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Chas. N. Gould, Director

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OIL AND GAS IN OKLAHOMA

TULSA COUNTY

By
W. F. Cloud

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CONTENTS

ILLUSTRATIONS

FOREWORD

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

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

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

Professor Wilbur F. Cloud of the school of Petroleum Engineering, University of Oklahoma, has prepared the separate on Tulsa County. In this he has been assisted by a number of geologists of Tulsa, and especially by Dr. Ed. Bloesch who has kindly revised the manuscript. Professor Cloud also wrote Cotton County for this series of bulletins.

Norman, Oklahoma
May, 1930.

CHAS. N. GOULD,
Director.

TULSA COUNTY

By

W. F. Cloud

INTRODUCTION

The purpose of this report is to present a brief and concise summary and history of oil and gas development in Tulsa County since these products were first discovered in 1901. The information presented is largely a revision of that published in Oklahoma Geological Survey Bulletin 19 published in April, 1917.

This report summarizes past and present drilling operations and production in Tulsa County; describes the surface and subsurface geology; discusses surface and subsurface structure, as to location, origin, and effect upon the accumulation of oil and gas; and shows in a general way what may be expected as to future production and development.

The information presented here has been compiled from many sources, a large part of which has been previously published. Such detailed and professional information is available in public libraries, past issues of various technical journals of the oil industry, and in the libraries and records of the many oil companies that have operated within Tulsa County.

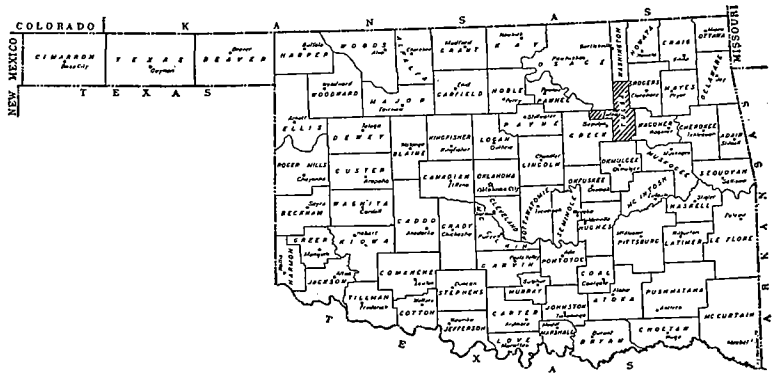

Figure 1. Index map of Oklahoma showing location of Tulsa County.

Location

Tulsa County is located in the central part of northeastern Oklahoma. It extends from the north half of T. 16 N. northward to include all of T. 22 N., and from R. 10 E. to R. 14 E., inclusive. This county is bounded on the north by Osage, Washington, and Rogers counties, on the east by Rogers and Wagoner counties, on the south by Wagoner and Okmulgee counties, and on the west by Creek and Osage counties. It is composed of 12 entire townships and parts of 11 others. The county is somewhat irregular in outline, and has a maximum length north and south of 39 miles. Its maximum width east and west is 30 miles through T. 19 N. The approximate area is 587 square miles.

Topography and Drainage

Tulsa County is located in the Sandstone Hills Region of the State. That part of the county lying north and east of the Arkansas River is largely a level prairie plain broken in places by low escarpments. South and west of the Arkansas River is also a prairie plain, but upon that plain are many rugged sandstone capped hills, which are covered with blackjack oak trees. These sandstone capped hills reach their maximum relief near the town of Red Fork in T. 19 N., R. 12 E., where they are approximately 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. Here 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 the Arkansas River crosses the east county line into Wagoner County. The elevation here is 550 feet above sea level.

The southern part of the county is drained by the Arkansas River and its tributaries, the principal ones of which are; Haikey Creek, Broken Arrow Creek, Polecat Creek, Posey Creek, and Snake Creek. The part of the county which lies in T. 19 N., west of the city of Tulsa is drained into the Arkansas River by Mud and Anderson Creeks. The northern part of the county is drained into the Verdigris River by Bird Creek and its numerous tributaries.

Acknowledgments

The writer wishes to thank the following individuals, geologists who have cheerfully aided and assisted in compiling the information presented in this report: Frank C. Green, Shell Petroleum Corporation; Robert H. Dott, Sunray Oil Company; Robert H. Wood, and Ed Bloesch, consulting geologists; H. E. Rothrock, Superior Oil Corporation; and L. H. White, J. A. Hull Co. The stratigraphic research project of the American Association of Petroleum Geologists and the Reiter-Foster Oil Corporation, as well as the Shell Petroleum Corporation furnished information used in compiling the geologic cross-sections. The Oklahoma Geological Survey and its staff furnished valuable counsel and information.

STRATIGRAPHY

Surface Formations

The formations exposed on the surface of Tulsa County are shales, sandstones, and limestones of Pennsylvanian age, including Allegheny and Conemaugh time. The oldest rocks belong to the Cherokee shale group. The youngest rocks are the sandstone and shale members of the Ochelata formation. Arranged in ascending order, that is, the oldest first, they are as follows: Cherokee shales, Fort Scott limestone; Wewoka formation the equivalent of the Labette, Oologah, and part of the Nowata; Nowata shale; Coffeyville formation, including the Checkerboard limestone near the base; Hogshooter limestone; Nellie Bly formation; Dewey limestone; and the Ochelata formation, including the Avant limestone about 200 feet above its base. These formations extend across the county irregularly in a northeast-southwest direction, the oldest occurring in the area south of the city of Broken Arrow. Reference to the accompanying areal map (plate III) will show this relationship in detail.

In that part of the county north of the Arkansas River there are more limestones than south of the river. South of the river shales and sandstones predominate over the limestones, the whole area for the most part being covered by the Wewoka formation and the Nowata shale. However, the writer maintains that the information published to date on that part of the county south of the river is in error in several respects, and that a more detailed survey and reconnaissance will show the surface geology to be more differentiated than that mapped and published at present.

CHEROKEE SHALE

The Cherokee shale, is exposed in the southeast part of the county south of Broken Arrow and in the vicinity of Leonard. The shales vary in color from light gray to almost black, and are interbedded with limestones and several dominant sandstones, the following of which have produced oil in commercial quantities in this area; Red Fork, Bartlesville (Glenn), Taneha, Tucker, and Dutcher sands. The top of the Cherokee includes the equivalent of the Calvin, and according to Miser, some lower Wetumka beds. Bloesch[1] correlates the top of the Cherokee with the base of the Wetumka.

The shales and sandstones vary both vertically and laterally, and often grade into each other within comparatively short distances. The sandstones of this group are usually dull red and muddy brown in color.

The total thickness of the Cherokee shales in this part of the county is over 1,200 feet. However, only the top part of the formation is exposed in Tulsa County.

1. Bloesch, Edward, Fort Scott-Wetumka correlation. Bull. Am. Assoc. Pet. Geol. vol. 10, pp. 810-11, 1926.

FORT SCOTT (OSWEGO) LIMESTONE

The Fort Scott limestone, which is known to the oil fraternity as the "Oswego" lime, lies immediately above the Cherokee shales. A long, narrow ledge is exposed in the southeastern part of the county in the vicinity of Leonard and Broken Arrow, and extends northeastward through T. 17 N., R. 14 E., Tps. 18 and 19 N., R. 14 E., into Rogers County where it attains a thickness of about 100 feet. In Tulsa County it is only about 38 feet thick, consisting of an upper limestone member 20 feet thick, a dark shale parting 8 to 10 feet thick, and lower limestone member about 10 feet thick. From the vicinity of Leonard southward the limestone disappears and the formation grades into the Wetumka shale.

WEWOKA FORMATION

This formation covers a large portion of the surface of the southern part of the county, including Tps. 16, 17, and 18 N., and Rs. 13 and 14 E. It is about 350 to 400 feet thick, and is composed mostly of sandstone with shale between the upper and lower sandstone members. The upper part is cross-bedded and shaly, but the middle part contains a hard, massive and persistent sandstone member. The lower part is composed of a thin but hard, medium- to coarse-grained sandstone. The color of the sandstone members is predominately brown, but the shales vary from gray to blue in color.

LABETTE SHALE

Most of this formation as exposed in Tulsa County is found in the east half of T. 19 N., R. 14 E. It lies upon the Ft. Scott (Oswego) limestone, and is overlain by the Oologah limestone. These shales vary from blue to pale green, and are known to contain appreciable amounts of brownish shaly sandstones in places. Their thickness is about 60 to 75 feet in this area.

OOLOGAH LIMESTONE

This formation has been popularly called the "Big" lime. In the northern part of the State and in southern Kansas it has been divided into the Pawnee limestone, the Bandera shale, and the Altamont limestone. However, northeast of Tulsa County in the northern part of Rogers County, the Altamont limestone joins the Pawnee limestone. From there on southward the collective name of Oologah has been applied. It is characteristically hard, massive, and cherty, and is usually bluish-gray in color when freshly broken.

There is a general opinion among several reputable geologists located in Tulsa that the geologic map of Oklahoma as compiled by H. D. Miser of the United States Geological Survey is in error as to the exact location and extent of the so-called "Oologah" limestone. Instead of

thinning-out and striking-off in the west half of T. 19 N., R. 14 E. in a southeastern direction toward the city of Broken Arrow, where it has been customarily purported to merge into the Nowata shale above and the Labette shale below to form the Broken Arrow formation, it apparently trends southwestward from the north central part of T. 18 N., R. 14 E., crossing the Arkansas River northwest of the town of Bixby. From this locality it is traceable southward through T. 17 N., R. 13 E., into T. 16 N., where it grades into the Wewoka formation or the Holdenville shale.

NOWATA SHALE

This formation overlies the Oologah formation, and is widespread in Tulsa County. It enters the county at the northeast corner, in T. 22 N., R. 14 E., and follows a southwestward trend across the county to the Arkansas River near Jenks where it is covered and made obscure by the river and dune sand deposits in that area. The Nowata shales consist of a series of shales and a few interstratified sandstones and limestones being mostly sandy in the upper part and clayey in the lower part. The Dawson coal is found near the top of the formation. In the area east of the city of Tulsa these shales are 550 to 600 feet thick.

COFFEYVILLE FORMATION

This formation is very widespread in Tulsa County, especially in the northern and western parts. The approximate thickness in this area is 275 to 325 feet. The upper portion is sandy in many localities, but the lower part is composed largely of homogeneous clay shales, which are bluish- to greenish-gray in color. Near the base of this formation the Checkerboard limestone is located. These strata continue southwestward into Creek and Okmulgee counties, and northeastward into Washington and Nowata counties.

The Checkerboard limestone member has an irregular southwest trend from the northeast corner of T. 22 N., R. 13 E., to the southwest corner of the county in the vicinity of Glenn pool. In T. 20 N., R. 12 E., its trend is southward along the east side of the township, thence it passes through the city of Tulsa southward past Red Fork then swings westward over into Creek County, passing on southward through Tps. 18 and 17 N. along the western boundary of Tulsa County. This thin but persistent limestone is fine-grained, and usually contains an appreciable amount of fossils. It is usually bluish-white in color, and is characteristically only about three feet thick.

HOGSHOOTER LIMESTONE

Thils is the so-called "Lost City" limestone. It is characteristically a massave limestone and is, for the most part only a few feet thick outside of Tulsa County. The Hogshooter lies conformably upon the

Coffeyville formation. While this limestone can be traced northeast-southwest for many miles in northeastern Oklahoma, it is well exposed in many places in Tulsa County. In T. 19 N., R. 11 E. it is more massive and about 40 feet thick.

NELLIE BLY FORMATION

The Nellie Bly formation is exposed in the vicinity of Skiatook, and covers a large part of T. 19 N., R. 11 E., where it is approximately 125 feet thick. It lies upon the Hogshooter limestone, and is overlain by the Dewey limestone. This formation is composed of alternating bluish-gray shales and gray sandstones. In the north part of T. 19 N., R. 11 E., it is made somewhat obscure locally by the terrace and dune sands of the Arkansas River.

DEWEY LIMESTONE

The Dewey limestone lies upon the Nellie Bly formation, and is overlain by the Ochelata formation. It occurs as a narrow outcrop extending north to south along the east side of T. 19 N., R. 10 E., being only about 6 to 10 feet thick in this area. This limestone is characteristically a shaly blue-gray in color, and is usually quite fossiliferous.

OCHELATA FORMATION

This formation covers almost all of T. 19 N., R. 10 E., where it is approximately 450 to 500 feet thick. It is composed mostly of variegated shales, but it also includes several sandstone and limestone members, the most prominent of which is the Avant limestone located about 150 to 200 feet above the base of the formation. The Avant member is usually bluish-gray in color, and contains an appreciable amount of ferruginous material, which upon weathering causes the limestone to have a reddish-brown color. Due to its persistence the Avant is a good key bed in this area, being noticeable as low cliffs and terraces along the hillsides and wooded slopes.

Subsurface Formations

PRE-CAMBRIAN

For the most part the exact location and lateral extent of the buried granite hills and ridges of Tulsa County are only partially known. However, to date approximately ten wells have been reported as having encountered granite in this area. Through the courtesy of Frank C. Greene[2] the writer is able to submit the following wells which encountered granite, together with their location and depth. Not all of these are in Tulsa County, however.

It is possible that igneous rocks other than granite underlie the county. However, our knowledge of this is rather meager at the

2. F. C. Greene, Geologist, Shell Petroleum Corporation.

present time, as only comparatively few wells have been drilled into igneous rocks. Our present data indicate that the granite surface is very uneven. It also appears that there are many isolated granite peaks and possibly ridges around which the sedimentary rocks were deposited. Wells drilled on structure usually encounter 400 to 500 feet of Arbuckle limestone before drilling into the granite; whereas, wells drilled off structure may penetrate 1,000 to 1,500 feet of Arbuckle limestone before the granite is reached.[3] This probably means that not all of the granite floor was submerged and that granite islands existed during the deposition of sediments in the early Arbuckle sea.

Table I. List of wells penetrating granite in and near Tulsa County.

LOCATION	COMPANY	FARM	Depth To Granite Feet	TOTAL DEPTH Feet	REMARKS
NW 27-17-14	Wilcox Co.	Hulputta	2424	2435	Top of red for mation, 3360′
SE 22-19-11	Sweeney Co.	Husky	2867	3071	Red Granite
SW 1-19-15	Winters	Billy	2700	2704	Wagoner Co.
NE 8-20-12	Grimes and Gillespie	?	2215	2250	Osage County
SW 3-20-8	Tidal	Arnold	3215	3217	Dark Red "Sand" 3206′
NW 9-20-12	Barnsdall		2424	2435	Osage County
SW 23-20-14	J. W. Irwin	Cox	3195	3360	Rogers County
SE 26-21-13	Superior	B akemore No. 1	1365	1462	Red Granite
SE 26-21-13	Superior	Blakemore No. 2	1566	1580	Red Granite
SE 31-22-15	Duquesne	Doublehead	1785	2765	Rogers County
NE 32-22-10	Tidal-Osage	?	2217	2222	Pinkish red
NE 32-22-10	Tidal-Osage	?	2240	2290	

CAMBRO-ORDOVICIAN

ARBUCKLE LIMESTONE

Examination of well logs and drill cuttings taken from various areas of Tulsa County indicate that the Arbuckle limestone underlies the entire county. Its upper surface is unconformable to all overlying formations. While the maximum thickness of this formation is unknown in this region, it probably varies from several hundred feet over the buried granite ridges to possibly 1,000 to 1,500 feet in the structural valleys. However, in a well drilled directly over a granite hill the drill evidently passed out of the Chattanooga formation into the granite.

For the most part the Arbuckle limestone is characteristically a siliceous, crystalline, medium-grained dolomitic limestone, occasionally containing some quartz. The color varies from almost white to brown, and the magnesium content varies from 20 to 40 per cent.

3. White, Luther H., Subsurface distribution and correlation of the Pre-Chattanooga ("Wilcox" sand) series of northeastern Oklahoma: Oklahoma Geol. Survey Bull. 40-B, p. 9, 1926.

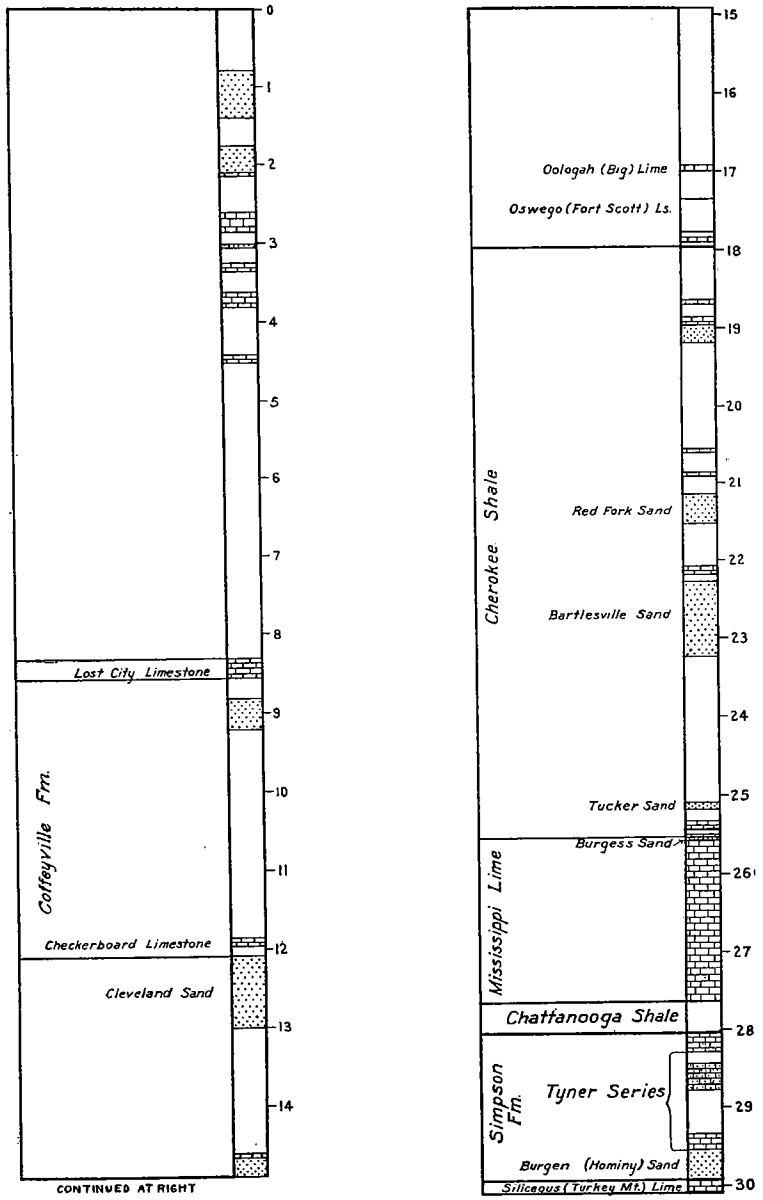

Figure 2. Log of well (W. W. Alexander No. 1, sec. 18, T. 19 N., R. 18 E.) showing thickness of formations.

"SILICEOUS LIME" OR TURKEY MOUNTAIN SAND

The logs of many wells drilled in Tulsa County usually record either one or the other of these terms before recording the Arbuckle limestone. Reference to the two geologic cross-sections accompanying this report will show some of the wells in which this horizon has been identified and recorded. The horizon that has been called the Turkey Mountain is the weathered top of the Arbuckle except in a few places where due to poor samples or lack of fossils, it may be Simpson. Regarding the age, character, and correlation of these formations the reader is referred to the work of White.[4]

ORDOVICIAN

BURGEN ("HOMINY") SAND

The "Burgen" sand, which is thought by some to be equivalent to the St. Peter sandstone, was first called the "Hominy" sand because it was thought to be the principal source of deep production in the vicinity of Hominy, Oklahoma. It lies upon the weathered surface of the Arbuckle limestone, and varies in thickness from 10 to 75 feet in Tulsa County. This is a hard, massive sandstone composed of rounded and angular grains of various sizes. The color varies from light gray to yellowish brown.

Until recently the Burgen sandstone was not differentiated from the overlying Tyner formation, and the "Wilcox" sand above was correlated with the Tyner. This correlation was erroneous, as in almost all the deep wells drilled a hundred feet or more of green sandy shales (Tyner formation) are encountered, after which 30 to 50 feet of sandstone ("Burgen") is penetrated before reaching the Arbuckle Limestone.

TYNER FORMATION

This formation lies beneath the Wilcox sand. Apparently it ranges in thickness from 40 to more than 200 feet in Tulsa County. In the central, northern, and eastern parts of the county, where the Wilcox sand is absent, the Tyner lies directly beneath the Chattanooga shale. It consists of clay shale and sandy shale, and is easily recognized by its light green color. In many wells two distinct sandy horizons have been recognized in the Tyner. The upper Tyner sand which may vary 10 to 40 feet in thickness is separated from the lower sand by green shales of variable thickness.

WILCOX SAND

The Wilcox sand, the Tyner formation, and the Burgen sandstone of northeastern Oklahoma seem to be the northern equivalents of the Simpson formation of the Arbuckle Mountain section of southern Oklahoma. The Wilcox is separate and distinct from the underlying Tyner

4. White, Luther H., op. cit., pp. 12-13.

formation, and should not be correlated with it. The sandstone is composed of both angular and rounded fine-grained white quartz, usually loosely cemented.

MISSISSIPPIAN

CHATTANOOGA SHALE

In Tulsa County this formation lies unconformably above the Tyner formation and the Wilcox sand where the latter is present. It is characteristically a brown to black, slaty, bituminous shale of uniform texture. It is remarkably persistent in both lithologic character and thickness in Tulsa County as well as in adjoining counties, being usually about 30 to 60 feet thick.

Regarding the age and correlation of the Chattanooga Ulrich[5] says:

> The Bois d'Arc is succeeded by the more or less cherty shales of the Woodford formation which I correlate with the widely distributed Ohio and Chattanooga shales and classify as earliest Mississippian. Black shales regarded as strictly contemporaneous occur in northeastern Oklahoma, Arkansas, Missouri, Iowa, southern Illinois, Indiana, Michigan, central Tennessee, and in the Appalachian Valley from Alabama to well into southwestern Virginia. In the last State they pinch out northwardly from a maximum thickness of 500 feet and rest with an intervening break on much thicker often sandy, late Devonian shales that pinch out southwardly in northeast Tennessee.

"MISSISSIPPI LIME" (BOONE-MAYES-PITKIN-MORROW)

This series of limestone beds underlies all of Tulsa County. It is still debatable as to whether the upper part is the equivalent of the Pitkin or the Morrow group, but the middle and lower members have been definitely correlated as being Boone and Mayes equivalents. Regarding this correlation of the members of the "Mississippi lime" to the east of Tulsa County Bush says:

> The faunas of the Pitkin and Morrow groups are very similar, the Pitkin being classified as Chester in age, and the Morrow as lowermost Pennsylvanian. It must be noted, though, that the latter group has a decided Mississippian facies, together with the Pennsylvanian. The Pennsylvanian elements of this fauna are termed proemial and the Mississippian residual by Mather[7] who has made a careful study of them. Then on the basis of lithology, and faunas also, the Morrow and Pitkin limestones are not rapidly distinguishable, and where the stratigraphic position of each may be clear in Arkansas, it is not in Oklahoma. The fact that the Morrow is resting directly on the Mayes formation in this well, suggests that the Pitkin-Fayetteville formations may be absent entirely in this area, and that what has often been mistaken for Pitkin in both well records and outcrop is part of the Morrow.

5. Ulrich, E. O., Fossiliferous boulders in the Ouachita "Caney" shale and the age of the shale containing them: Oklahoma Geol. Survey Bull. 45, p. 32, 1927.
6. Bush, F. A., Quoted by Woodruff, E. G. and Cooper, C. L., Geology of Rogers County: Oklahoma Geol. Survey Bull. 40-U p. 14, 1928.
7. Mather, K. F., the fauna of the Morrow group of Arkansas and Oklahoma: Bull. Sci. Lab. Denison Univ., vol. 18, art. 3, 1915.

The limestones and shale beds composing the "Mississippi Lime" vary somewhat in thickness over Tulsa County. They seem to be thinnest in the southern and extreme western parts, being about 215 feet thick in T. 16 N., R. 13 E., and about 220 feet thick in T. 16 N., R. 10 E. In the northern part of the county, in T. 22 N., R. 13 E., the apparent thickness is 250 to 300 feet; whereas, in the eastern part, in T. 19 N., R. 14 E., these beds average 350 to 400 feet thick. In the vicinity of Tulsa they are quite thick also, being about 350 feet.

The "Mississippi lime" is characteristically a grayish to brown to almost black cherty limestone with occasional shale partings. The upper member, which is usually about 60 to 80 feet thick, is gray limestone and chert, coarsely crystalline, platy, granular, and locally micaceous. This is the Morrow-Pitkin(?) member. The middle member consists of dark gray to black finely granular, platy, siliceous, argillaceous limestone, locally separated by thin beds of black shale. This middle member is the Mayes formation. The lower part consists of 40 to 50 feet of light gray massive chert and finely crystalline buff limestone, which is the Boone limestone member.

PENNSYLVANIAN

CHEROKEE SHALE

The upper part of the Cherokee shales, including the Senora formation and the Stuart shale, is exposed at the surface in southeastern part of Tulsa County. The stratigraphic interval composing the Cherokee shales includes all the shales and interbedded coal seams and sandstones lying unconformably above the Morrow-Pitkin group up to the base of the Fort Scott limestone. Within this group of rocks commercial production of oil and gas has been obtained from the Prue (Squirrel), Red Fork, Bartlesville (Glenn), Taneha (Tucker), and Dutcher sands.

Reference to the two cross-sections shows that the Cherokee shales are approximately 900 feet thick and are encountered at about 400 feet in depth in eastern Tulsa County; that is, in SE.¼ sec. 16 T. 19 N., R. 14 E. In SW.¼ sec. 17, T. 19 N., R. 10 E., the thickness is 625 feet found at a depth of 1,800 feet. This shows a thinning toward the west, as well as a dip of approximately 45 to 55 feet to the mile. In the northern part of the county, in sec. 8, T. 21 N., R. 13 E., these shales are encountered at 700 to 725 feet, and are about 650 to 700 feet thick; whereas, in the southern part of the county, in sec. 16, T. 16 N., R. 13 E. the thickness is 1,300 feet, and the average depth is 550 to 600 feet. This shows an appreciable thickening toward the south.

FT. SCOTT (OSWEGO) LIMESTONE

This formation lies above the Cherokee shales. The outcrop can be traced southwestward from the northeast corner of T. 18 N., R. 14 E., into the Quaternary deposits near the Arkansas River northwest of

the town of Leonard. The upper and lower limestone members are usually called the upper and lower "Oswego" limes. The upper member is found about 1,650 feet deep in sec. 17, T. 19 N., R. 10 E., and 600 feet deep in sec. 8, T. 21 N., R. 13 E. The thickness varies throughout the county, but reaches a maximum of about 100 feet.

LABETTE SHALE

Above the Fort Scott (Oswego) limestone the drill may encounter from 20 to 250 feet of brown and blue to greenish sandy, clay shales, known collectively as the Labette shale. They are exposed at the surface in the east half of T. 19 N., R. 14 E., but dip rather rapidly westward until in T. 19 N., R. 10 E., they lie about 1,600 feet below the surface. In this area these shales are only 30-50 feet thick; whereas, they obtain a thickness of 250 feet in sec. 16, T. 19 N., R. 14 E. These beds are thinnest in the extreme northwest part of the county.

OOLOGAH ("BIG") LIME

Oologah or "Big lime" is the name applied to the hard, massive, cherty limestone formed by the merging of the Pawnee and Atlamont limestones. It is exposed in Tps. 18, 19, and 20 N., R. 14 E., according to the geologic map compiled by Miser, and becomes thicker and more shaly to the south. There is a gentle westward dip from the outcrops mentioned until in sec. 18, T. 19 N., R. 10 E., it is encountered at an average depth of 1,575 feet. In this area the limestone has thinned to approximately 12 feet. The Oologah is thickest in T. 20 N., R. 13 E., where it is about 135 feet thick.

In the northern part of the county the Oologah has an average thickness of 105 feet, and thickens toward the north. In T. 21 N., R. 13 E., it is encountered at depths ranging from 250 to 475 feet. This formation thins out and becomes more and more shaly toward the south until from sec. 6, T. 18 N., R. 13 E., southward it is logged as either shale, sandy shale, or very thin limestone.

NOWATA SHALE

Lying above the "Big lime" is a series of shales and a few interstratified sandstones which attain a thickness of 425 to 475 feet in T. 19 N., R. 10 E., and are encountered at an average depth of 925 feet. This group of rocks is known as the Nowata Shale. The Cleveland sand is found in this formation. The Nowata thickens toward the east, and has a widespread outcrop in the central and northeastern parts of Tulsa County.

COFFEYVILLE FORMATION

The interval from the top of the Nowata shale to the base of the Hogshooter (Lost City) limestone is known as the Coffeyville formation. In T. 19 N., R. 10 E. these beds are about 375 feet thick, and

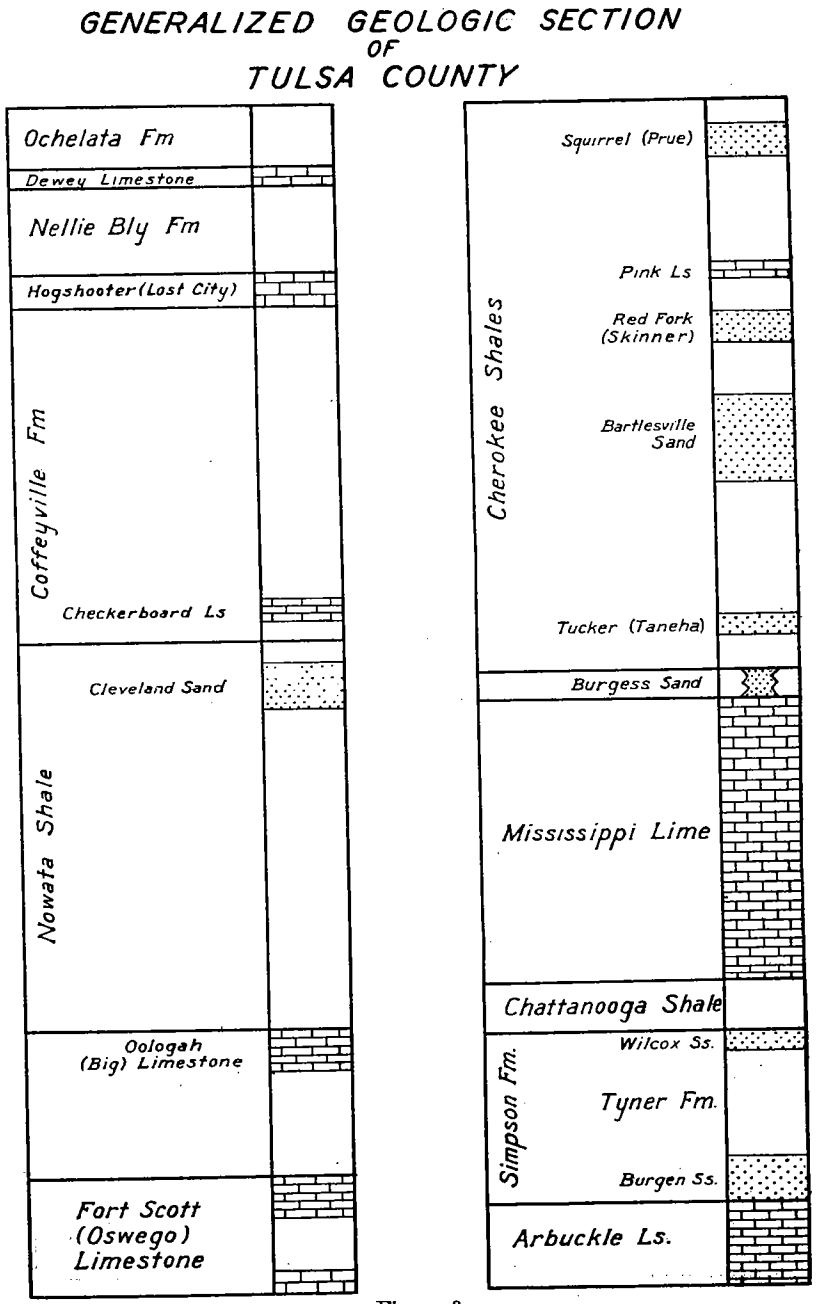

Figure 3.

are encountered at an average depth of 450 to 500 feet. It has been concluded by geologists in the past that the Checkerboard limestone belongs near the base of the Coffeyville formation.

HOGSHOOTER (LOST CITY) LIMESTONE

This thin but persistent limestone is encountered in wells only in the western part of Tulsa County, in T. 19 N., Rs. 10 and 11 E. It dips to the west at the rate of 60 feet to the mile, and in wells in the west part of T. 19 N., R. 19 E. it is about 740 feet below the surface.

Figure 3 is a generalized geologic section of the central part of Tulsa County.

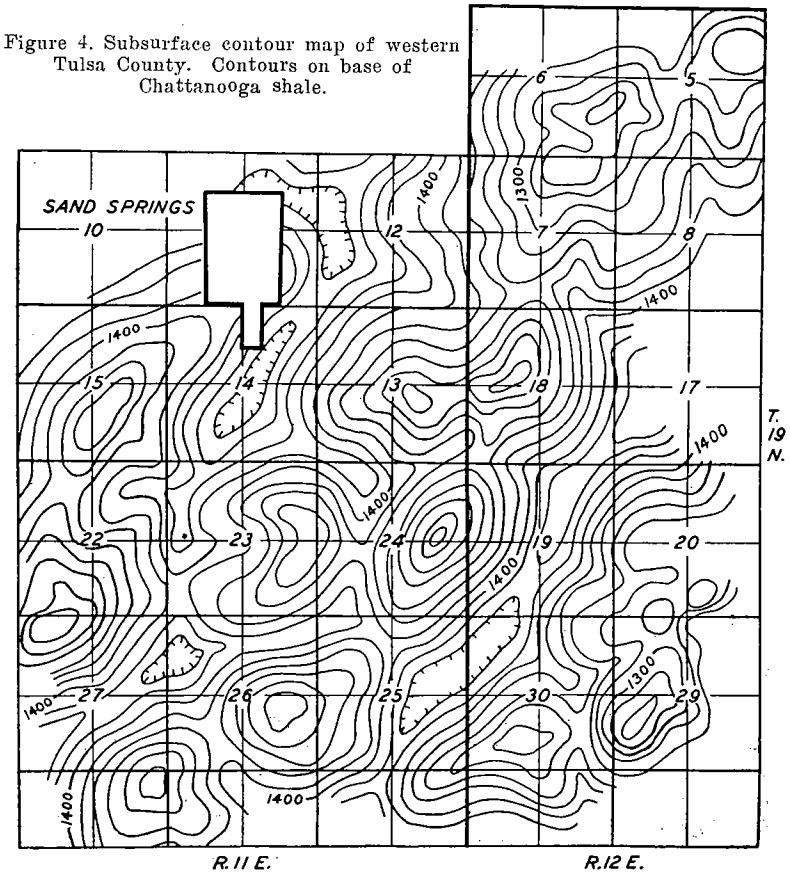

Figure 4. Subsurface contour map of western Tulsa County. Contours on base of Chattanooga shale.

STRUCTURE

The strata exposed at the surface in Tulsa County have a northeast-southwest strike. The geologic map accompanying this report shows the position and direction of strike of these formations. The surface structure for the most part is a portion of the large monocline which is well known in this section of the State. This monocline dips toward the northwest.

The westward dip of the surface formations is traceable with depth down to and including the Mississippi lime. The formations below the Mississippi lime are also monoclinal except where interrupted by folding, but the general regional dip is toward the southwest.

The productive structures in the Pennsylvanian sediments are usually reflected at the surface in this county, but where the oil and gas have accumulated in sandstone lenses this is not generally true. Structures which have been mapped on subsurface strata as anticlines and domes are often reflected at the surface in this area as small noses and terraces.

Various theories have been advanced as to the origin of the structures that have proved productive in Tulsa County as well as in the adjoining counties in this area. Some geologists maintain that tangential compression accompanying the Ozark uplift was the major cause; whereas, others believe that differential condensation and compaction of the various sediments themselves was the principal cause. Vertical thrust resulting from the intrusion of the granite ridges has also been advocated as the cause, and rotational stresses transmitted to overlying sediments by shearing in the basement rocks has also been advanced as a possible cause.

It is quite probable that no one of the above theories can be interpreted as being applicaple to the cause of all the types of structures found in Tulsa County.

OIL AND GAS DEVELOPMENT

History

The first oil produced in Tulsa County was at Red Fork on June 15, 1901 by Dr. F. S. Clinton and associates on the Bland allotment in sec. 22, T. 19 N., R. 11 E. This well had an initial production of approximately 100 barrels from the Big lime at about 600 feet in depth and is still producing. The Red Fork pool was responsible for the first commercial production of Oklahoma. Oil has been found in other places previous to 1901, but it had not been developed commercially.

The oil found above the Mississippi lime in Tulsa County possibly had its source in the thick Cherokee black shales. The production obtained from the Siliceous (Arbuckle) lime, Burgen (Hominy) sand, Tyner formation, and the Wilcox sand may have originated in the Chattanooga shale.

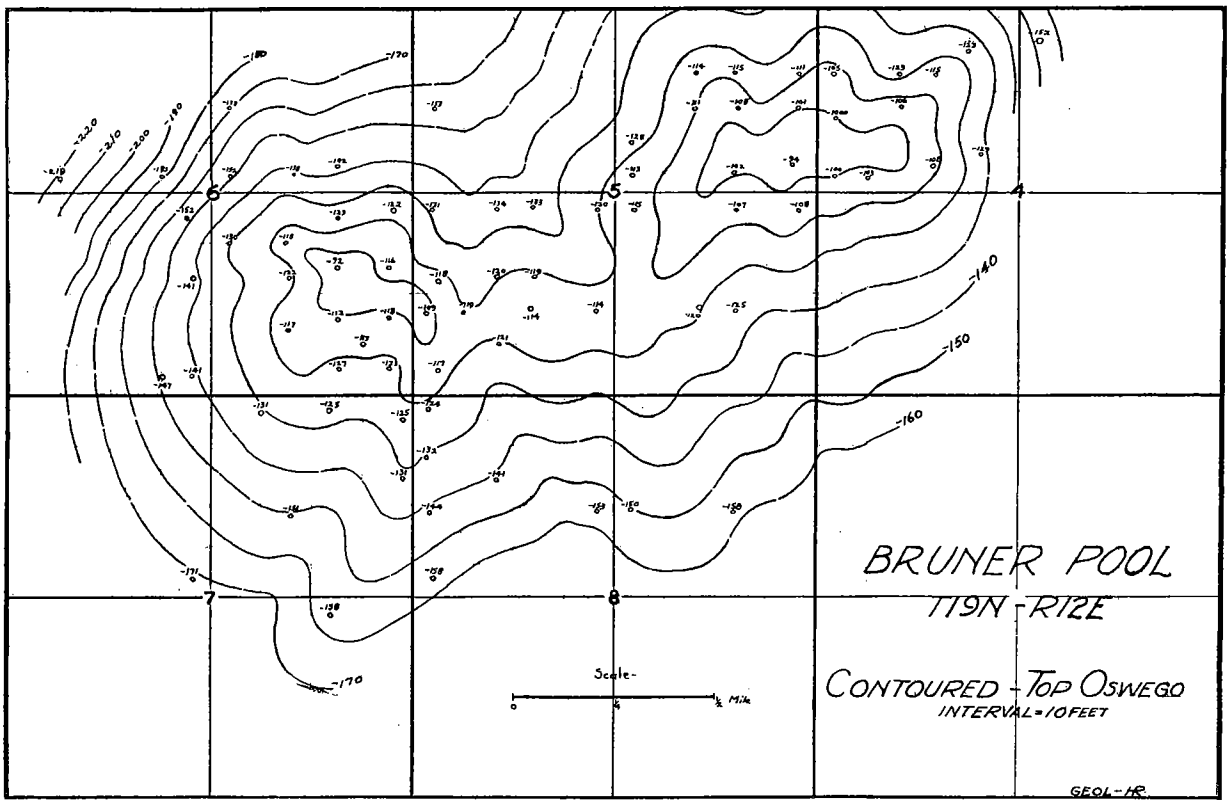

Figure 5. Bruner pool, contoured on the top of the Oswego lime.
From Paul Ruedemann and H. E. Redmon, "Turkey Mountain lime pools, Oklahoma", Structure of Typical American Oil Fields, vol. I, (A. A. P. G., 1929.)

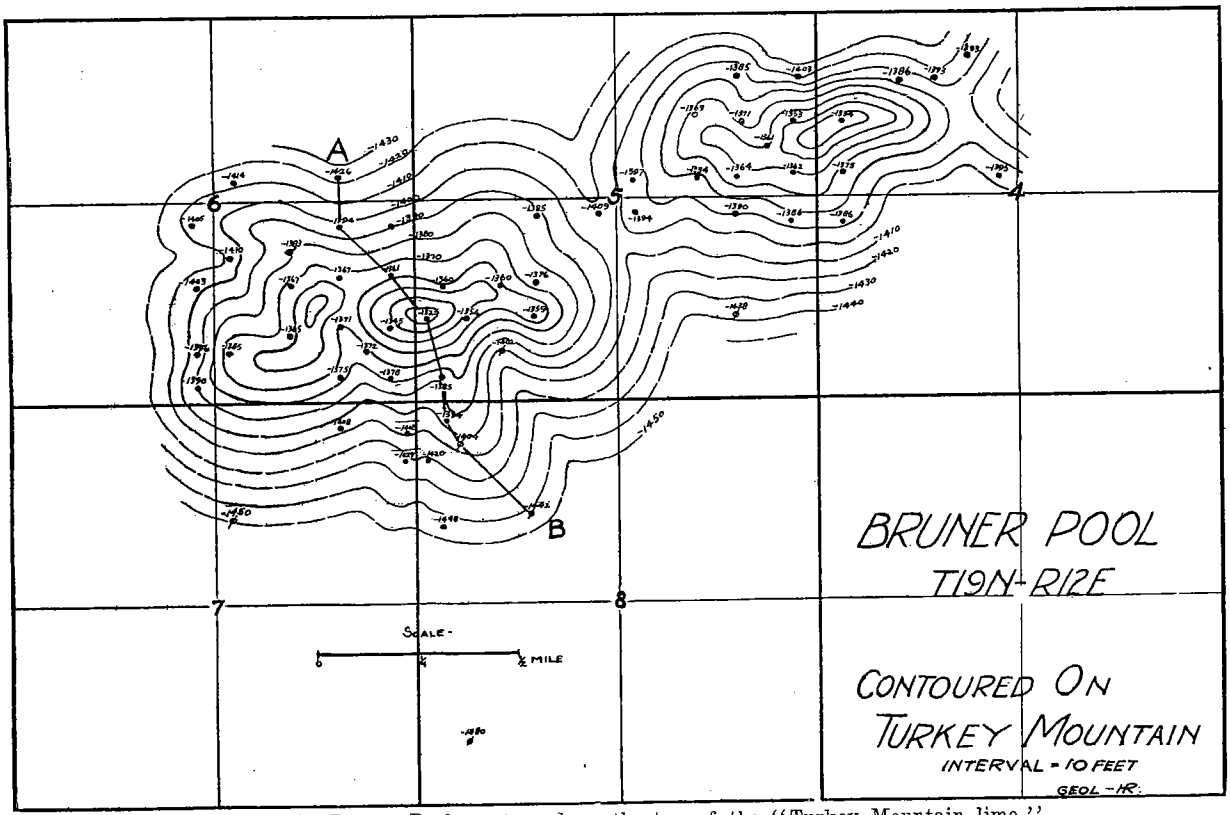

Figure 6. Bruner Pool, contoured on the top of the "Turkey Mountain lime."
From Paul Ruedemann and H. E. Redmon, "Turkey Mountain lime pools, Oklahoma", Structure of Typical American Oil Fields, vol. I, (A. A. P. G., 1929.)

Table II. Productive Horizons of Tulsa County

NAME	AGE	AVERAGE THICKNESS Feet	DESCRIPTION	AREAS WHERE PRODUCTIVE
Big Lime	Penn.	12	Coarse-grained, comparatively soft, porous, fairly uniform in texture and porosity.	Red Fork.
Oswego (Wheeler-Ft. Scott)	Penn.	32	Has upper and lower limestone members; coarse, brownish	Red Fork, Owasso, Bird Creek, Collinsville.
Perryman (Prue-Squirrel)	L. Penn.	28	Very fine-grained, muddy brown in color, shaly in places.	Tulsa, Jenks.
Red Fork	L. Penn.	21		Red Fork, Tulsa, Owasso, Leonard, Jenks, Glenn Pool, Collinsville, Keystone, Sand Springs.
Bartlesville (Glenn)	L. Penn.	45	Light muddy brown color, angular grains, fine to coarse-grained, contains some shale. Porosity 12 to 39 per cent.	Tulsa, Sperry, Glenn Pool, Owasso, Leonard, Bixby, Flat Rock, Bird Creek, Dawson, Collinsville.
Taneha (Tucker) Booch	L. Penn.	28	Medium- to fine-grained, mostly well-rounded but some angulr grains. Pale yellowish white with some dark micaceous material. Traces of iron oxide.	Dawson, Owasso, Sperry, Glenn Pool, Bixby, Fisher, Sand Springs, Broken Arrow, Taneha, Flat Rock, and Jenks.
Dutcher	L. Penn.	42	Looks like pepper. Fine- to medium-grained, very angular, highly crystalline.	Jenks, Tulsa, Bixby, Broken Arrow.
Burgess	Penn.	26		Sand Springs, Broken Arrow, Dawson, Sperry, Owasso, Bruner-Vern, Bird Creek Fisher, Collinsville, and Flat Rock.

Table II., Cont'd.

	AGE	Feet THICKNESS	DESCRIPTION	PRODUCTIVE AREAS WHERE
Mississippi Lime	Miss.	54	Mostly limestones with thin shale beds, grayish to brown, cherty, platy, granular, micaceous locally. Produced mostly gas.	Bixby, Jenks, Dawson, Sperry, Owasso.
Wilcox (Mounds)	Ord.	50	Almost all pure quartz. Well-rounded grains. Uniform, medium sized grains. A white sand.	Jenks, Tulsa, Sand Springs, Turkey Mountain, Glenn Pool, Bixby.
Tyner	Ord.	12-40	Consists of two distinct sand horizons where productive. Is shaly in places.	Sperry, Owasso, Fisher, Leonard, Sand Springs.
Turkey Mountain. (Siliceous Lime, Arbuckle)	Cambro-Ordovician	23	Highly crystalline, dolomitic, soft and porous, drills easily.	Truley, Fisher, Turkey Mountain, Red Fork, Sperry, and Sand Springs.

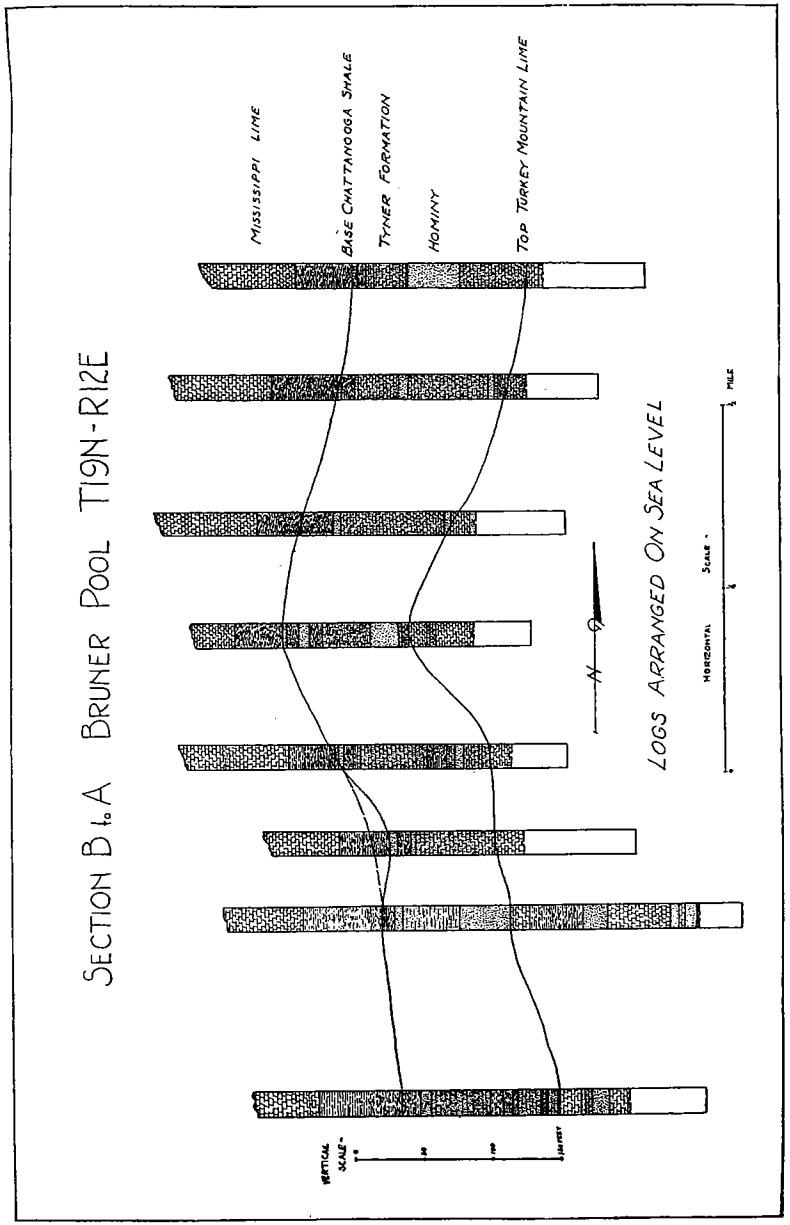

Figure 7. Section showing thinning of interval on the apex of the anticline. From Paul Ruedemann and H. E. Redmon, "Turkey Mountain lime pools, Oklahoma", Structure of Typical American Oil Fields, vol. I, (A. A. P. G., 1929.)

Producing Horizons

Table II shows the producing horizons of Tulsa County arranged in stratigraphic order, the youngest at the top, together with a brief description and the average thickness of each.

Most of the producing horizons have a wide range in quantity of oil and gas, but the Taneha (Tucker), Burgess, Mississippi lime, have produced mostly gas.

*Table III. Analysis of Crude Oils**

	1	2	3	4
A. P. I. Gravity	32.4	31.3	34.5	34.1
Per cent sulphur	0.30	0.23	0.27	0.19
Saybolt Universal Viscosity at 70o F.	70.2	83.4	54.8	58.4
Per cent water		0.2		
Gasoline and naphtha	24.8	20.3	26.9	26.2
Kerosene	17.4	18.5	18.8	17.8
Gas oil	12.5	6.4	12.6	10.9
Light lubricating distillate	5.2	12.6	5.9	11.5
Medium lubricating diatillate	11.5	13.6	11.1	5.2
Carbon residue	9.3	7.5	7.5	6.2

* U. S. Bureau of Mines report of Investigations, Serial No. 2364. 1. Glenn pool, 2. Skitook, Sperry, Turley pools. 3. Owasso field. 4. Broken Arrow field.

Productive Areas

Table IV shows the names of the various commercial oil and gas fields of Tulsa County, together with their location and date of opening.

Previous to the discovery of the Wilcox sand near Bixby by H. F. Wilcox in April, 1914, most of the production in Tulsa County had been obtained from the Bartlesville, Red Fork. The initial production in the Bartlesville sand has ranged from 10 to 2,000 barrels per day; but the Red Fork sand was not so prolific, the wells ranging from 3 to 200 barrels initial. Average initial daily production in the Big lime was only about 10 barrels, but many wells have produced from this horizon.

Some widely scattered production as high as 200 barrels per day has been reported from the Dutcher sand. Commercial production in the Burgess sand has ranged from about 5 to 500 barrels per day. The Mississippi lime production has been as high as 40 to 50 barrels.

The most prolific wells in Tulsa County have been discovered in the Wilcox and Turkey Mountain (Siliceous lime) sands, ranging as high as 2,000 to 2,500 barrels daily in the former, and as high as 3,000 barrels in the latter. Initial production from the Tyner series has been as high as 500 barrels per day in the field near Sperry and at Bruner-Vern.

Possibilities of Future Production

It is quite possible that there are still some undeveloped structures in Tulsa County, although the area has been quite extensively prospected. The writer does not predict any highly productive areas of wide extent, as has been the case in the past; but since the process of re-pressuring has proved its worth, it is now possible to complete commercial wells of very small initial production and operate them at a profit by this method. Also, operators can now afford to complete small producers, since it is quite probable that some of the upper sands in northeastern Oklahoma are adaptable to the water "flooding" process or to mining. This of course will not be applied until the oil property has been re-pressured to its economic limit.

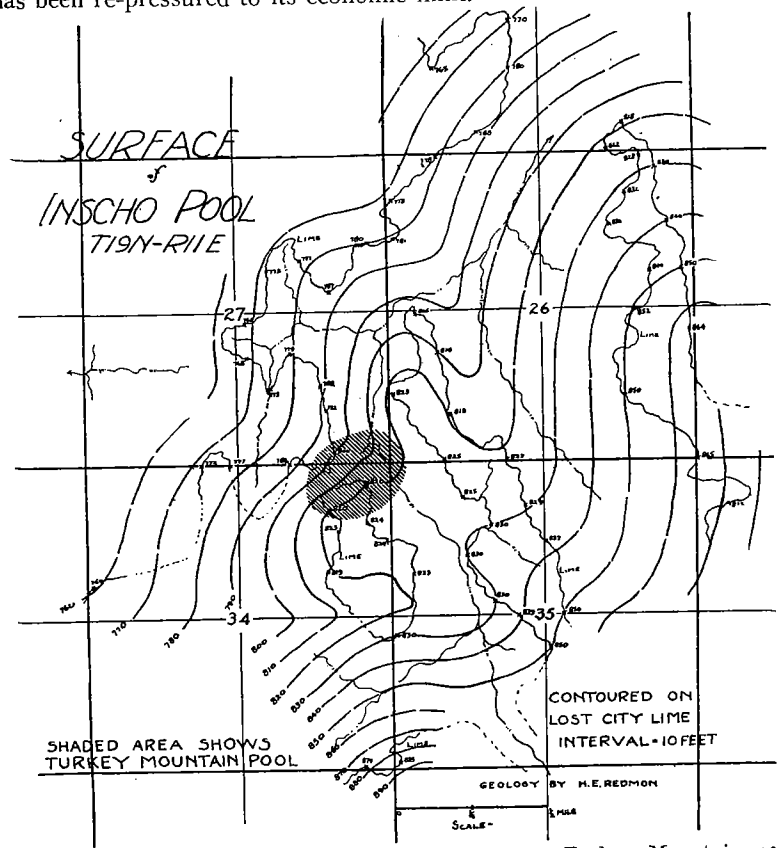

Figure 8. Inscho pool, showing the relation of the Turkey Mountain pool to the surface terrace.

From Paul Ruedemann and H. E. Redmon, "Turkey Mountain lime pools, Oklahoma", Structure of Typical American Oil Fields, vol. I, (A. A. P. G., 1929.)

Table IV. Oil and Gas Fields in Tulsa County

FIELD	LOCATION	DATE OF OPENING	REMARKS
Red Fork	T. 19 N., R. 12 E.	1901	Small production of oil.
Tulsa	T. 19 N., R. 13 E.	1901	Small oil and gas wells.
Jenks	T. 18 N., R. 13 E.	1901	Produces both oil and gas.
Bird Creek	Tps. 20-21 N., Rs. 12-13 E.	1906	Good oil wells. Not much gas.
Dawson	T. 20 N., R. 14 E.	1906	Mostly dry gas. Small oil wells.
Flat Rock	T. 20 N., Rs. 12-13 E.	1906	Oil and gas; good deep production.
Glenn Pool	T. 17 N., R. 12 E.	1906	Much oil and wet gas.
Sperry	T. 21 N., R. 12 E.	1909	Both oil and gas.
Collinsville	T. 22 N., R. 14 E.	1911	Many large gas wells; not much oil.
Owasso	T. 21 N., R. 14 E.	1913	Mostly gas; some oil wells.
Broken Arrow	T. 18 N., R. 14 E.	1913	Small oil and gas wells.
Lost City	T. 18 N., R. 12 E.	1913	Production from Taneha and Burgess.
Bixby	Tps. 16-17 N., R. 13 E.	1914	Good oil wells.
Sand Springs	Tps. 19-20 N., R. 11 E.	1916	Small gas and oil wells; good deep production.
Leonard	T. 17 N., R. 14 E.	1916	Small oil wells; good gas wells.
Taneha	T. 19 N., Rs. 11-12 E.	1917	Small oil and gas production.
Fisher	T. 19 N., R. 11 E.	1918	Small oil and gas wells; good deep production.
Turkey Mountain	T. 18 N., R. 12 E.	1922	Small oil and gas wells in upper sands; deep production better.
Bruner-Vern	T. 19 N., R. 12 E.	1912-1923	Produces both oil and gas from Burgess, Tyner, and Turkey Mountain.
Inscho	T. 19 N., R. 11 E.	1925	Good production in Turkey Mountain sand.

The oil sands above the Mississippi lime have been quite extensively tested in Tulsa County, but apparently there are still several areas in which the Wilcox, Tyner, Burgen, and Turkey Mountain sands should prove productive. The Wilcox is found below only a portion of the county.

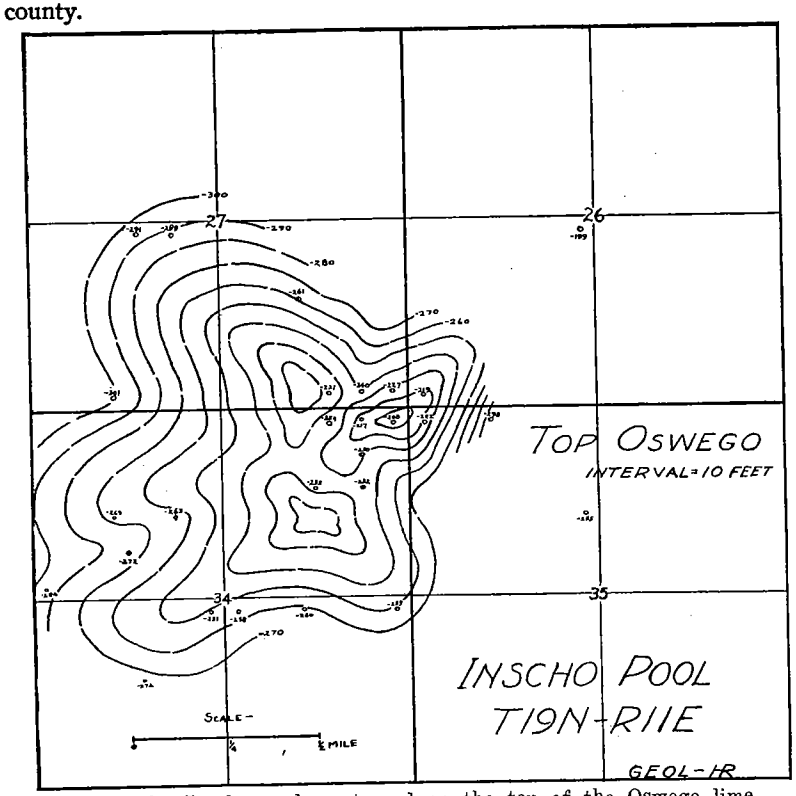

Figure 9. Inscho pool, contoured on the top of the Oswego lime.

From Paul Ruedemann and H. E. Redmon, "Turkey Mountain lime pools, Oklahoma", Structure of Typical American Oil Fields, vol. I, (A. A. P. G., 1929.)

SUMMARY

The rocks outcropping at the surface are composed of the Cherokee shales and younger deposits of Pennsylvanian age. The rocks penetrated in drilling belong to the Pennsylvanian, Mississippian, Ordovician, and Cambrian systems. In a few areas pre-Cambrian granite has been encountered.

The general structure of Tulsa County is similar to that of other counties in this region, and can be divided roughly into two classes: (1) that of the Mississippi lime and younger rocks, generally a westward dipping monocline, interrupted at intervals by noses, terraces, anticlines and synclines, and (2), those sedimentary rocks lying below the Mississippi lime which form a southwestward dipping monocline except where interrupted by anticlinal folds and terraces.

Oil and gas development began actively at Red Fork in 1901, and has continued more or less intensively and extensively until the present time.

Commercial production has been obtained from the Big lime, Cleveland, Oswego(?), Perryman (Prue), Red Fork, Bartlesville, (Tucker) Taneha, Dutcher, Burgess, Mississippi lime, Wilcox, Tyner, Burgen(?), and Turkey Mountain (Siliceous lime) sands at depths ranging from 400 to 2,800 feet. The majority of the wells were small producers initially, but they have been usually long lived. Many of the earlier wells drilled in this county are still being pumped.

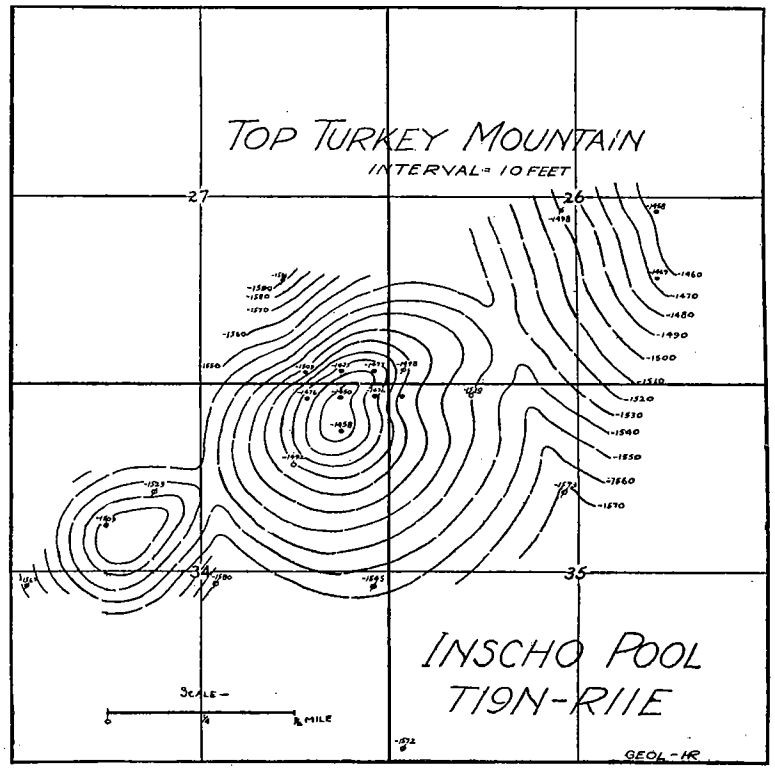

Figure 10. Inscho pool, contoured on the top of the "Turkey Mountain lime."

From Paul Ruedemann and H. E. Redmon, "Turkey Mountain lime pools, Oklahoma", Structure of Typical American Oil Fields, vol. I, (A. A. P. G., 1929.)

GEOLOGIC MAP OF TULSA COUNTY

MODIFIED AFTER U.S.G.S. GEOLOGIC MAP OF OKLAHOMA

BY

W. F. CLOUD ET AL