	10	160	Slate, black	80	946
Shale	50	210	Lime	24	970
Lime	5	215	Slate, black	90	1,060
Shale	135	350	Lime	20	1,080
Slate, black	40	390	Slate	100	1,180
Lime	6	396	Sand (gas)	5	1,185
Slate, white	100	496	Slate, white	45	1,230
Slate, black	60	556	Shale, etc.	288	1,518
Lime	10	566	Sand (gas)	9	1,527

The Bird Creek-Flat Rock pool produces both oil and gas. The production is for the most part oil. There is a narrow gas belt bordering the northeastern edge of the oil productive area of this pool.

THE COLLINSVILLE-OWASSO-DAWSON POOL.

This pool extends from sec. 25, T. 22 N., R. 14 E. in a southwesterly direction to sec. 22, T. 20 N., R. 13 E., a distance of about 12 miles. The average width of this pool is about one mile. Some oil is produced here, but this pool is far more important as a gas producer. The large zinc smelters located at Collinsville utilize most of the gas from this pool. Some large gas producing wells have been brought in. As a rule, the wells are small and long-lived.

The following log is typical of the Owassa area.

Measles No. 1, in sec. 30, T. 21 N., R. 14 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil and shale	60	60	Shale	68	577
Lime	95	155	Lime	14	591
Black shell	165	330	Shale	228	819
Lime	40	370	Gas sand	6	825
Shale	65	435	Shale	162	987
Lime	20	455	Water sand	12	999
Black shale	20	475	Shale	6	1,005
Sand	18	493	Oil sand	49	1,054
Shale	21	514	Sand	2	1,056
Sand	5	519	"Mississippi Lime"	66	1,122

RED FORK-JENKS POOL.

As stated above, the production in this area is closely associated with the Glenn pool. For this reason the extent and width of the pool is indefinite and the discussion will be confined to that part which is found in Tulsa County.

Oil was first discovered in Tulsa County near Red Fork. In fact, some writers claim that the Red Fork pool has the honor of first producing oil in paying quantities. The wells in the Red Fork pool have been small, though long-lived producers. It is reported that one well has been producing for about 15 years. This well started with a production of about 55 barrels daily and is now producing 5 barrels daily.

The production of wells in the Jenks pool has been reputed as high as 300 barrels per day. The entire production of wells brought in in the Jenks pool within the last year will average not far from 55 barrels daily.

T. 19 N., R. 10 E.

The W. ½ of sec. 8 and the E. ½ of sec. 7 are producing oil. The limits of this pool have not yet been defined.

T. 19 N., R. 11 E.

This township produces both gas and oil, though the production of both these substances is small. The major production is found to the south of Sand Springs in sections 22, 23, 25, 26, 27, 33, 34, 35, and 36. The production is chiefly gas. The following log will give a general idea of the underground strata:

Log of Tulsa County well, 250 *feet N. and* 200 *feet W. of SE. cor. sec.* 25, *T.* 19 *N., R.* 11 *E.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface	20	20	Black shale	3	1,077
Sandstone and yel. soil	20	40	Lime shell	83	1,160
Blue shale	20	60	Brown shale	9	1,169
Gray sandy shale	240	300	Lime shell	181	1,350
Dark shale	24	324	Brown shale	3	1,353
Water sand	36	360	Lime shell	27	1,380
Blue shale	8	368	Black slate	165	1,545
Lime shell	32	400	Brown and white shale	3	1,548
Blue shale	40	440	Lime shell	102	1,650
White sandy shale—show of gas	360	800	Blue shale	3	1,653
			Lime shell	22	1,775
Brown shale	30	830	White and blue shale	108	1,883
Black slate	50	880	Taneha sand	14	1,897
Big lime	145	1,025	Blue and black shale	22	1,919
Sandy shale	33	1,058	Oil sand	4	1,923
Oswego lime	16	1,074			

T. 19 N., R. 13. E.

The largest production in this township, aside from that associated with the Red Fork-Jenks pool, is found in sec. 16, and the NW. ¼ of sec. 21. Both oil and gas are produced.

T. 19, N., R. 14 E.

A small oil and gas pool has been found near the center of sec. 8.

The productive sand is found at a depth of about 1,350 feet. Small oil and gas production has been found in the N. ½ of sec. 11.

T. 18 N., R. 14 E.

A very productive oil pool has been opened up about 2 miles south of Broken Arrow. This pool extends from the E. ½ of sec. 22, in a southeastern direction to section 8, T. 17 N., R. 15 E., a distance of 5 miles. Its average width is about one mile. The southeastern end of this pool is in Wagoner County.

Some wells are reported to have had as high as 200 barrels daily production. The average initial production is not far from 60 barrels daily. The productive sand is found at a depth of about 1,300 feet. The following log will give a general idea of the underground strata:

Log of Tulsa County well, 200 *feet N. and* 200 *feet. W. of SE. cor. sec.* 36, *T.* 18 *N., R.* 14 *E.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Clay	35	35	Shale and slate	52	900
Slate	85	120	Lime	10	910
Water sand	10	130	Slate and shale	240	1,150
Slate and shale	225	355	Lime	20	1,170
Sand white	10	365	Slate	10	1,180
Slate	80	445	Lime	40	1,220
Sand	8	453	Gas sand	14	1,234
Slate	77	530	Shale	38	1,272
Lime	30	560	Sand	5	1,277
Slate	40	600	Slate	4	1,281
Water and gas sand	50	650	Oil sand	10	1,291
Slate	90	740	Total depth—production 15 barrels	7	1,298
Lime	8	748			

T. 17 N., R. 14 E.

There is a small, highly productive oil pool about one mile southwest of Leonard. Most of the production is located in sec. 33. One well in this area was reported as having started off with a production of 1,200 barrels of oil daily. Reports show that the average initial production is about 160 barrels of oil daily.

T. 16 N., R. 13 E.

There is another small, highly productive oil field found about 4 miles southwest of Bixby. The following sections are productive: 3, 4, 9, 10, 11, and 12. The production extends to the north into secs. 33 and 34 of T. 17 N., R. 13 E. Wells have been reported as having initial production as high as 700 barrels of oil daily. The average initial production in secs. 3, 4, and 10 is probably about 200 barrels daily. The production is found at depth varying from 1,600 to 2,100 feet.

Stewart Farm, No. 1, in sec. 4, T. 16 N., R .13 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Slate	250	250	Slate	258	1,495
Lime	15	265	Shell	5	1,500
Slate	75	340	Slate	75	1,575
Lime	20	360	Lime shell	5	1,580
Slate	40	400	Slate	50	1,630
Sand—show oil	18	418	Lime	10	1,640
Slate	434	852	Slate	127	1,767
Shell	13	865	Lime	120	1,887
Slate	362	1,227	Slate	158	2,045
Shell	10	1,237	Oil sand		2,053

SUMMARY.

Tulsa County has some of the oldest and most long-lived oil wells in the State. The main productive pools have long since been defined. Recent drillings within these main productive pools have found productive areas. Outside the main productive pools several very productive small pools have been found. Correlation of well logs, together with a study of surface conditions, will no doubt find undiscovered productive areas within the large pools, as well as small productive areas outside the main pools. Development in Tulsa County has reached the intensive stage.

WAGONER COUNTY.

LOCATION.

Wagoner County lies in the northeastern part of Oklahoma. It extends from T. 15 N. to T. 19 N. inclusive, and from R. 15 E. to R. 20 E. It includes 11 whole townships and parts of 10 others. It is very irregular in shape, on account of some of the streams being boundary lines. The approximate area of the county is 580 square miles.

TOPOGRAPHY.

Wagoner County lies entirely within the Sandstone Hills region, with the exception of the extreme northeastern corner, which is in the Ozark Plateau. The greater part of the surface is a level prairie. The country adjacent to Grand River is cut by a number of small streams forming hills of considerable size. The highest point in the county is on the so called Conjada Mountains which have an elevation of over 900 feet in the northeastern part of T. 16 N., R. 14 E. The lowest point in elevation is about 500 feet where Arkansas River flows out of the county.

Arkansas River and its tributaries drain the entire county. The

Verdigris drains the greater portion, and flows in a meandering channel diagonally across the county. Grand River, named Neosho River on some maps, drains the extreme eastern part of the county. All of these streams have broad, flat valleys and meandering channels.

GEOLOGY.

The surface rocks of Wagoner County are Pennsylvanian in age. The subdivisions exposed are the Morrow, Winslow, Fort Scott formations, and a small area of the Labette shales.

The Morrow formation, the lowest of the group, consists of limestone and shale with local beds of thin sandstone. The limestone is thicker than the shale, but the latter is abundant in the upper part of the formation. This formation is exposed in a few places in the county along Grand River, one east of Wagoner and another north of Ft. Gibson.

The Winslow formation covers almost the entire county. It consists of blue and black clay shale, sandy shale, brown sandstone, and thin beds of coal. The sandstone varies in character from thin-bedded to massive, and occurs in two groups, one near the base and the other above the middle of the formation. The thickness of the whole formation throughout the several counties in which it is exposed varies from 800 to 1,000 feet. South of Arkansas River Taft* has subdivided the Winslow into the Atoka formation, Hartshorne sandstone, and McAlester shale, and possibly several other succeeding formations. It is also equivalent to the Cherokee formation to the north.

The Fort Scott formation succeeds the Winslow formation as mapped in Wagoner County and is exposed over a small area in the extreme northwestern edge of the county. It consists of several limestone members separated by shale partings. The thickness is on the average about 50 feet.

The Labette shale succeeds the Fort Scott formation in Wagoner County and is exposed over a very small area in this county several miles east of Broken Arrow, Tulsa County. The Labette consists of thin shales with occasional heavy sandstones.

For a more detailed discussion of the different formations exposed in Wagoner County the reader is referred to Part I of this report.

STRUCTURE.

The structure of Wagoner County in general is that of a westward-dipping monocline. Some folds have been reported from this county, but there are no available data concerning them.

*Taft, Joseph A. Geologic Folio No. 132; U. S. Geol. Survey, 1906.

DEVELOPMENT.

GENERAL STATEMENT.

The entire County has had considerable development with more success in the western than in the eastern part. The following areas have received some attention: Coweta, Porter, Redbird, Wagoner, and Stone Bluff.

COWETA DISTRICT.

LOCATION AND DEVELOPMENT.

The Coweta district lies in the southwestern part of Wagoner County in T. 17 N., R. 15 E., west of the town of Coweta. The center of drilling is in secs. 7, 8, 12, 17, 20, and 31, T. 17 N., Rs. 15 and 16 E. Only a few completions were made during 1914. One of these produced about 40 barrels during the first 24 hours from a sand at a depth of 892 feet. Two other wells were completed which made 60 and 125 barrels per day, respectively.

Most of the development in 1915 and up to June, 1916 has been in T. 17 N., R. 15 E., and T. 17 N., R. 16 E. The production of the wells completed range from a few barrels to 300 barrels. The Edgar Oil Company completed a 300 barrel well in sec. 32, T. 17 N., R. 15 E. Braden and Goble have recently completed a 200 barrel well in sec. 12 of the same township and range. In sec. 7, T. 17 N., R. 16 E. Crosbie and Gillespie completed a well producing 100 barrels daily.

SANDS.

At least two producing sands have been found at 1,050 and 1,450 feet, respectively. Other writers record three additional sands at the following depths: 600, 880, and 1,350 feet. A sand at 650 feet is probably the Bartlesville, that at 1,050 feet the Burgess, and the one at 1,450 feet equivalent to the Mounds sand.

PORTER DISTRICT.

Some drillings have been made in the vicinity of Porter, but only a few showings were obtained. Tests were made in secs. 6 and 28, T. 16 N., R. 17 E., and sec. 19, T. 17 N., R. 17 E. Shallenbarger and Ardizone completed a gas well of 10,000,000 cubic feet daily initial volume in the SW. 1/4 of sec. 16, T. 17 N., R. 17 E. A number of other wells have been completed in this area, some of which were small oil or gas producers.

The following logs are typical of the formations encountered in drilling in this area:

Wansan Oil & Gas Co. Well, in sec. 5, T. 17 N., R. 17 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	15	15	Slate	60	735
Slate	315	330	Lime	200	935
Lime	5	335	Slate	35	970
Shale	90	425	Lime	25	995
Gray shale	40	465	Sand	10	1,005
Lime	50	515	Slate	50	1,055
Gas water	30	545	Water sand	100	1,155
Lime	30	575	Lime	48	1,503

Porter Well, in sec. 15, T. 16 N., R. 17 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Drive pipe	20	20	Gray sand	20	725
Shale	330	350	White lime	37	762
Lime (Morrow-ls)	25	375	Gray lime	8	770
Shale	30	405	Gray sand	54	824
Lime shells	195	600	Sandy lime	1	825
Shale	10	610	Gray sandy lime	193	1,018
Lime	20	630	Blue sandy lime	39	1,057
Lime sand	10	640	Gray sandy lime	102	1,159
Lime	40	680	Brown shale	61	1,220
Sand	11	691	Gray sand	40	1,260
Shale	9	700	White lime	158	1,418
Blue lime	5	705	Mississippi lime	85	1,503

REDBIRD DISTRICT.

West of Redbird, Wilson, Rhode, Gillespie and others drilled a well in sec. 8, T. 16 N., R. 16 E., which gave a showing for a small producer at a depth of 1,586 feet. The Redbird Oil Company have made a location for a test well in sec. 2, T. 16 N., R. 16 E.

WAGONER DISTRICT.

The Wagoner pool lies northwest of the town of Wagoner in T. 18 N., R. 18 E. The chief production is in a shallow sand between 600 and 800 feet, and the wells are generally light pumpers. The wells vary from 2 to 50 barrels per day. During November, 1914, a well with a capacity of 100 barrels initial daily production, was reported from the Gordon farm about a mile north of Wagoner. If true this is the best well in the Wagoner field and may lead to better production in T. 17 N., R. 18 E. The following log gives an idea of the formations encountered in drilling in this area.

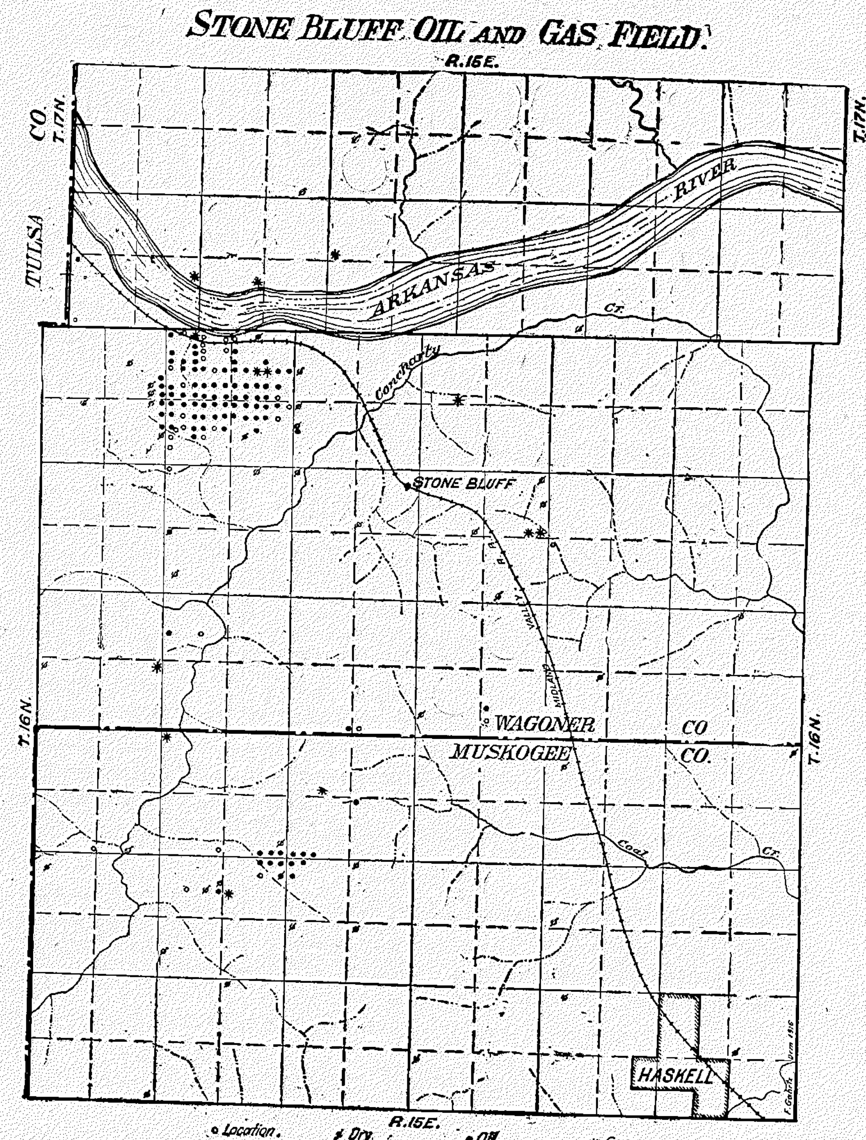

STONE BLUFF OIL AND GAS FIELD.
R.15E.
T.17N.
TULSA CO.
ARKANSAS
RIVER
Cr.
Concharty
STONE BLUFF
MIDLAND VALLEY R.R.
WAGONER CO
MUSKOGEE CO.
T.16N.
Coal
Cr.
HASKELL
R.15E.
Location.
Dry.
Oil
Gas.

Figure 23.

Parkinson Well No. 1, in NW. ¼ SE. ¼ sec. 10, T. 17 N., R. 18 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Unrecorded	40	40	Slate	30	400
Black shale	20	60	Lime	100	500
Lime	5	65	Shale	100	600
Shale	35	100	Sand	156	756
Lime	12	112	Slate	74	830
Slate	48	160	Sand	70	900
Lime	80	240	Lime and water (Boone)	220	1,120
Water sand	5	245			
Sand	125	370			

STONE BLUFF POOL.

The Stone Bluff pool is located in the southwest corner of Wagoner County, about a mile from the town of Stone Bluff. The producing territory lies principally in sec. 5, T. 16 N., R. 15 E. The first well was drilled by Braden and Goble on the Jackson Culbert farm in sec. 5. The well was completed in November, 1915, and had an initial production of about 200 barrels per day. Considerable development followed with the result that a new pool was opened up which had a prolific production for that section of the State. The producing wells range from 10 to 1,500 barrels initial daily production, the average of the better wells being about 400 barrels. Ufer and Galbraith completed a well on the Davis farm in sec. 5 and obtained a daily initial production of about 1,500 barrels. A few producing wells have been completed in secs. 6, 20, 21, but practically all of the production comes from sec. 5. A few gas wells having an initial volume of about 25,000,000 cubic feet per day were completed in sec. 5. A few dry holes have been drilled in sec. 5 and adjoining sections. Over 80 wells have been drilled in this area since the pool was first opened up. The pool seems to be fairly well outlined, as the surrounding territory is dotted with failures. The productive sand is encountered at about 1,200 feet.

SUMMARY.

The entire county may be considered as favorable territory. It is thought that the production in the deep wells is from productive horizons below the Mississippi lime. Shallow production is secured from the Pennsylvanian formations.

WASHINGTON COUNTY.

LOCATION.

Washington County is located in the northeastern part of the State. It is included with the northern tier of counties bordering Kansas. It extends from T. 23 N. to T. 29 N. inclusive, and from

R. 12 E. to R. 14 E. inclusive. The county includes 6 whole townships and a portion of 13 others. The total area is approximately 420 square miles.

TOPOGRAPHY.

Washington County lies in the Sandstone Hills region. Along the western border of the county several hills ranging from 150 to 200 feet in elevation are prominent. These hills have broad, flat tops. The limestones of the region form prominent eastward-facing escarpments. East of Caney River the topography is characterized as a rolling plain, varying from 700 to 860 feet above sea level. The lowest point in the county is along Caney River in the southeastern part of the county. The highest point is in the extreme northeast corner of the county in sec. 6, T. 29 N., R. 14 E., where it is 960 feet above sea level. The county is drained by Caney River and its tributaries.

GEOLOGY.

Washington County lies in the region of Pennsylvanian rocks. They consist chiefly of sandstones, shales, and limestones. The subdivisions of that system outcropping in this county from oldest to youngest are: Notawa shales, Lenapah limestone, Curl formation, Hogshooter limestone, Copan member, and Stanton member of the Wann formation. In the southern part of the county the section is somewhat different so that the stratigraphic equivalents of these formations have different names. The southern group from oldest to youngest is as follows: Lenapah limestone, Skiatook shale, and Dewey, Ochelata, and Avant members of the Ramona formation. The northern section and also the remainder of the Pennsylvanian section have already been discussed under "Nowata County," hence only a brief description of the southern section is given here.

SKIATOOK FORMATION.

The Skiatook includes a series of shales, sandstones, and limestones between the top of the Nowata shales and the base of the Ramona formation. In Washington County the Skiatook outcrops over the greater portion of T. 23 N., R. 13 E. In this area the thickness is about 250 feet, and farther south, in Tulsa County, it becomes about 500 feet thick. A bluish, massive limestone which is the southern extension of the Lenapah, occurs at the base of the Skiatook formation. Above this limestone is a bed of shale having a thickness of about 150 feet. In the upper part of the Skiatook heavy beds of sandstone occur. The Skiatook formation has been correlated with the Lenapah limestone, Nowata shales, Hogshooter limestone, and the lower 50 feet of the Copan.

RAMONA FORMATION.

The Ramona formation, which includes shales, sandstones, and limestones between the top of the Skiatook formation below and the top of the Avant limestone above, outcrops in the southwestern part of the country. The Ramona formation consists of a lower and upper limestone and intervening shales and sandstones. The Dewey limestone. which lies at the base of the formation, is about 7 feet thick. The Ochelata, or middle member, consists principally of shale and a sandstone. The average thickness is about 85 feet. The Avant limestone, or upper member, has an average thickness of 12 feet. Large red boulders are associated with it in many places. The Dewey and Avant members are continuous with the Dewey and Avant lenses, respectively, of the northern section.

STRUCTURE.

The structure in Washington County is in general that of a westward-dipping monocline, the average dip being about 20 feet per mile. Reversal dips to the east have been found. Anticlinal folding is associated with the accumulation in the principal fields of the county. ,

DEVELOPMENT.

GENERAL STATEMENT.

Owing to its proximity to producing fields in Kansas, Washington County received early development. In 1894 the Cudahy Oil Company leased 200,000 acres in the vicinity of Bartlesville. The first operations were carried on in this area. Development was retarded up to 1904 on account of the necessary approval of allottees' leases by the Department of the Interior. During 1904 development became very active in the vicinity of Dewey and Bartlesville. At the close of the year over 100 wells had been drilled at Bartlesville. In 1905 development continued in Bartlesville-Dewey pool and a new pool was opened northwest of Dewey. In 1906, besides the development in the above pools, a remarkable pool was opened a little south of Dewey. Rapid development followed. Some of the wells had an initial production of 1,000 barrels. During 1907 a good field was developed along Hogshooter Creek, about 15 miles southeast of Bartlesville. Some of the large wells had a daily initial production of 500 barrels, and gas wells of from 5 to 15 million cubic feet per day. During the next few years no remarkable pools were opened. In 1911 production in the Hogshooter field increased. From 1906 the production began to decline and has continued to do so. At present all of the fields are practically exhausted. The following pools are discussed under Washington County: Dewey-Bartlesville, Canary, Copan-Wann, and Hogshooter. Lesser developments in the vicinity of Vera are also mentioned. The Avant-Ochelata pool of Osage County extends into Washington County and for that reason it is included with that of Osage County.

DEWEY-BARTLESVILLE FIELD.

LOCATION AND EXTENT.

The Dewey pool, which lies in T. 27 N., Rs. 12, 13, and 14 E., is practically continuous with the Bartlesville pool in T. 26 N., Rs. 12, 13, and 14 E. The two pools, though nearly as distinct as are other pools in the same general district, are discussed together because of the close similarity of conditions and past histories. The Dewey-Bartlesville field extends west for several miles into Osage County. The Copan pool to the north is practically continuous with this field, and also the Hogshooter pool to the southeast and the Avant-Ochelata pool to the southwest. The lines of separation, though not distinct, are drawn at pronounced breaks in development.

STRUCTURE.

The production in this field seems to be in general closely associated with anticlinal folding.

GEOLOGY.

The wells of the region begin at about the horizon of the Dewey limestone, especially at the north end of the field. Farther south they start nearer the Hogshooter limestone. To give a better understanding of the subsurface geology the following logs are given.

C. B. Sixkiller No. 1, in sec. 32, T. 27 N., R. 13 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Lime	30	30	White slate	15	720
Slate—to gas sand	30	60	Peru sand	20	740
Slate	60	120	Red hole	50	790
Lime	35	155	Top of Oswego	45	835
Slate	65	220	Gas sand	5	840
Slate—oil sand (good show)	20	240	Bottom of Oswego	65	905
Slate to gas sand	180	420	Slate, white	30	935
Sand	45	465	Sand	40	975
Slate	163	628	Slate, white	175	1,150
Top of Big Lime	25	653	Red hole	38	1,188
Break	15	668	Gas sand	40	1,228
Bottom of Big lime	37	705	Gas		1,234

Albert Whiteturkey No. 2, in NE. cor. sec. 18, T. 26 N., R. 13 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Unrecorded	42	42	Shale, light	15	438
Shale	28	70	Sand	30	468
Lime	30	100	Shale, light	114	582
Shale, light	95	195	Lime	24	606
Sand	10	205	Break	12	618
Shale, light	145	350	Lime (little gas)	34	652
Lime	4	354	Slate, black	2	654
Break	5	359	Lime	5	659
Lime	6	365	Shale	6	665
Shale	27	392	Sand	15	680
Lime	5	397	Shale	112	792
Slate, black	8	405	Lime, Big	33	825
Lime	18	423	Slate, black	6	831

Albert Whiteturkey No. 2, *in NE. cor. sec.* 18, *T.* 26 *N., R.* 13 *E.*—Continued.

Character of rock.	Thick-ness.	Depth.	Character of rock.	Thick-ness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Lime, Big, (little gas)	23	854	Shale, light	45	1,050
Break	6	860	Shell	3	1,053
Lime, hard	9	869	Shale, light	37	1,090
Slate, black	20	889	Slate, black	10	1,100
Oil sand	24	913	Shale, sandy	454	1,145
Slate, black	6	919	Slate, black	17	1,162
Lime, hard	9	928	Sand, gas	7	1,169
Slate, black	15	943	Slate	26	1,195
Shale	37	980	Sand	89	1,284
Shell, hard	5	985	Sand, oil	7	1,291
Slate	17	1,002	Slate and shale	83	1,374
Shell, hard	3	1,005	Miss. lime, Total depth		1,378

DEVELOPMENT.

This field was one of the early discoveries and has been a heavy producer ever since. The whole area within the 6 townships is developed with the exception of a small strip along the eastern line of Washington County. The limits and extensions of the developed area have already been discussed under "Location" and "Development."

Development in this field was very active during 1904, 1905, and 1906. Some of the wells drilled during this period had an initial production of 1,000 barrels per day. In 1906 the average initial production per well was about 73.2 barrels. This average gradually decreased from that time and in 1914 it was only 10.4 barrels. At the close of 1914 there were 4,816 producing oil wells in this field. During 1915 and 1916 the high price paid for oil stimulated development in this field. The range in initial daily production was a few barrels to about 60 barrels, the average being about 20 barrels.

The region has developed a number of prolific gas wells. The main gas horizon is the Burgess sand encountered at a depth of 1,400 to 1,500 feet. The gas region lies chiefly near Bartlesville, though a narrow belt extends toward the northeast, even beyond the town of Dewey. Some wells have been brought in with an average initial capacity of 15,000,000 cubic feet per day, and an average rock pressure of 464 pounds. In most cases wells of such capacity were among the early finds. By the latter part of 1911 the pressure on these same wells had decreased to 219 pounds, and the gas production to 9,283,000 cubic feet. The initial capacity of gas wells ranges from 500,000 to 3,000,000 cubic feet per day.

A small gas field is located southeast of Dewey. The wells here, about 20 or 30 in number, yielded 20,000,000 to 30,000,000 cubic feet per day originally, and had a rock pressure as great as 500 pounds. By November, 1911, this pressure had decreased to an average of 300 pounds, and by January, 1914 to about 100 pounds.

Drilling record and initial production of wells in the Dewey-Bartlesville pool, 1906-1915.

	Wells completed.				Initial production.	
Year.	Total.	Oil.	Dry.	Gas.	Total. Barrels.	Average per well. Barrels.
1906	790	606	123	61	44,367	73.2
1909	415	390	19	6	16,540	37.8
1910	443	420	14	9	16,269	38.1
1911	493	455	30	8	12,513	28.1
1912	1,120	980	71	69	24,022	24.6
1913	(a) 948	829	75	44	19,412	28.4
1914	(a) 520	441	55	24	4,573	10.4
1915	90	80	9	1	1,120	14.0
Total	4,819	4,201	396	222	138,816	31.8

(a) Includes Hogshooter.

SANDS.

The Bartlesville sand, which has undoubtedly produced more oil than any other sand, and possibly more than all of the other sands of the State, is the main producing horizon. It is from this region that the Bartlesville sand takes its name. In thickness it varies from about 30 feet in the south end of the field to about 60 feet in the north end. Generally the Fort Scott formation, or Oswego lime, as it is commonly called, is found about 350 feet above the Bartlesville, which occurs at 1,250 to 1,500 feet. In appearance the sand is coarse in texture and brown in color.

The Burgess sand is the most important gas-bearing sand in this field. It lies about 150 feet below the Bartlesville and seems to be continuous throughout the region.

Other productive sands at shallower depths are the Dewey, Peru, and Squirrel. It will be noted that these are local names which are applicable for the most part to this and adjoining fields. Two of the shallow sands are now productive. The first producing horizon occurs at a depth of 525 to 650 feet and is made up of 30 feet of medium porous, light-colored sand. This sand is known locally as the McEwin sand.

The Peru sand, 30 feet in thickness, lies below the big lime, or Oologah formation.

FUTURE DRILLING.

In early drilling no attention was paid to the shallower horizons, because the deeper sands yielded much more. The smaller wells at shallower depths will, as the deep sands are drained and the price of oil advances, become more and more important. It seems probable that shallow drilling will in a short time offer the best inducement in this region and that the life of the pool will be extended a number of years by such work.

CANARY POOL.

LOCATION AND EXTENT.

The Canary pool lies in T. 29 N., Rs. 13 and 14 E., in the extreme northeast part of Washington County. The area covered is approximately 10 square miles, with the long axis extending northeast-southwest.

SANDS.

The wells in this area start about the horizon of the Copan member of the Wann formation. The productive horizons are at 1,175 and 1,450 feet, with these formations deepest at the western limits of the pool. The Bartlesville sand which is encountered at about 1,175 feet is the productive oil sand, and also furnishes some gas. The 1,450-foot sand is the Burgess and furnishes gas. The Bartlesville is about 50 feet in thickness, the upper part yielding gas and the lower part usually producing oil.

DEVELOPMENT.

The northeast part of the field is principally oil producing, with a few scattered gas wells. The reverse is true farther southwest. The average initial production per well is given by the United States Geological Survey as 54.4 barrels for 1909, and 33.7 barrels for 1910. For 1912 to 1916, inclusive, the average initial production per well could not be secured.

The gas field of this pool is continuous with the Caney pool in Kansas. The average initial capacity of the early gas wells was about 31,500,000 cubic feet per day. The average rock pressure was about 444 pounds. By 1911 the capacity of these wells was reduced to about 915,000 cubic feet per day and the rock pressure to 18 pounds. Drilling in search of deeper sands has been only moderately successful.

COPAN POOL.

LOCATION AND EXTENT.

The Copan pool is located in T. 28 N., Rs. 12 and 13 E., and occupies an area of about 8 square miles. It is almost continuous with the Canary pool to the north and the Bartlesville-Dewey field to the south. Some of the developed area extends into Osage County.

DEVELOPMENT.

The Copan field was opened in 1907 and development soon became very active. The average initial production of the wells in 1907 was 54.4 barrels and in 1910 it was 33.7 barrels. This average gradually decreased from that time. A few small oil and gas wells were the result of development in 1915.

The gas wells which originally had a rock pressure of 450 to 530 pounds had been depleted so that during the fall of 1911 the pressure was not more than 25 pounds, mainly because the sand was coarse and the drain rapid. Probably the maximum capacity of the field was about 300,000,000 cubic feet per day. In 1914 the capacity of the field was probably not more than 50,000,000 to 75,000,000 cubic feet. The following table gives the development from 1909 to 1915.

*Drilling record and initial production of wells in the Copan pool,** 1909-1915 *by years.*

Wells completed.					Initial production.	
Year.	Total.	Oil.	Dry.	Gas.	Total.	Average per well.
1909	95	43	17	35	2,340	54.4
1910	208	121	22	65	4,082	33.7
1911	282	216	45	21	5,890	27.3
1912	(a)573	482	50	41	10,972	22.8
1913	(a)469	393	50	26	6,309	16.1
1914	450	294	80	76	8,729	29.7
1915	105	76	10	19	926	12.2
Total	2,182	1,625	274	283	39,248	28.0

(a) Includes Ramsey.

*Includes also Wann and Canary pools.

SANDS.

The wells begin near the horizon of the Copan member of the Wann formation. A shallow sand, which was overlooked in the first development, is encountered at 700 to 800 feet and is probably the sandstone in the upper part of the Labette shale. The Bartlesville, which has a thickness of 29 feet, occurs at a depth of about 1,300 feet and is oil producing. The interval between it and the top of the Oswego lime is about 350 feet. The Burgess sand produces gas and occurs at a depth of about 1,500 feet. The following log is thought to be typical of this region.

William Miller No. 5, in NW. ¼ SW. ¼ NW. ¼ NW. cor. of farm sec 2, *T.* 28 *N., R.* 13 *E.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil and shale	30	30	Shale	110	720
Slate, blue, soft	100	130	Lime, big	102	822
Sand, white, loose	10	140	Shale	108	930
Sand, white, loose, hard	40	180	Lime, Oswego	80	1,010
Shale	40	220	Shale	10	1,020
Lime	40	260	Sand, white, hard	20	1,040
Shale, light, soft	118	378	Shale	90	1,130
Lime, white, hard	22	400	Slate, blue, soft	80	1,210
Slate, blue, soft	100	500	Slate, white, hard	10	1,220
Shale	70	570	Shale	45	1,265
Lime, white, hard	40	610	Gas sand, brown	35	1,300
			Oil	43	1,343

WANN POOL.

GENERAL.

The Wann pool is located in the west part of T. 28 N., R. 14 E., and lies to the east of the Copan pool. The general conditions are similar to those of the Copan pool. The Bartlesville sand, which is the chief productive oil sand, occurs at a depth of about 1,000 feet, 300 feet shallower than in the Copan pool. The Burgess is encountered at about 1,200 feet below the surface. The development is shown with that of the Copan pool.

HOGSHOOTER POOL.

LOCATION AND EXTENT.

The Hogshooter pool is located in Tps. 24, 25, and 26 N., R. 14 E., and lies on both sides of Hogshooter Creek in the southeastern part of Washington County. The developed area includes a strip about 12 miles long from north to south, and from a fraction of a mile to about 4 miles in width. This pool is continuous with the Dewey-Bartlesville field on the north.

GEOLOGY.

The wells on the east side of Hogshooter Creek and south of Oglesby begin on, or near, the horizon of the Curl formation. The wells on the west side of this creek begin near the horizon of the Hogshooter limestone.

DEVELOPMENT.

The Hogshooter pool was opened in 1907 and during that year development was very active. Some of the larger wells had an initial production of 500 barrels per day, and gas wells from 5,000,000 to 15,000,000 cubic feet per day. In 1909 the average initial production was 50 barrels per well. This average remained practically the same for the next 3 years, but decreased considerably from 1913 to 1916. The oil producing area is in the northwestern part of the pool. At the close of 1914 there were 61 producing oil wells in this area. The daily production at the present time (October, 1916) is estimtated at 460 barrels. The larger portion constitutes one of the greatest gas fields of the State.

Most of the large gas companies have lines to this field. The gas is piped to Dewey, Bartlesville, and other towns in northeastern Oklahoma and southeastern Kansas.

The following table gives the development from 1909 to 1914.

Drilling record and initial production of wells in the Hogshooter pool.

	Wells completed.				Initial production.	
Year.	Total.	Oil.	Dry.	Gas.	Total.	Average per well.
1909	107	71	12	24	3,750	50.
1910	155	109	8	38	5,115	46.9
1911	339	192	31	116	8,795	45.8
1912	392	285	43	64	13,151	46.1
1913*	948	829	75	44	19,412	28.4
1914*	520	441	55	24	4,573	10.4
Total	2,461	1,927	224	310	54,796	37.9

*Includes Hogshooter and Bartlesville pools.

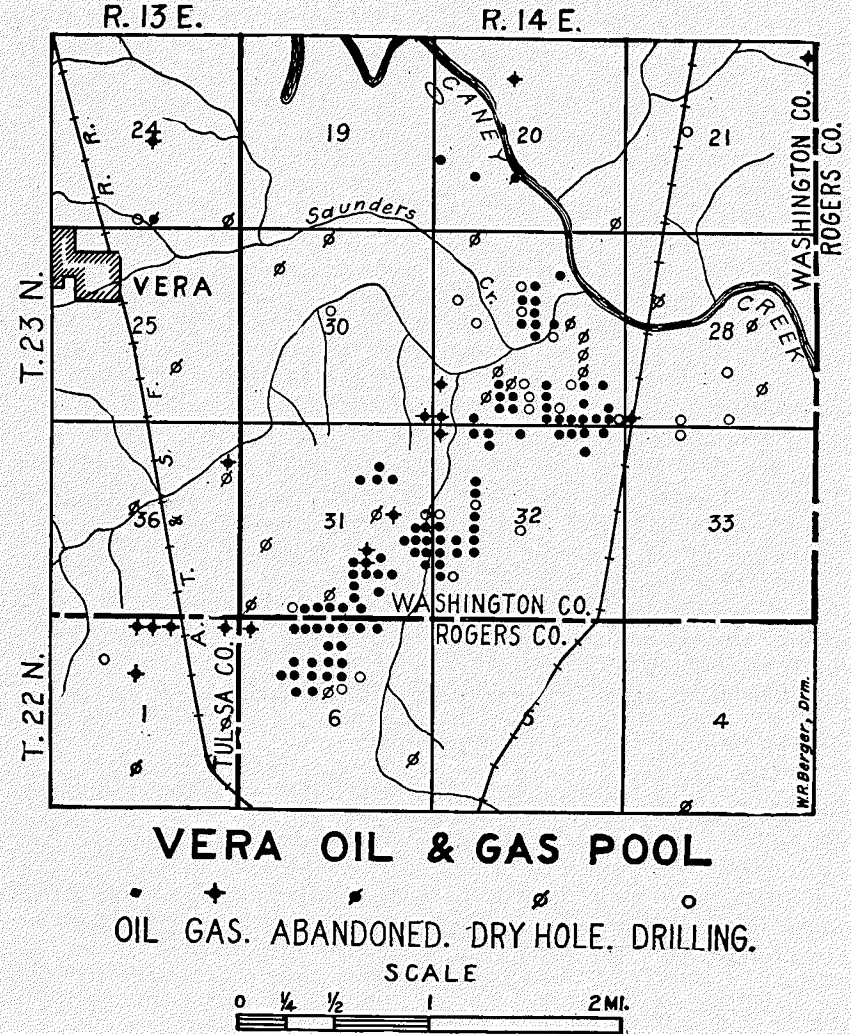

R. 13 E.
R. 14 E.
T. 23 N.
T. 22 N.
24
19
20
21
25
30
28
36
31
32
33
1
6
5
4
VERA
Saunders
Cr.
CANEY
CREEK
WASHINGTON CO.
ROGERS CO.
TULSA CO.
A. T. & S. F. R. R.
W. R. Berger, Drm.
VERA OIL & GAS POOL
OIL GAS. ABANDONED. DRY HOLE. DRILLING.
SCALE
0 ¼ ½ 1 2 MI.

Figure 24.

SANDS.

The sands in this pool are encountered at the following depths: 500, 710, 880, 1,080, and 1,160. The highest sand—the 500-foot sand is about 40 feet below the "Big Lime" which is encountered at about 450 feet. The Bixler sand which is just below the Oswego lime, occurs at about 710 feet. A productive oil sand is found 200 feet below the Oswego, or at a depth of 880 feet. The Bartlesville, which is the main producing oil sand of this pool, lies about 400 feet below the Oswego. or at a depth of 1,080 feet. A gas sand which is thought to be the Burgess is encountered at a depth of 1,160 feet.

VERA POOL.

LOCATION.

The Vera oil and gas pool is located in the extreme southeastern corner of Washington County. The principal producing area lies near the corner of four townships, namely: T. 22 N., R. 13 E., T. 22 N., R. 14 E., T. 23 N., R. 13 E., and T. 23 N., R. 14 E. This pool has been of recent development, having been opened in 1915. After the first wells were drilled much activity followed. At the end of the year about 40 wells had been completed, 25 of which were oil producers, 9 gas, and 6 dry holes. The total initial production was about 2,063 barrels, an average of about 60 barrels per well. In October of that year the daily production of the field was about 650 barrels.

During the first 6 months of 1916 over 70 wells had been completed. The average initial daily production of the oil wells for this period was about 50 barrels. The oil wells range in initial production from a few barrels to as high as 350 barrels, and the gas wells from 2,000,000 to 18,000,000 cubic feet.

The daily production in October, 1916 was estimated at 500 barrels.

SUMMARY.

Washington County is in proved oil and gas territory. The surface rocks are Pennsylvanian and generally dip to the west at a low angle. The oil and gas accumulations so far developed are associated with folding. This county includes several important oil and gas fields. Development began early and has continued intermittently up to the present time. Some of the old fields are almost exhausted. Considerable territory has been developed, but there are still areas which have not been tested. The productive horizons are fairly shallow, ranging from 500 to 1,700 feet.

WASHITA COUNTY.

LOCATION.

Washita County is located in the southwestern part of the State. It extends from T 8 N. to T. 11 N., inclusive, and from R. 14 W. to R. 20 W., inclusive. It is regular in shape, being that of a rectangle 24 miles wide and 42 miles long. It contains 28 townships. The total area is 1,008 square miles.

TOPOGRAPHY.

The topography is that of a high prairie plain, into which Washita River has cut a narrow valley, and into which the smaller streams have made narrow canyons and gulches. All the county is drained by Washita River and its tributaries, except the southwestern part which is drained by tributaries to North Fork of Red River.

GEOLOGY.

The rocks at the surface in Washita County are Permian and Quaternary.

The following Permian formations are exposed: Woodward, Greer, and Quartermaster. The Woodward occupies an area of about 36 square miles, in the northeastern corner of the county. This formation consists of shales, sandstones, and dolomites. The Greer formation is found immediately southwest of the Woodward formation and covers an area of approximately 500 square miles. It consists of red clays, shales, and sandstones interbedded with gypsum and dolomite. The Quartermaster formation is found in the northwestern part of the county and covers an area of approximately 300 square miles. It consists of soft red sandstones and arenaceous clays and shales. In the extreme northeastern part of the county there is an area of about 70 square miles which belongs to the Permian Redbeds, but which has not yet been classified.

The Quaternary occupies a narrow strip along Washita River. It consists of alluvium.

STRUCTURE.

The general dip of the strata in the north and northeastern part of the county is southwest. In the southern and southwestern parts of the county the general dips are to the northeast. The attitude of these latter strata is the result of the Wichita Mountain uplift.

The character of the dips as shown by the surface outcrops indicates a large synclinal trough in Washita County. Sufficient detailed work has not been done in this county to determine definitely the structural conditions. However, any work which is done in the area must be undertaken on the supposition that a large synclinal depression has been formed by the influence of the Wichita Mountain uplift on normally southward-dipping strata. Minor folds may occur within this depression and also to the north and northeast, where the areas are considerably removed from the axial part of the synclinal fold.

DEVELOPMENT.

A well is being drilled near Canute in the northwestern part of the county, in sec. 18 T. 11 N., R. 19 W. This well has had considerable caving trouble and in fact the original hole had to be abandoned and the rig skidded over to a new location. A well is also being drilled in the NE. 1/4 of sec. 31, T. 8 N., R. 17 W.

SUMMARY.

Washita County lies in an area in which it is difficult to determine the exact character of the structural features. As indicated above the normal dip in the area would be to the southwest, but the influence of the Wichita Mountains to the southward has brought about changes in the structure which will require specially detailed work to determine. While conditions which would lend encouragement to the drilling of test wells are not so favorable as in many other sections of the State, yet the general conditions are such that anticlinal folding of importance may be found in parts of the county. The nearest production is in the vicinity of Gotebo, just to the south of the limits of the county. In making definite locations for the drilling of any wells in this county very carefully detailed geologic work should be done in the area in which the test is to be made.

WOODS COUNTY.

LOCATION.

Woods County is located in the northwestern part of the State. It extends from T. 22 N. to T. 29 N. inclusive, and from R. 13 W. to R. 21 W. inclusive. It includes 25 entire townships and parts of 20 others. The total area is approximately 1,320 square miles.

TOPOGRAPHY.

Woods County has two general types of topography: Redbeds Plains and Gypsum Hills. The Redbeds Plains area occupies the eastern two-thirds of the county. This area is a gently rolling prairie plain. The western one-third of the county is in the Gypsum Hills region. This area consists of south and eastward-facing gypsum escarpments which have been dissected by streams.

The northern part of the county is drained by Salt Fork of Arkansas River, and streams tributary to it. The southern and western parts are drained by Cimarron River and streams tributary to it.

GEOLOGY.

The rocks at the surface in Woods County are Quaternary, Cretaceous, and Permian. The following Permian formations, named in order from youngest to oldest, outcrop in Woods County: Woodward, Blaine, and Enid.

The Enid formation occupies an area of about 550 square miles in the central and eastern parts of the county. The erosional effect of Cimarron River on the westward-dipping formations has caused the surface outcrop of these formations to extend considerable distances westward in Woods County. The Enid formation outcrop extends in an east-west direction along Cimarron River, entirely across the county. The Enid formation consists of brick-red clay shales, with some interbedded ledges of red and white sandstones.

The Blaine formation occupies an area of about 130 square miles, lying in a narrow belt immediately north of the Enid formation outcrop. The Blaine consists of red shales with interbedded strata of massive gypsum and thin ledges of dolomite.

The Woodward formation occupies an area of about 260 square miles in the northwestern part of the county. This formation consists of shales, sandstones, and dolomites.

The Cretaceous occupies several isolated outliers in the northwestern part of the county. The total area is about 20 square miles. These rocks consist of limestone and shale.

The Quaternary rocks occupy an area of about 360 square miles. These rocks outcrop in two separate areas within the county. One is found along and to the north of Salt Fork of Arkansas River in the northeastern part of the county. The other is found along and to the north of Cimarron River. The Quaternary in Woods County consists of dune sand and alluvium.

The following log will give a general idea of the underground strata:

Log of Alva well, in SE. 1/4 Sec. 24, T. 27 N., R. 14 W.

Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*
Red shale and sandstone	645	645
Shale, blue	80	725
Red shale and sandstone	40	765
Shale, blue	35	800
Red shale and sandstone	300	1,100
Shale, blue	120	1,220
Shaly lime	2	1,222
Shale	22	1,244
Shaly lime	1	1,245
Shale	40	1,285
Shaly lime	2	1,287
Shale, blue	180	1,467
Shaly lime	3	1,470
Shale	20	1,490
Lime shells	5	1,495
Shale	45	1,540
Shale and salt	20	1,560
Salt	80	1,640
Shale	40	1,680
Salt	20	1,700
Shale	20	1,720
Shelly lime	60	1,780
Shale and salt	20	1,800
Shale and shelly lime	240	2,040
Sandy lime	20	2,060

Log of Alva well, in SE. ¼ Sec. 24, T. 27 N., R. 14 W.—Continued.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Shale and shelly lime	32	2,092	Lime, gray, hard	17	2,976
Sandy lime	58	2,150	Shale, gray, soft	15	2,991
Sand and shelly lime	15	2,165	Lime, gray, hard	15	3,006
Sand, gray	45	2,210	Lime, gray, soft	10	3,016
Lime shells	22	2,232	Lime, gray, hard	10	3,026
Sand, white	18	2,250	Shale, blue, soft	17	3,043
Hard lime	152	2,402	Lime, gray, hard	7	3,050
Pawhuska limestone			Shale, blue, soft	28	3,078
Sandy lime	33	2,435	Lime, blue, hard	37	3,115
Impure lime (Bastard)	30	2,465	Shale, blue, soft	10	3,125
Shale	5	2,470	Sand, gray, hard	25	3,150
Lime, sandy	10	2,480	Lime, gray, hard	30	3,180
Shale	13	2,493	Sandy lime	15	3,195
Lime	56	2,549	Sandy shale	15	3,210
Lime	9	2,558	Sandy lime	30	3,240
Shale	13	2,571	Shale, blue, hard	22	3,262
Lime, gray and blue	37	2,608	Sandy shale, hard	15	3,277
Shale	5	2,613	Lime, white, hard	38	3,315
Lime	2	2,615	Sand, brown, hard	15	3,330
Shale	13	2,628	Sandy shale, soft	9	3,339
Lime	2	2,630	Lime, white, hard	42	3,381
Shale, blue and gray, soft	24	2,654	Lime, gray, hard	11	3,392
			Lime, white, soft	24	3,416
Limestone, hard, blue and gray	120	2,774	Lime, gray, soft	14	3,430
Shelly limestone and shale	21	2,795	Lime, gray, hard, and soft	9	3,439
			Lime, gray hard	4	3,443
Limestone, soft and white	30	2,825	Lime, gray, soft	4	3,447
			Lime, gray, hard	3	3,450
Shale and shells	2	2,827	Lime, gray, soft	50	3,500
Blue shale	9	2,836	Lime, gray, hard	39	3,539
Shale and shells	22	2,858	Shale, gray, hard	11	3,550
Blue shale and shells (lime)	89	2,947	Sand, gray, soft	10	3,560
			Sand, gray, hard	5	3,565
Blue shale and shells	12	2,959	Sandy shale, soft	116	3,681

STRUCTURE.

The general attitude of the strata in Woods County is that of a west-dipping monocline. There are local variations in this general west dip.

The presence of an anticline in the vicinity of Cara post office was determined by the Survey late in 1915. The axis of the anticline extends southwest from a point about two miles north of the Cara post office for a considerable distance. The limits of this fold were not definitely determined. Recently, however, geologists in the employ of oil companies have mapped the structure in detail and the conditions found show that structural features are well pronounced and worthy of being tested out by the drilling of wells on the structure. The surface rocks on which the structure was mapped consist of the Whitehorse sandstone and certain gypsum ledges. This is the only structure which has been mapped in detail in the gypsum-bearing portion of the Red-beds, and the outcome is being watched with much interest. The difficult feature to determine is whether the structure is deep-seated, or only occurs in the gypsum-bearing formations. The first well which began drilling on this anticline has now reached a depth of more than 1,000 feet, and from a study of the log of this well as compared with the log of the well drilled at Alva, conditions indicate that the drill is now in Pennsylvanian rocks at a shallower depth than encountered in the Alva well. All data available on the region and the character of the logs indicate that the structure apparent on the surface conforms to structure in the underlying Pennsylvanian. It is the purpose of the parties drilling this well to carry it to a depth of 4,000 feet or deeper if necessary in order to insure a good test of this anticlinal fold.

A ring of hills of the Whitehorse sandstone member of the Woodward formation rims a basin at the top of the structure. The Blaine formation gypsums occur inside the rim of hills at notably higher elevations than on the outside.

DEVELOPMENT.

A well was drilled sometime ago by the people of Alva. This well, located in the southeastern edge of the city, was drilled to a depth of 2,825 feet. (See log of Alva well, which appears in the discussion on "Geology" of Woods County.)

The Cosden Company is drilling a well in sec. 8, T. 27 N., R. 16 W. This well is located on the Cara anticline. Two other locations have been made in the county. One in sec. 2, T. 28 N., R. 17 W., and the other in sec. 7, T. 28 N., R. 17 W.

SUMMARY.

The Permian sediments are for the most part barren of carbonaceous material. Therefore, no accumulation of oil or gas is expected in these sediments unless they have migrated from formations in which carbonaceous materials occur. The Pennsylvanian, which, no doubt, underlies the Permian in Woods County, is the source of most of the oil and gas in the State. If we consider that the red shales and sandstones are Permian, and the blue shales and limestones are Pennsylvanian, then, according to the log of the Alva well, the Permian sediments in Woods County are about 1,100 feet thick. However, farther east, in Kay County, there are some limestones at the base of the Permian. It may be, then, that the Permian sediments are somewhat thicker than the above mentioned depth. It is necessary to drill to a depth of at least 1,100 feet at favorable locations before production is expected. How far into the Pennsylvanian it is necessary to drill before productive sands are reached is not known.

WOODWARD COUNTY.

LOCATION.

Woodward County is located in the northwestern part of the State. It extends from T. 20 N., to T. 27 N., inclusive, and from R. 17 W. to R. 22 W., inclusive. It consists of 33 entire townships and parts of 5 others. The approximate area is 1,266 square miles.

TOPOGRAPHY.

In general the topography of Woodward County may be divided into two parts—the Gypsum Hill region in the eastern part, and the High Plains in the western part. Each of these general areas has been modified by mantles of sand.

The most prominent gypsum hills are in the area of the Blaine formation outcrop. They consist of eastward-facing bluffs and escarpments capped by massive gypsum ledges. They are the result of stream erosion on the westward-dipping gypsums of the Blaine formation.

The northern part of Woodward county is drained by Cimarron River and streams tributary to it. The central and southern parts are drained by North Fork of Canadian River and streams tributary to it.

GEOLOGY.

The rocks at the surface in Woodward County are Quaternary, Tertiary and Permian, together with some outliers of Cretaceous.

Of the Permian the following formations are present: Greer, Woodward, Blaine, and Enid. The Enid formation occupies an area of approximately 60 square miles in the northeastern part of the county. It outcrops in a narrow belt running northwest-southeast, just southwest of and parallel to Cimarron River. This formation consists of brick-red clay shales, with some interbedded ledges of white and red sandstones. Very few sandstones are found in this formation in Woodward County.

The Blaine formation occupies an area of approximately 105 square miles. It outcrops in a narrow belt just southwest of the Enid formation outcrop. This formation consists of masive gypsum ledges interbedded with red shales. There are also thin ledges of dolomite. The characteristic of this formation is the abundance of gypsum.

The Woodward formation outcrops in two separate areas in Woodward County. Immediately southwest of the Blaine formation there is a narrow belt of this formation, covering an area of about 120 square miles. Just southwest of North Fork of Canadian River there is an irregular area of about 120 square miles of the Woodward. It is about six miles wide in the southern part of the county, becomes narrower to the northwest, and disapears under the Quaternary sand just before the north line of the county is reached. This formation consists of shales, sandstones, and dolomites. This formation is distinguished from formations immediately above and below it by the predominance of dolomites and the absence of gypsum.

About 8 miles northwest of the southeast corner of the county there is an area of about 38 square miles of Greer formation. This formation consists of red clays, shales, and sandstones, and intercalated beds of gypsum and dolomite. Gypsum is the characteristic deposit of this formation.

Tertiary rocks occupy an area of about 85 square miles in the southwestern corner of the county. They are for the most part clay, sand, and gravel.

The Quaternary rocks outcrop along the valley of Cimarron River, along the valley of and to the northeast of North Fork Canadian River, and in the southwestern part of the county. The total surface area of these rocks is about 738 square miles. The Quaternary rocks consist of alluvium and dune sand.

STRUCTURE.

In general the rocks in Woodward County dip at a low angle to the southwest. There may be local variations in this general dip. The massive gypsum ledges of the Blaine formation in the northeastern part of the county furnish the most reliable "key" rocks from which the underground structure may be determined. Very much of the surface in this county is covered with sand gravel, or alluvium, and very few indications of the underground structure can be found.

DEVELOPMENT.

Considerable leasing has been done along the gypsum outcrops in Woodward County. Some leasing has been done in areas where there are few and sometimes no outcrops.

The Home Producers' Oil Company has made a location in sec. 3, T. 21 N., R. 21 W.

SUMMARY.

Many geologists are of the opinion that petroleum and natural gas are organic in origin. The large deposits of gypsum found in and distributed through the Permian rocks indicate an arid climate during a large part of the time these sediments were being laid down. This climate inhabited organic life. Practically no organic deposits have been found native to the Permian sediments. The Pennsylvanian rocks probably underlie the Permian in Woodward County. These abound in carbonaceous material; carbonaceous shale, coal, oil and gas. Nearly all the oil and gas in Oklahoma has been found within or closely associated with the Pennsylvanian. So, before there would be much chance of encountering oil or gas, the drill would have to pass through the Permian and penetrate the Pennsylvanian. The thickness of the Permian in Woodward County is probably 1,500 to 2,000 feet.

SUMMARY.

The following paragraphs summarize the principal development in the various counties where the greatest activity is taking place in the oil and gas industry. It is the purpose of this report, as embodied in the preceding pages, to give as liberal a discussion to the geology, structure, and development of each county as possible. However, it would be a difficult task to publish a report which would be complete and give conditions of development up to date. The items given below indicate the special development conditions during March and the first half of April, 1917.

Caddo County.—The Keeche Oil Company encountered oil sands at 1,114 and 1,506 feet respectively, in their wells in the SE. 1/4 of sec. 32, T. 6 N., R. 9 W. Considerable oil and some gas was found. The Fortuna Oil Company is drilling in sec. 31 of the same township. The latter test is favorably located from a structural standpoint.

Carter County.—The "Wildcat Jim" No. 2 encountered 26 feet of oil sand at a depth of 1,680 feet in sec. 18, T. 2 S., R. 2 W. The production was reported to be about 50 barrels of oil daily. The Gypsy Oil Company encountered 70,000,000 cubic feet of gas in their well in sec. 28, T. 2 S., R. 3 W. The southeast extension of the Healdton field has been carried farther by the completion of two wells. One of these wells was drilled by the Carter Oil Company in sec. 18, T. 4 S., R. 2 W., and produced 150 barrels of oil daily from a sand found at a depth of 1,900 feet; the other well was drilled by Gunsberg and Forman in the SW. cor. sec. 19, T. 4 S., R. 2 W., which produced 20 barrels of oil daily from a 36-foot sand found at a depth of 1,188 feet.

Cleveland County.—Three tests are now being drilled in this county —one by the Cleveland County Development Company in the SE. 1/4 of sec. 31, T. 9 N., R. 1 E.; the Cleveland County Oil & Gas Company in the center of the NE. 1/4 of the NE. 1/4 sec. 26, T. 6 N., R. 1 E.; and the National Development Company in the NE. 1/4 sec. 14, T. 7 N., R. 1 W.

Comanche County.—A dry hole was recently completed at a depth of 2,570 feet in sec. 29, T. 2 N., R. 10 W.

Cotton County.—The first production of any consequence in this county was found by John C. Keys and others in sec. 23, T. 1 S., R. 10 W., where an initial gas production of about 8,000,000 cubic feet was obtained at a depth of 2,150 feet. A reconnaissance survey in the vicinity of this well has been made. There are very few outcrops in this area, and the underground structure could not be determined.

Creek County.—The most interesting recent development in Creek County has been in T. 15 N., R. 9 E., where considerable gas and some oil have been found. In sec. 22 the Abraham well encountered 40,000,000 cubic feet of gas at a depth of 1,220 feet. In the same section the Cosden Oil & Gas Company encountered 30,000,000 cubic feet of gas. In sec. 21, B. B. Jones encountered 15,000,000 cubic feet of gas. In sec. 16 the Berment Oil Company encountered 50,000,000 cubic feet of gas at a depth of 1,200 feet.

Garfield County.—The most recent reports from the Garber field are that the Sinclair Oil & Gas Company have a daily production of 200 barrels of oil in their well in sec. 23, T. 22 N., R. 4 W. A daily production of 40 barrels of oil was found at a depth of 1,115 feet in the SE. cor. SW. ¼ sec. 24, T. 22 N., R. 4 W.

Kay County.—Several deep wells have recently been drilled in this county. The Oklahoma Star Oil Company is reported to have encountered good production in sec. 34, T. 27 N., R. 3 E. This was found in a sand at a depth of 3,210 feet. J. S. Armstrong and associates are reported to have encountered considerable production in sec. 10, T. 27 N., R. 3 E. at a depth of 3,155 feet.

McIntosh County.—Recent reports show that 19,000,000 cubic feet of gas was encountered in the NW. cor. NE. ¼ sec. 16, T. 11 N., R. 14 E., at a depth of 1,557 feet.

Marshall County.—The Daniel Waite well in sec. 23, T. 7 S., R. 5 E. encountered 2,500,000 cubic feet of gas at a depth of 450 feet.

Muskogee County.—The New York-Oklahoma Oil Co.'s well No. 1, in the SE. cor. SW. ¼ sec. 6, T. 13 N., R. 18 E. was dry at a depth of 2,288 feet.

Noble County.—The reported "show" of oil at a depth of 2,000 feet in the Humphreys Petroleum Co.'s well in sec. 17, T. 24 N., R. 1 W. is the most interesting news recently received from Noble County.

Okfuskee County.—The Corbin Oil Company abandoned a hole in sec. 24, T. 13 N., R. 10 E. at a depth of 2,660 feet. The Oklahoma Star Oil Co.'s well No. 1 in sec. 35, T. 12 N., R. 11 E. was abandoned at a depth of 2,200 feet. The Carter Oil Co.'s well in sec. 23, T. 13 N., R. 10 E. produced 100 barrels of oil daily from a sand found at a depth of 2,703 feet.

Payne County.—In the Yale field four or five good oil wells ranging in capacity from 50 to 450 barrels of oil daily, have recently been completed in T. 19 N., R. 5 E. In the Ingalls pool the Fortuna Oil Company encoutnered a daily production of 200 barrels of oil at a depth of 3,800 feet. This is the deepest producing sand encountered in the State.

Pawnee County.—Some good wells have recently been completed in Pawnee County. The Prairie Oil & Gas Company encountered 25,000,000 cubic feet of gas in a well in sec. 23, T. 20 N., R. 7 E. The Cosden Oil & Gas Company found an hourly production of 17 barrels of oil in its well in sec. 36, T. 20 N., R. 5 E. The Quaker Oil & Gas Company encountered 2,000,000 cubic feet of gas in its well in sec. 12, T. 21 N., R. 6 E.

Pontotoc County.—Encouraging results are being obtained in Pontotoc County. The Mascho well in the NE. cor. SE. 1/4 of the NE. 1/4 sec. 3, T. 4 N., R. 7 E., which caused a good deal of excitement at the time it was drilled in, is now producing 20 barrels of oil daily. The Ohio State Oil Company encountered 3,000,000 cubic feet of gas in a well in sec. 34, T. 5 N., R. 7 E. The American Company of Oklahoma City brought in a big gas well in sec. 7, T. 4 N., R. 6 E. This proves that the limits of the Ada gas field have not been defined.

CORRELATION OF THE OIL SANDS IN OKLAHOMA.

METHODS OF CORRELATION.

Correlation of oil sands is a subject which takes into consideration many phases of geology. Formations are correlated on paleontological, paleobotanical, stratigraphical, or lithological data, any one or all of which may be used; or possibly from data other than that mentioned. Oil sands, on the other hand, cannot be correlated by all these methods. In fact, only a few can be employed.

The only way in which paleontology and paleobotany are used is in a correlation of the surface formations. There are exceptions to this. For example, many cases have been reported where fossils have been encountered in drilling wells. Data of this nature are important and conclusive if the fossils are typical and characteristic of a formation already studied at the surface, or encountered in drilling a well in another locality. It is apparent that this method, if possible to use, would be the best and most nearly correct. However, its use in this respect is very limited as a means of correlation of oil sands.

Some oil sands may be correlated if certain characteristic formations either above, below, or near, as the case may be, the oil sands may be recognized. Correlations by this method would be rather indefinite or open to doubt in many instances. Generally, it is necessary to use this method, on account of insufficient data to correlate by other means.

Oil sands are correlated more on lithological data than on any other. It is the most practical method, yet may lead to a serious error if other things are not considered. As an example, the logs of two wells eight miles apart are being compared. Certain limestones occur in both wells and if they were considered together there is a chance for error by mistaking one limestone for another. In this case other methods ought to be used in addition to that already employed. Then again, a formation may be found to change in character from place to place. A limestone may grade into a shale, then to a sandstone, or the reverse may take place. There is also a chance for it to differ materially in thickness or pinch out and then come in again in the section. There are so many variations that to correlate any horizon on lithological data alone would be questionable.

To correlate oil sands we see that it is necessary to use all available data. One method may be sufficient, but to have a correct correlation the surface geology, general and local, changes in dips, characteristic horizons in the logs, altitudes of the wells, and any other data should be used if possible. All these relations can be best shown by platting in columnar form the available well logs showing the data as mentioned above, then by a direct comparison correlations can be made with some degree of accuracy.

WELL LOGS.

As previously stated, the correlations depend upon well logs, together with the altitudes of the wells and surface geology. The log, being the most important factor, should be detailed and accurate. The inaccuracy of logs is one of the problems confronting one in this kind of work. It is a known fact that many drillers do not pay very much attention to the accuracy of the log. For example, in off-set wells drilled by different parties a comparison of the logs will show that the horizons vary in every manner, or may be present in one and missing in another. Many drillers will be confused as to the lithological character of the horizons. For instance, they may call a sandy shale a sand, shale, red rock, or most anything. Perhaps some mistakes cannot be accounted for, as it is not to be expected that drillers have a scientific knowledge of all rocks and their differentiation. In using a log, all these things must be considered and due allowance given for errors.

OIL SANDS.

An oil sand, as defined by common use, is a porous rock containing oil. This definition would be applicable to a limestone if it contained oil. In many instances drillers have reported great thicknesses of dry oil sands. These are not to be considered oil sands, according to the definition, but may, however, be classified as a sand consisting of the proper-sized grains and of sufficient amount of pore space for the rock to serve the purpose of an oil reservoir if the oil were present.

It often happens that one well will prove a "gusher," while another near by, at the same depth and in the same sand, comes in dry. This may be attributed to several causes, the chief of which is that the drill has pierced a close-grained or non-porous part of the reservoir rock.

GEOLOGICAL FORMATIONS.

The geology which is of particular interest to the practical oil man is the extent of formations which are or may be productive of oil and gas. The one series of rocks in Oklahoma that is of special importance from this standpoint is the Pennsylvanian. Practically all of the productive horizons in the Oklahoma fields are from the Pennsylvanian. There are four general areas of exposed Pennsylvanian; The area north of Arkansas River, the area south of Arkansas River, the area north of the Choctaw fault, and the area south of the Arbuckle Mountains.

GENERAL PROBLEMS IN THE CORRELATION OF SANDS IN THE PENNSYLVANIAN.

Several questions arise as to the extent and interval between succeeding formations, and also as to the constancy and correlation of horizons on the formations are traced westward and southward from the northeastern part of Oklahoma. The Cherokee formation, which is the approximate equivalent of the Vinita formation, has a thickness of 450 feet at the southern Kansas line. Southward from this point they thicken rapidly to at least 1,000 feet at Pryor Creek and continue to thicken southward. In the Muskogee quadrangle the Winslow and Boggy formations, about 1,500 feet in thickness, are correlated by Taff with the Cherokee formation. In the Coalgate quadrangle Taff has correlated the Atoka, Hartshorne, McAlester, Savanna, and Boggy formations with the Cherokee. Thus the Cherokee, which has a thickness of 450 feet at the Kansas line, is equivalent to the 9,000 feet of sediments from the base of the Atoka to and including the Boggy. Siebenthal makes the same correlation. On the other hand, Ohern says: "I cannot agree with Siebenthal in saying that in the Coalgate and Atoka quadrangles these 9,000 feet of Pennsylvanian shale sand sandstones are represented at the Kansas line by a thickness of but 500 feet of Cherokee. Assuming the verity of his correlation of the Fort Scott of Kansas with the Calvin sandstone of Coalgate quadrangle, still his statement is probably not correct; for the relation of the Vinita formation to the Mississipian below is for the most part, at least, one of overlap. Thus as one follows the Mississippian-Pennsylvanian contact line southward and eastward from the Kansas line, successively older formations appear from beneath those overlying. At most, then, the Cherokee shales can be the equivalent of only a part of the 9,000 feet of Pennsylvanian sediments near Coalgate."

It would appear, then, that productive horizons near the base of the Pennsylvanian encountered in the territory to the north of Muskogee and Okmulgee counties are not the same as the basal horizons encountered in the above-mentioned counties. The writer takes this view, and the correlations as platted on the chart have been made with that in mind.

DISCUSSION OF THE OIL SANDS AND ASSOCIATED HORIZONS FROM OLDEST TO YOUNGEST.

SIMPSON SANDSTONE.

The Simpson sandstone, in the Arbuckle Mountains, and of Ordovician age, is the oldest oil horizon in Oklahoma. As found in places in the Arbuckle Mountains, certain horizons in the Simpson formation are impregnated with asphalt. In this respect it may be considered as a fossil oil sand, but in the Healdton field there is a possibility, according to some geologists, of the Simpson being a productive horizon.

MISSISSIPPIAN LIME.

The "Mississippi lime" of the drillers may be either the Pitkin limestone, limestone in the Fayetteville shales, the Mayes limestone, or the Boone chert. Drilling is usually discontinued when the driller is satisfied that these horizons have been reached. As before stated, oil and gas are not definitely known to occur in, or below these horizons, and in nearly every case where they have been penetrated strong flows of salt water have been encountered. It is probably true that drilling is often discontinued when some of the limestones in the Lower Pennsylvanian are encountered and mistaken for the "Mississippi lime."

PENNSYLVANIAN SANDS.

The oldest sands in the Pennsylvanian occur in the Morrow formation. In the Beland pool two gas sands have been referred to this horizon. One is encountered at a depth of 1,500 feet, and the other at 1,745 feet.

Only brief reference is given to the succeeding sands with their correlations. Some of the main productive horizons will be discussed.

BARTLESVILLE SAND.

The Bartlesville sand is the most widely known oil sand in the State, and more oil has been produced from this sand than from any other horizon in Oklahoma. This sand occurs near the base of the Cherokee formation. The heavy sandstone outcropping east of Welch, at Bluejacket, and northwest of Vinita, is probably the Bartlesville. It has been recognized to the westward through Osage County, as far as the drilled areas in Kay County, and to the southwest in the Cushing field, where it has proven the sand of big production. In the latter field it occurs at depths from 2,400 to 2,800 feet. This formation is not an oil sand in all of its areal extent, although the term is very properly applied to the strata occurring at this horizon.

WHEELER SAND.

The Wheeler "sand" of the Cushing field is a good example of formations other than true sands forming oil reservoirs. This sand. which changes in character from an impure limestone to a sandy lime. is probably the equivalent of the Fort Scott or Oswego lime, which is one of the most constant formations underlying practically the entire oil and gas area of northeastern Oklahoma.

LAYTON SAND.

The Layton sand, which has been extensively developed in the Cushing field, probably occurs in the Curl formation. This sand, or its equivalent, has been recognized in various fields in northeastern Oklahoma. At Wynona a sand encountered at a depth of 1,180 feet is probably the Layton or its equivalent. The same sand is encountered in the Boston, Cleveland, Lunderdale, Cushing, Yale, Ripley, Ponca City, and Blackwell fields at depths of 1,240, 1,300, 1,480; 1,975; 2,072; 2,300 and 2,655 feet; respectively.

PONCA AND NEWKIRK SANDS.

The Ponca sand probably occurs in the Buxton formation. At Ponca City this sand is productive of both oil and gas and is encountered at a depth of about 1,550 feet. In the Blackwell field a sand encountered at a depth of about 1,960 feet is probably the Ponca.

The Newkirk sand, which is the equivalent or a part of the Elgin sandstone, is encountered in the Newkirk field, where it is productive of oil at a depth of 900 feet. In the Ponca City and Blackwell fields it is encountered at depths of 975 and 1,440 feet, respectively.

MISCELLANEOUS SANDS.

In the Healdton field about 7 sands productive of oil and gas have been encountered. The deepest is that of the 2000-foot sand encountered in the Fox district. Other sands are encountered at the following depths: 725, 781, 820, 925, 1,040, 1,070 feet. Several other sands are also encountered. It is thought that all these sands, with possibly the exception of the deepest sands, occur in the Permian Redbeds.

In the Wheeler, Duncan, Gotebo, and Lawton fields various oil sands have been encountered in the Permian Redbeds.

The highest stratigraphic productive sand in Oklahoma is that of the 450-foot sand in the Madill pool. This sand occurs in the Trinity sand of Lower Cretaceous age.

SUMMARY.

Data have been collected from most of the important fields of the State. The interpretation of these data is shown on the correlation table accompanying this publication.

The writer* is especially indebted to Messrs. Fohs and Gardner, Tulsa, Okla., for information furnished from their correlations of Oklahoma oil sands.

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*Aurin, F. A., Field Geologist, Okla. Geol. Survey.

PRODUCTION TABLES.

MARKETED PRODUCTION.

Petroleum marketed in Oklahoma in 1914 *and* 1915, *in barrels.*

1914.

Month.	Glenn.	Cushing.	Healdton.*	Other.	Total.
January	839,483	652,076	15,315	4,388,308	5,895,182
February	769,809	751,637	64,741	3,731,696	5,317,883
March	871,334	1,577,168	157,035	4,239,589	6,845,126
April	849,316	1,668,866	129,928	3,893,752	6,541,862
May	897,397	2,040,454	207,141	3,964,709	7,109,701
June	852,901	1,904,627	315,446	3,770,712	6,843,686
July	828,350	1,691,460	394,251	3,671,066	6,585,127
August	535,027	1,442,817	368,355	2,447,856	4,794,055
September	431,051	1,644,857	403,977	1,872,264	4,352,149
October	584,178	2,398,686	351,166	2,702,988	6,037,018
November	604,397	2,946,265	186,457	2,718,004	6,455,123
December	614,346	3,226,072	273,947	2,740,447	6,854,812
	8,677,589	21,944,985	2,867,759	40,141,391	73,631,724

1915.

Month.	Glenn.	Cushing.	Healdton.*	Other.	Total.
January	464,627	3,395,637	233,389	2,263,157	6,356,810
February	421,922	3,477,229	102,043	2,552,509	6,553,703
March	459,546	4,169,535	93,759	2,706,095	7,428,935
April	455,184	8,092,059	238,591	2,464,989	11,250,823
May	508,786	4,209,234	190,446	2,854,497	7,762,963
June	462,224	4,866,060	306,820	2,728,038	8,363,142
July	551,222	4,407,729	408,050	3,746,459	9,113,460
August	555,514	3,712,734	378,099	3,320,413	7,966,760
September	518,546	3,789,488	431,687	3,134,428	7,874,149
October	534,608	3,197,077	550,766	3,561,007	7,843,458
November	520,012	2,932,428	901,725	3,569,701	7,923,866
December	541,437	2,830,494	983,460	5,121,783	9,477,174
	5,993,628	49,079,704	4,818,835	38,023,076	97,915,243

*Includes Wheeler.

1914.

Month.	Runs from wells.		Field fuel and rail shipments not included in pipe-line runs.	Total.
	Gulf, Magnolia, Prairie, and Texas companies' trunk lines.	Private and other lines supplying refineries in Oklahoma and Kansas		
January	4,598,535	991,915	304,732	5,895,182
February	4,193,255	915,729	208.899	5,317,883
March	5,480,133	1,173,397	191,596	6,845,126
April	5,252,138	1,090,695	199,029	6,541,862
May	5,822,786	978,818	308.097	7,109,701
June	5,500,908	994,942	347,836	6,843,686
July	5 196,925	1,100,406	287,796	6,585,127
August	3.635,911	878,805	279,339	4,794,055
September	2,854,628	981,394	516,127	4,352,149
October	4,217,248	1,179,743	640,027	6,037,018
November	4.344,929	1,298,479	811,715	6,455,123
December	4,796,614	1,350,576	707,622	6,854.812
	55,894,010	12,934,899	4,802,815	73,631,724

Petroleum marketed in Oklahoma in 1914 *and* 1915, *in barrels*—Continued.

1915.

Month.	Runs from wells.		Field fuel and rail shipments not included in pipe-line runs.	Total.
	Gulf, Magnolia, Prairie, and Texas companies' trunk lines.	Private and other lines supplying refineries in Oklahoma and Kansas		
January	4,216,615	1,518,054	622,141	6,356,810
February	4,425,688	1,515,636	612,379	6,553,703
March	4,840,940	1,813,975	774,020	7,428,935
April	8,634,387	1,854,699	761,737	11,250,823
May	5,438,069	1,981,651	343,243	7,762,963
June	5,178,439	2,861,332	323,371	8,363,142
July	5,962,230	2,856,166	295,064	9,113,460
August	4,819,057	2,950,314	197,389	7,966,760
September	4,568,122	3,126,145	179,882	7,874,149
October	4,783,173	2,908,577	151,708	7,843,458
November	4,844,727	2,880,357	198,782	7,923,866
December	6,279,221	3,015,245	182,708	9,477,174
	63,990,668	29,282,151	4,642,424	97,915,243

GLENN POOL.

Petroleum marketed from Glenn pool, 1911-1915, *in barrels.*

	1911	1912	1913	1914	1915
January	1,099,192	882,385	792,336	839,483	464,627
February	967,924	867,566	718,580	769,809	421,922
March	2,584,464	924,144	807,022	871,334	459,546
April	1,570,947	898,527	823,645	849,316	455,184
May	1,069,863	927,182	850,607	897,397	508,786
June	958,519	816,028	816,789	852,901	462,224
July	965,122	880,906	787,274	828,350	551,222
August	981,946	927,675	734,476	535,027	555,514
September	937,886	794,958	773,847	431,051	518,546
October	969,247	921,736	817,628	584,178	534,608
November	864,519	768,254	753,115	604,397	520,012
December	910,489	886,157	794,551	614,346	541,437
	13,880,118	10,495,518	9,469,870	8,677,589	5,993,628

The table following shows the number of wells owned in Osage County by the Indian Territory Illuminating Oil Co. and its sub-lessees.

Date	Completed	Pro-d'ctve	Gas	Dry*	Date	Completed	Pro-d'ctve	Gas	Dry
Jan. 1, 1903	30	17	2	11	Dec. 31, 1908	1,422	936	78	408
Dec. 31, 1904	361	243	21	97	Dec. 31, 1909	1,574	1,027	81	466
June 10, 1905	544	355	34	155	Dec. 31, 1910	1,735	1,175	82	478
Dec. 31, 1905	704	462	45	197	Dec. 31, 1911	2,233	1,562	90	581
June 10, 1906	862	569	55	238	Dec. 31, 1912	2,682	1,887	112	683
Dec. 31, 1906	1,080	716	66	298	Dec. 31, 1913	3,307	2,323	145	839
June 30, 1907	1,155	779	67	309	Dec. 31, 1914	3,785	2,654	172	959
Dec. 31, 1907	1,277	837	71	369	June 30, 1916	4,211	2,838	227	1,146

*Wells that have been exhausted and abandoned in addition to wells that were dry when drilled in.

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade journal sources and differ somewhat from those obtained from reports received directly from the oil producers:

Well record in Oklahoma in 1914 *and* 1915.

District and pool	1914					1915				
	Wells completed			Initial daily production —barrels		Wells completed			Initial daily production —barrels	
	Oil	Dry	Total	Total	Avrg per well	Oil	Dry	Total	Total	Av. per well
Cherokee, deep sand:										
Bartlesville, Hogshooter	389	44	454	3,925	10.1					
Copan, Ramsey, Wann	266	79	421	7,022	26.4	183	33	242	2,223	12.1
Dewey	440	33	486	5,093	11.6					
Bird Creek, Turley, Owasso, Collinsville, Vera	236	80	428	3,946	16.8	141	45	229	5,703	40.4
	1,331	236	1,789	19,186	15.0	324	78	471	7,926	24.5
Cherokee, shallow sand: Delaware, Alluwe, Chelsea	1,472	77	1,558	16,172	11.0	519	54	600	10,595	20.4
Pawnee: Cleveland	77	27	111	3,905	50.7	47	26	76	1,328	28|3
Creek:										
Bald Hill	472	104	579	40,135	85.0	197	70	275	11,110	56.4
Cushing	670	52	758	668,365	997.6	967	66	1,056	834,980	863.5
Glenn, Taneha, Sapulpa, Tulsa, Inola, Wicey, Kelleyville	872	252	1,195	56,920	65.3	413	108	575	20,934	50.7
Morris, Okmulgee	256	85	358	16,197	63.3	75	32	113	3,575	47.7
Muskogee, Wagoner Coweta, Haskell, Broken Arrow, Okfuskee	200	139	380	7,532	32.7	318	237	623	39,077	122.9
Shulter, McIntosh	139	70	235	5,427	39.0	41	37	92	2,345	57.1
Mounds, Hamilton Switch	42	17	68	2,484	59.1	33	11	44	1,300	30.4
Miscellaneous	......	......	......	......	......	......	4	6	......	......
	2,651	719	3,573	797,060	300.7	2,044	565	2,784	913,321	446.8
Osage	423	99	572	26,787	63.3	139	21	190	15,830	113.9
Carter County	340	43	292	106,171	312.3	289	22	318	85,320	295.2
Comanche County	5	2	14	59	11.8	5	8	18	35	7.0
Hughes County	......	......	......	......	......	1	5	6	40	40.0
Kay County	58	49	113	5,417	93.4	16	10	32	1,630	101.9
Kiowa County	33	1	36	185	5.6	......	......	......	......	......
Marshall County	......	......	......	......	......	2	24	37	10	5.0
Pontotoc County	10	10	26	172	17.2	1	10	23	5	5.0
Stephens County	......	......	......	......	......	10	6	18	130	13.0
Miscellaneous	10	80	108	330	33.0	......	46	51	......	......
	6,410	1,343	8,292	976,244	152.3	3,397	885	4,624	1,036,170	305.0

Wells completed in Oklahoma, 1911-1915.

Distric	Oil					Dry					Total completed°				
	1911	1912	1913	1914	1915	1911	1912	1913	1914	1915	1911	1912	1913	1914	1915
Cherokee, deep	806	2,444	2,724	1,331	324	114	256	299	236	78	1,074	2,906	3,249	1,789	471
Cherokee, shallow	1,381	761	1,071	1,472	519	109	87	139	77	54	1,576	881	1,231	1,558	600
Cleveland	129	196	187	77	47	31	46	68	27	26	165	253	262	111	76
Creek	536	852	2,404	2,651	2,044	175	344	654	719	565	746	1,346	3,313	3,573	2,784
Osage	438	417	506	423	139	40	54	69	99	31	494	489	620	572	190
Carter County			15	340	289			5	43	22			23	392	318
Comanche County				5	5				2	8				14	18
Hughes County					1										6
Kay County		31	29	58	16		20	23	49	10		58	55	113	32
Kiowa County				33					1					36	
Marshall County					2					24					37
Pontotoc County				10	1				10	10				26	23
Stephens County					10					6					18
Miscellaneous	4	11	29	10		20	36	51	80	46	32	60	98	108	51
	3,294	4,712	6,965	6,410	3,397	489	843	1,308	1,343	885	4,087	5,993	8,851	8,292	4,624

°Incluing gas wells.

Oil wells and dry holes drilled in Oklahoma in 1915.

District	January		February		March		April		May		June		July	
	Oil	Dry	Oil	Dry	Oil	Dry	Oil	Dry	Oil	Dry	Oil	Dry	Oil	Dry
Cherokee, deep	18	8	12	3	11	3	10	4	13	1	7	2	11	3
Cherokee, shallow	50	1	35	1	38	3	29	3	23	......	11	2	22	3
Cleveland	......	......	......	......	......	......	......	......	5	6	4	1	4	......
Creek	122	30	146	35	127	42	178	38	165	28	188	37	145	39
Osage	10	......	22	10	12	2	11	3	2	1	1	......	5	......
Carter County	7	5	2	......	6	......	7	3	5	......	7	......	14	......
Comanche County	......	2	......	......	......	......	......	......	......	......	......	......	......	......
Hughes County	......	1	......	......	......	......	......	......	......	......	......	......	......	......
Kay County	3	1	1	......	......	......	1	......	1	......	......	......	4	......
Marshall County	1	1	......	1	......	8	......	......	......	1	1	2	......	......
Pontotoc County	......	......	......	......	......	......	......	2	......	......	......	3	......	......
Stephens County	2	......	7	......	1	1	......	......	......	2	......	......	......	......
Miscellaneous	......	7	......	2	......	4	......	3	......	......	......	4	......	......
	213	56	225	52	195	63	236	56	214	39	219	51	205	45

District	August		Septembr		October		Novembr		Decemb'r		Total	
	Oil	Dry	O	Dry	Oil	Dry	Oil	Dry	Oil	Dry	Oil	Dry
Cherokee, deep	16	1	14	2	51	10	64	20	97	21	324	78
Chrekee, shallow	13	5	16	1	59	13	102	11	121	11	519	54
Cleveland	2	2	......	3	8	1	9	8	15	5	47	26
Creek	160	41	124	50	181	41	237	96	271	88	2,044	565
Osage	5	4	2	1	14	3	22	3	33	4	139	31
Carter County	20	2	20	6	47	4	59	1	95	1	289	22
Comanche County	......	......	......	......	3	1	2	4	......	1	5	8
Hughes County	......	1	......	2	......	1	......	......	1	......	1	5
Kay County	......	......	2	4	1	1	2	3	1	1	16	10
Marshall County	......	......	......	5	......	......	......	6	......	......	2	24
Pontotoc County	......	2	......	......	......	2	......	......	1	1	1	10
Stephens County	......	......	......	......	......	......	......	2	......	1	10	6
Miscellaneous	......	......	......	8	......	4	......	10	......	4	......	46
	216	58	178	82	364	81	497	[illegible]	635	138	3,397	885

Wells completed in Oklahoma, 1911-1915.

Month	Oil.					Dry.					Total completed.				
	1911	1912	1913	1914	1915	911	1912	1913	1914	1915	1911	1912	1913	1914	1915
January	245	135	375	684	213	30	28	69	153	56	290	180	483	876	292
February	278	269	433	653	225	16	61	61	138	52	309	366	520	849	297
March	329	288	401	733	195	27	46	67	149	63	375	361	492	929	285
April	393	388	470	725	236	56	77	46	190	56	479	508	548	975	324
May	356	386	624	796	214	56	77	111	178	39	436	501	793	1,044	275
June	265	495	664	660	219	64	86	135	116	51	364	636	885	829	285
July	225	458	647	531	205	46	70	180	101	45	313	566	884	668	263
August	217	430	691	469	216	35	62	130	81	58	275	526	864	588	287
September	240	427	626	438	178	32	70	97	72	82	301	527	775	527	292
October	222	456	656	282	364	32	97	125	44	81	275	592	830	372	485
November	294	506	669	186	497	45	100	122	52	164	367	654	846	278	711
December	230	474	709	253	635	50	69	165	69	138	303	576	931	358	828
	3,294	4,712	6,965	6,410	3,397	489	843	1,308	1,343	885	4,087	5,993	8,851	8,292	4,624

°Incluing gas wells.

Initial daily production of new wells completed in Oklahoma in 1915, *in bbls.*

District	January	February	March	April	May	June	July
Cherokee, deep	396	365	170	153	270	230	255
Cherokee, shallow	380	808	1,410	1,130	540	185	345
Cleveland					200	165	50
Creek	119,858	111,590	80,465	145,813	122,995	111,310	70,770
Osage	1,735	4,095	1,070	760	50	100	775
Carter County	900	300	1,950	1,450	350	1,215	3,320
Comanche County							
Hughes County							
Kay County	190	50		100	50		925
Kiowa County							
Marshall County	5					5	
Pontotoc County							
Stephens County	20	105	5				
	123,484	117,313	85,070	149,406	124,455	113,210	76,440

Disrtict	August	September	October	November	December	Total
Cherokee, deep	265	605	1,157	1,805	2,255	7,926
Cherokee, shallow	140	215	1,230	2,528	1,684	10,595
Cleveland	58		185	235	435	1,328
Creek	45,465	20,525	33,495	28,030	23,005	913,321
Osage	905	80	2,970	1,690	1,600	15,830
Carter County	1,865	3,185	22,165	29,845	18,775	85,320
Comanche County			15	20		35
Hughes County					40	40
Kay County		120	25	95	75	1,630
Kiowa County						
Marshall County						10
Pontotoc County					5	5
Stephens County						130
	48,698	24,730	61,242	64,248	47,874	1,036,170

Total and average initial daily production of new wells in Oklahoma, 1911-1915, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1911	1912	1913	1914	1915	1911	1912	1913	1914	1915
Cherokee, deep	30,135	76,025	67,505	19,986	7,926	37.4	31.1	24.8	15.0	24.5
Cherokee, shallow	70,221	10,930	17,672	16,172	10,595	50.8	14.3	16.5	11.0	20.4
Cleveland	22,100	33,903	15,787	3,905	1,328	171.3	173.0	84.4	50.7	28.3
Creek	49,879	77,588	193,796	797,060	913,321	93.1	91.1	80.6	300.7	446.8
Osage	89,660	25,400	34,856	26,787	15,830	204.7	60.9	68.9	63.3	113.9
Carter County	----	----	844	106,171	85,320	----	----	56.3	312.3	295.2
Comanche County	----	----	----	59	35	----	----	----	11.8	7.0
Hughes County	----	----	----	----	40	----	----	----	----	40.0
Kay County	----	4,790	2,964	5,417	1,630	----	154.5	102.2	93.4	101.9
Kiowa County	----	----	----	185	----	----	----	----	5.6	----
Marshall County	----	----	----	----	10	----	----	----	----	5.0
Pontotoc County	----	----	----	172	5	----	----	----	17.2	5.0
Stephens County	----	----	----	----	130	----	----	----	----	13.0
Miscellaneous	338	250	626	330	----	84.5	22.7	21.6	33.0	----
	262,333	228,886	334,050	976,244	1,036,170	79.6	48.6	48.0	152.3	305.0

Total initial daily production of new wells in Oklahoma, 1911-1915, by months, in barrels.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Monthly Average
1910	15,840	17,785	20,915	18,932	19,545	26,378	14915	16,680	18,998	18,585	17,915	20,150	226,638	18,887
1911	23,366	23,615	40,539	30,440	28,190	23,970	16,255	12,121	14,709	18,165	17,223	13,740	262,333	21,861
1912	9,448	13,807	12,281	17,329	10,993	17,617	18,507	24,635	22,096	27,519	27,599	27,055	228,886	19,074
1913	19,220	19,505	21,615	29,847	27,139	32,192	26,071	27,897	27,267	30,953	29,211	43,133	334,050	27,838
1914	27,785	40,344	60,201	61,233	102,674	128,886	84,652	91,886	92,453	81,357	71,488	133,285	976,244	81,354
1915	123,484	117,313	85,070	149,406	124,455	113,210	76,440	48,698	24,730	61,242	64,248	47,874	1,036,170	86,343

The above tables are from "Mineral Resources of the United States. calendar year 1915—Part II." Statistics for the year 1916 were not completed for publication, but considerable data on the production for the year is given under county discussions. The production for 1916 was 106,190,240 barrels, an average daily production of 290,658 barrels. More than 7,700 wells were completed, of which 1,136 were dry, 359 gas producers, and 6,205 producing oil wells.

ERRATA.

Page 32, line 23, for "Ouachita" read "Ozark."

Page 41, line 35, after "T. 1 N." insert "to T. 5 N. inclusive."

Page 59, line 16, for "in a hill" read "as a strip."

Page 59, line 25, for "country" read "county."

Page 97, items in first column of log out of order, should insert to read consecutively in "depth" column.

Page 106, line 5, for "Canadian" read "Cimarron."

Page 106, line 15, for "ciliceoes" read "siliceous."

Page 107, line 10, for "member shave," read "members have."

Page 107, line 34, for "from 1 feet" read "from 10 feet."

Page 110, omit line 23.

Page 120, following line 41, read line 1 page 121, then back to line 42, page 120.

Page 179, line 15, after "cubic" read "feet."

Page 266, line 15, for "To," read "The."

Page 282, line 38, for "products" read "production."

Page 448, line 4, for "Quachita" read "Ouachita."

Page 458, line 4, for "Oklahoma-Kansas line" read "Oklahoma-Arkansas line."

Note: A few slight errors occur in the figure columns in some of the well logs. Except as otherwise noted, these occur in the "Thickness" column and when discrepancies are found the reader may readily adjust the error.