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Chas. N. Gould, Director

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OIL AND GAS IN OKLAHOMA

OKLAHOMA COUNTY

By
A. Travis

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FOREWORD

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

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

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

The author of 40-SS, Mr. A. Travis, is a graduate student at the University of Oklahoma. This separate is essentially the thesis which he has submitted for the degree of master of science. The work has been done under the direction of Professor G. E. Anderson of the University who has had much to do with the geologic work in connection with the early development of the Oklahoma City field. The present paper, which is published while the field is in stage of active development, represents our best information as of the date of publication. It is altogether possible that later drilling may cause a revision of certain ideas set forth in Mr. Travis' report. However, it is the policy of the Oklahoma Geological Survey, wherever possible, to publish papers of vital current interest, rather than post-mortems.

Norman, Oklahoma
May, 1930.

CHAS. N. GOULD,
Director.

OKLAHOMA COUNTY

By

A. Travis

INTRODUCTION

During the last year Oklahoma County has attracted the interest and attention of oil men as a large oil producing area. The Oklahoma City field has had a total recovery, to March 1, 1930, of 15,473,973 barrels of oil under a stringent proration program. This curtailment has been in effect almost from the beginning of development. Production is now prorated at 16 2/3 per cent of initial flow. The production in the county is almost entirely from the Oklahoma City pool. The gravity of the oil is 38° to 42° A. P. I. The several wildcat tests now being drilled in the county, when completed, will indicate future prospects of Oklahoma County as an oil producing area.

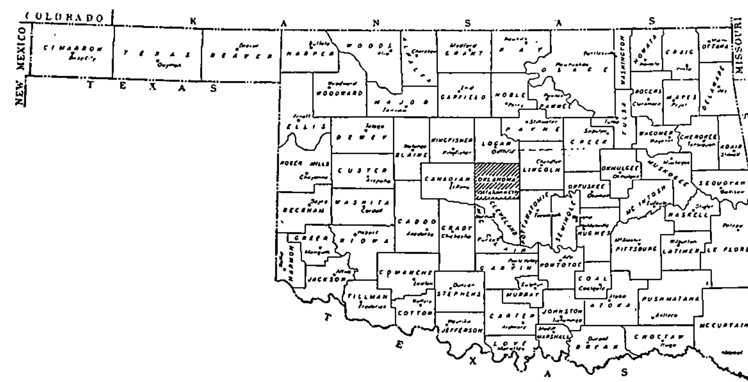

Figure 1. Index map of Oklahoma showing location of Oklahoma County.

The study of geology in Oklahoma County has been along the most modern methods. Oil companies have established subsurface departments, micro-paleontological departments, and so on.

This paper is not a complete one but summarizes the information obtainable to April 16, 1930.

The writer has been aided in gathering ideas and facts by numerous geologists. He gratefully acknowledges the assistance and guidance of Dr. G. E. Anderson of the School of Geology, University of Oklahoma. He also is greatly indebted to Mr. Robert Whiteside, Mr. Charles Love, and Mr. R. D. Jones of the Shell Petroleum Corp.; to Mr. Hubert E. Bale of the Atkinson Oil Co.; to Mr. J. T. Richards of the Gypsy Oil Co.; to Mr. Frederick Bush of the Sinclair Oil and Gas

Co.; and to Mr. Glenn Grimes of the Wirt Franklin Petroleum Corp. He also wishes to thank the Indian Territory Illuminating Oil Company for permission to publish the surface structure map accompanying this report.

HISTORY OF DEVELOPMENT[1]

It very often happens that differences of opinion arise regarding the discovery of the structure of an oil field. The Oklahoma City field is no exception. I have been at some pains to endeavor to sift out the claims of the different geologists who have been connected with the finding of the structure at Oklahoma City. The statements herewith represent my best judgment in the matter.

The first well drilled for oil in Oklahoma County which reached a depth of over 500 feet was located one-fourth mile south of Spencer. The company which financed the well was organized by E. J. Streeter, a hardware merchant in Oklahoma City, who was the moving factor of the organization. L. C. Hivick was the contractor. The well was drilled in 1903, and reached a reported depth of 2,002 feet.

From time to time other wells were drilled in Oklahoma and adjoining counties. Six wells drilled in Oklahoma County are reported in Bulletin 19, pt. 2, Oklahoma Geological Survey, published in 1917, (p. 365).

All these wells were located without geological advice and for the most part were drilled by promoters and financed by local capital.

The two geologists who first observed a favorable oil structure near Oklahoma City were probably Geo. D. Morgan and Jerry B. Newby. The exact dates when these first observations were made seem to have been lost. Morgan says, "In either 1917 or 1919, and I can not remember which year, I worked out the structure at Oklahoma City." Everett Carpenter, to whom Morgan referred me, says, "I am of the opinion it was about 1917." Jerry B. Newby, who also worked out the structure, says, "My work north and northeast of Oklahoma City was done in the early part of 1919."

L. E. Trout, in the fall of 1919 maade a reconnaissance of the area and "Late in 1920 or early in 1921," mapped an area in southern Oklahoma and northern Cleveland counties in what is now the southern part of the Oklahoma City field. This seems to have been the first structure map prepared of the region. With Trout were associated S. H. Woods, Claude Dalley, and L. R. Trout. In 1925 a well located by Trout in sec. 36, T. 11 N., R. 2 W., near the Cleveland County line, was drilled to a depth of 4,480 feet. Several minor shows of oil were reported.

In 1925 John R. Bunn worked out a surface high north of the State Capitol and a deep test (7,180 feet) drilled by Cromwell-Franklin,

1. Gould, Chas. N., Personal communication; the quoted material in this discussion of the history of development in Oklahoma County is from letters on file at the Oklahoma Geological Survey.

Thompson No. 1, (SE.¼ NE.¼ sec. 15, T. 12 N., R. 2 W.) found water in the Wilcox. This well had several minor shows in shallower horizons. An earlier well drilled not far away is the discovery well of Oklahoma County.

E. A. Paschal in 1926, while employed by the Coline Company traced the Hennessey-Garber contact and recognized the presence of a fold south of Oklahoma City. Upon the recommendation of C. T. Moore, then chief geologist of the company, three leases were purchased in the area, all of which are now producing.

So the presence of a structure lying north, northeast, and southeast of Oklahoma City has been a matter of general geologic knowledge for several years, and a number of geologists not mentioned herewith have at various times noted the structure.

In 1927 Dr. G. E. Anderson, working independently while doing reconnaissance work for the Indian Territory Illuminating Oil Company, reported a southward projecting nose running through Oklahoma City. He outlined this nose on the Garber-Hennessey contact, and it is shown in the surface geologic map accompanying this report (plate III). Following Anderson's report, the detailed geology of Tps. 10 and 12 N., Rs. 2 and 3 W., was structurally mapped for the geological department of the Indian Territory Illuminating Oil Company in February, 1928, by C. L. Wagner, under the supervision of J. H. Derden and C. W. Roop; and this work was approved by R. J. Riggs, chief geologist.

The Indian Territory Illuminating Oil Company then blocked approximately 10,000 acres on this structure. A location was made in the SE.¼ SE.¼ sec. 24, T. 11 N., R. 3 W., and drilling began in June, 1928. This well had several showings, the most important ones being 3,997 to 4,012 feet where 25,000,000 cubic feet of gas was encountered, and another at 4,805 to 4,816 feet where 47,000,000 cubic feet of gas was encountered. Passing out of Pennsylvanian rocks at 6,100 feet, the well went into Ordovician and was completed as a producer of approximately 5,000 barrels of 39° oil per day, at a depth of 6,355 to 6,498 feet in a porous dolomite. This well was called the I. T. I. O.-Foster, Oklahoma City No. 1. This well has since passed the million barrel mark and is still making about 370 barrels per day. This produces, completed December 4, 1928, started a tremendous drilling campaign and at this date of writing there are more than 200 oil and gas wells in the Oklahoma City area, with a potential production of over a million barrels per day.

GENERAL FEATURES

Oklahoma County covers an area of 720 square miles and geographically is located approximately in the center of the State. It includes Tps. 11 to 14 N., Rs. 1 E. to 4 W.

Drainage and Relief

There are three general drainage areas in the county. The largest drainage system is in the southern part of the county. The North Fork of Canadian River flows east, draining this southern area. This river heads in the northern part of New Mexico and flows in a general southeastern direction, draining into Canadian River. It has wide, flat alluvial valleys. An interesting feature of this river is that it is 200 feet higher than the drainage system north of it, Deep Fork of Canadian River. This tributary of the Canadian flowing northeast, drains the northeastern part of the county, and where it leaves the county (northeastern part) is the lowest point in the area, NE.¼, NE.¼, SE.¼ sec. 12, T. 14 N., R. 1 E., at an elevation of 870 feet. This drainage pattern extends as far southwest as Bethany, and trends to the northeast into Canadian River in the eastern part of the State. The northwestern part of the county drains to the north into Cottonwood Creek which in turn drains into the Cimarron River. This threefold drainage system has many well developed short tributaries.

The highest point, 1,390 feet above sea level, is in the southwestern part of the county. The topography, which represents a mature stage of erosion, consists of low rounded hills, prairie flats, and Recent stream deposits of sand and alluvium.

The soil is chiefly sandy and shaly, and much of the land is not cultivated. Wheat, cotton, alfalfa, and corn are the main crops. Scrub oaks in great number are found growing in the sandy phases of the county, but are not found in the shale areas.

Soft water is found in the Garber sandstone of the Permian rocks while hard water is found in the Hennessey shale.

GEOLOGY

Surface Formations

The surface rocks of the county belong to the Enid group of the Permian, which is the lower part of the Permian found in Oklahoma. The Enid group of Oklahoma correlates with the lower part of early Permian of Germany, the Rotliegende formation. Unconsolidated gravels cap the hills, Recent alluvium is found in the river flats, especially in the North Fork of Canadian River. Sand dunes are also found along the banks of this river. Wind blown sand may be found at a distance of 4½ miles from the river, mainly on the north side due to prevailing south winds.

ENID GROUP:
- Chickasha
- Duncan
- Hennessey
- Garber
- Wellington
- Stillwater

The Enid formation is divided into six members, Stillwater being the oldest and Chickasha the youngest.[1]

In going from west to east across Oklahoma Ciunty, the following members of the Enid outcrop: Duncan, Hennessey, Garber, and Wellington. An areal map of the county shows the extent of each formation. These formations have a general north-south strike and dip to the west at the rate of approximately 30 to 35 feet per mile. They are apparently conformable.

RECENT SEDIMENTS

The river valley flats have large deposits of alluvial material, especially on the north side of the North Fork of Canadian River. Wind blown sand is found covering the adjacent country several miles away from the river, due to the prevailing south winds. Dunes having a height of 20 feet are found. Along the Deep Fork of Canadian River the deposits are much thinner and less widespread.

DUNCAN SANDSTONE

The Duncan sandstone conformably overlies the Hennessey. It is found only in the extreme southwestern corner of the county, near Wheatland. The base is composed of massive red sandstone, soft and friable. The total thickness of the Duncan ranges from 100 to 300 feet, but in Oklahoma County only the lower 50 feet are exposed.

HENNESSEY SHALE

The Hennessey shale rests upon the Garber and is overlain by the Duncan sandstone. Both upper and lower contacts are apparently conformable. The Hennessey covers the western one-third of the county and is characterized by predominately red shales. The shales generally thin and weather to a grayish brown loam, which is rather easy to follow along the outcrop. The Hennessey at the type locality[2] has been divided into two members, a lower member, the Fairmont shale, and an upper member, the Bison. The Fairmont is composed chiefly of deep red clay shale, laminated. It has scattered thin white or greenish bands, which have the same composition and character. The Fairmont is composed of alternating hard and soft layers of clean sandstone which, on erosion, leave ridges or shoulders. The Bison banded member is composed of red shales not quite as deep a red as the Fairmont member. Another distinguishing characteristic is the occurrence of white or greenish bands of shale, which are, in places, sandy or limy. These divisions of the Hennessey are not indicated on the areal map. The thickness of the Hennessey is about 650 feet in Oklahoma County, and it weathers to a dark soil, giving a relatively smooth topography.

1. Aurin, F. L., Officer, H. G., and Gould, Chas. N., The subdivision of the Enid formation: Bull. Am. Assoc. Pet. Geol. vol. 10, pp. 786-799, 1926.
2. Aurin, F. L., Officer, H. G., and Gould, Chas. N. The subdivisions of the Enid formation; Bull. Am. Assoc. Pet. Geol., vol. 10, no. 8, pp. 786-799, 1926.

Generalized geologic section, Oklahoma County

SYSTEM	FORMATION	THICKNESS	TYPE OF ROCK
QUATERNARY	Recent	0–60	Alluvium, sand, and clay
PERMIAN	Duncan ss.	50±	Massive red sandstone
	Hennessey sh.	650±	Red shales
	Garber ss.	300±	Massive red and orange sandstone, interbedded with thin red shales
	Wellington fm.	500±	Red sandstone with interbedded shale
	Stillwater fm.*	800±	Red and gray sandstones and red shales
PENNSYLVANIAN	Pontotoc group	1,350±	Red and brown shales with a few thin limestones
	Pawhuska fm.	350±	Light gray limestones with intervening shale
	Hoover series	600±	Brown and gray sands
	Oread ls.	100±	Limestone with a little sand and shale
	Tonkawa series	500±	Brown and gray shale
	Layton series	500±	Sandstone series with interbedded thin limestones
	Checkerboard ls.	90±	Limestone with small shale break
	Uncorrelated sec.	700±	Dark shales
	Oswego ls.	40±	Thin limestone with interneving shale
	Cherokee sh.	100-300	Dark shale with few limestones and sandstones; "Prue Sand" near top.
			"Detrital Zone"
MISSISSIPIAN	Mayes ls.	0–35	Gray cherty limestone
	Woodford sh.	0–60	Black shale, with chert
SILURO-DEVONIAN	Hunton fm.	0–350	Limestone, buff in color
ORDOVICIAN	Sylvan sh.	0–130	Green shale.
	Viola ls. (Fernvale)	0–40	Coarsely crystalline limestone, light buff in color
	Upper Simpson (Simpson Formation)	0–200	Dense limestone with dolomite break below
	Wilcox sand horizon (Simpson Formation)	0–250	Chiefly sand; may have shale interstratified; productive.
	Lower Simpson (Simpson Formation)	0–490	Sandstone and shale members. Productive
ORDOVICIAN / CAMBRIAN	Arbuckle ls.	500	Chiefly dolomite. Productive

*NOTE: Formations down to the Stillwater outcrop.

GARBER SANDSTONE

The Garber sandstone is overlain by the Hennessey shale and underlain by the Wellington formation. Both contacts are apparently conformable. However, the actual contact of the Garber and Wellington is only approximately shown on the areal map because of the wind blown sand which blankets the outcrops along North Fork of Canadian River. The Garber sandstone covers the middle one-third of the county and weathers to rough, hilly topography.

The Garber, approximately 300 feet thick, is characterized by massive red and orange sandstone lenses interbedded with thin shales. The lower part of the Garber is principally red shale with some lenticular red sandstones, especially at the base where a rather prominent red sandstone is found. At the type locality the Garber has been differentiated into two members.[3] The lower member, chiefly shale, has been called the Lucien shale, a portion of the Garber composed largely of red clay shales with several ledges of red sandstone interfingered. The upper member of the Garber has been called the Hayward sandstone member. This member, composed of massive red sandstone is cross-bedded and interstratified with thin beds of red shale. This upper sandstone enables one to differentiate the Garber from the overlying Hennessey. Above this sandstone occurs a red shale, which maintains a rather constant thickness of 5 feet. The writer places the top of the Garber at the top of this 5-foot shale bed. The difficulty of remaining on the same sandstone member has caused a great deal of uncertainty in the surface work in the county.

Above this 5-foot shale occurs a dolomitic red conglomerate one to three feet in thickness. Overlying this is a sand member about 14 feet thick. Then succeeds a red shale containing small dolomite concretions about ¼- to ½-inch in diameter, having a thickness of about 30 feet. Overlying this is a red sandstone, 2 to 6 feet thick, with finely laminated red shales. This sandstone forms escarpments in the basal Hennessey. Above this is found another red shale with white dolomite streaks running through it. It has a thickness of about 30 feet. Overlying this is found a 4-foot red sandstone having white, thin dolomite streaks. Figure 2 is a diagram showing the relationships of the above described beds.

The Garber-Hennessey contact crosses the south county line in sec. 35, T. 11 N., R. 2 W., continues north very irregularly to sec. 14, T. 12 N., R. 2 W., where it abruptly turns southwest to the SE.¼ sec. 7, T. 11 N., R. 2 W. From there the trend is directly south to the center of sec. 30, T. 11 N., R. 2 W., where it swings around to the north, until it reaches the Oklahoma City city limits in the northwest part of sec. 11, T. 11, N., R. 3 W. It then swings west through the city, coming out just north of the State Capitol where it takes an irregular trend east of Britton and the eastern part of Edmond, then north to sec. 1, T. 14 N., R. 3 W., where it abruptly swings west to the

3. Aurin, F. L., Officer, H. G., and Gould, Chas. N., op. cit.

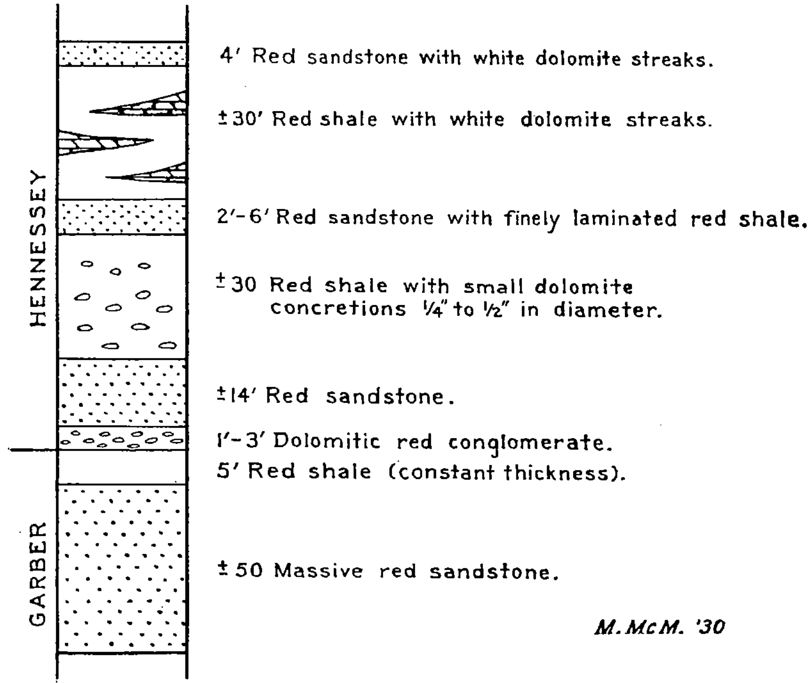

Figure 2. Ideal section of Garber sandstone overlain by sandstone members of lower Hennessey.

southwest part of sec. 3, T. 14 N., R. 3 W. Thence south to sec. 29 T. 14 N., R. 3 W., where it swings north, making another large protuberance. It crosses the north county line in sec. 5, T. 14 N., R. 3 W. (See plate I.)

WELLINGTON FORMATION

The Wellington formation, underlain by the Stillwater and overlain by the Garber, occupies the eastern one-third of the county and is composed of essentially red sandstone with interbedded shale. At the base of the formation is the Herington limestone which outcrops north and east of Oklahoma County. The sandstone is massive, red to gray in color, and fine grained. The shales are usually red but may vary to gray or black, and are moderately thick. The sandstones are covered with timber, chiefly scrub oak, though the shales are quite barren. The sandstones are cross-bedded and barite crystals (roses) are found at several horizons in the sandstone phases of the formation. The Wellington correlates with the Wellington shale of the Kansas section of the Permian, but the character is different. In Kansas it is made

up chiefly of gray-blue shales and has the Herington limestone at the base. The Wellington has a strike approximately north-south and dips to the west at the rate of 30 to 35 feet per mile. It has an approximate thickness of 500 feet. The contact of the Wellington and Stillwater is not well defined and becomes increasingly obscure southward.

Subsurface Formations

PERMIAN

STILLWATER FORMATION

The Stillwater formation underlies the Wellington and it is found outcropping in Lincoln County. It is a series of red and gray sandstones and red shales. The base of the formation is the base of the Cottonwood limestone which is used as the Pennsylvanian-Permian contact by the U. S. Geological Survey. The top of the formation is the top of the Herington limestone, which occurs as a limestone north into Kansas. Neither the base nor the top of the Stillwater has been accurately mapped at this time. The thickness is believed to be approximately 800 feet.[4]

PENNSYLVANIAN

Pennsylvanian rocks vary in thickness in the Oklahoma City area from 4,000 to 4,100 feet, and are first encountered at a depth of approximately 2,000 feet. In the northeastern part of the county the Pennsylvanian is reached at about 1,400 feet below the surface. The Pennsylvanian sediments dip approximately 50 feet per mile to the west. These rocks are composed chiefly of shale with about equal quantities of sandstone and limestone. In one Pennsylvanian section (in the Oklahoma City area) 75 per cent is shale, 13 per cent sandstone, and 12 per cent limestone. At the present time this section can not be subdivided into its various formations with certainty due to the differences in lithology, thickness, and additional beds that do not correspond with exposed outcrops. Therefore the Pennsylvanian correlations are generalized and by no means final. At the present time the Pennsylvanian-Permian contact cannot accurately be drawn. Only an approximation can be used because, in going east across the strike of the Garber and Wellington, the base of the Wellington is not distinguishable from the top of the Stillwater formation. The same is true with the Stillwater formation and the Pontotoc group.

PONTOTOC GROUP

The Pontotoc group as defined by Morgan,[5] consists of three formations, in ascending order; the Vanoss, Stratford, and Konawa. The Konawa consists chiefly of red shales, while the Stratford and Vanoss are composed of drak brown shales with a few thin limestones. The combined thickness of the group in Pontotoc County is 1,400 feet. The

4. Aurin, F. L., Officer, H. G., and Gould, Chas. N., op. cit.
5. Morgan, George D., Geology of the Stonewall quadrangle: Bureau of Geology, Bull. 2, pp. 132-141, 1924.

age, according to Morgan is upper Pennsylvanian and lower Permian.[6] The upper Pontotoc is the time equivalent of the Stillwater to the north.

The correlation of the Pennsylvanian formations in Oklahoma County with Pennsylvanian sections to the east and to the north do not check in detail. From the east the general correlation is higher, while from the north the subsurface correlation seems to fit better if shifted some 200 feet lower.

The general correlation used in this bulletin is after Bush who was the first to correlate the entire section in the Oklahoma City area with a section from the east.[7]

PAWHUSKA FORMATION

Below the Pontotoc group is the Pawhuska formation. This formation consists of three limestones generally light gray, with intervening brown and gray shales. White massive sand and some white tripoli are also found in the formation. It has an approximate thickness of 350 feet, and correlates with the lower part of the Shawnee formation of the Kansas section.

HOOVER SERIES

Underlying the Pawhuska formation is a series of sediments called Hoover, consisting generally of a sand zone at the top, shale in the center, and another sand zone at the base. The sands are brown and gray, even grained, subangular, and loosely cemented. The shales are brown and gray. A few thin light gray and platy limestones are found at the top of the sands. At the base of the Hoover series are more limestone beds which are dark brown and oolitic. The series has a thickness of about 550 to 600 feet. It is upper Pennsylvanian in age and correlates with the lower part of the Shawnee and the upper part of the Douglas formations of the Kansas section.

OREAD LIMESTONE

The Oread limestone is immediately below the Hoover series and at the top has a limestone member 20 feet thick. It is white, finely arenaceous, containing the microfossil *Triticites*. Fine sand and shale make up the lower part of the formation. It has a total thickness of approximately 100 feet. The age is Conemaugh, correlating with the upper part of the Douglas formation of the Kansas section.

TONKAWA SERIES

Underlying the Oread is the Tonkawa series which is essentially brown and gray shale with some sandstone and limestone members at the top. The sands are loosely cemented, fairly porous, buff colored,

6. Morgan, George D., op. cit., pp. 132-141.
7. Bush, F. A., personal communication.

and the grains are angular. The shales are intercalated with red clays. The limestones which occur in the upper portion of the series are drab gray in color, finely crystalline, intercalated with dark brown clay shale. The series has an average thickness of about 500 feet. The age of the Tonkawa series is Conemaugh and it correlates with basal Douglas and all of the Lansing formation in the Kansas section.

LAYTON SERIES

The Layton series is below the Tonkawa series. It is primarily a sandstone with shale and intercalated limestone. At the top of the series are some thin platy limestones which are white to drab in color. The shales found at the top and at the base are dark brown. The sandstones might be placed in four zones, the uppermost being about 60 feet thick, a fine subangular sand, well cemented. Below this is another zone which is sandy shale, being an arenaceous light gray shale and sand with gray arenaceous bond, about 60 feet thick. The third zone is a massive light brown, well bonded, quartzose sand about 70 feet thick. The lowest sandstone, composed of subangular and well assorted grains, is about 20 feet thick. This series has been found to contain gas production in the upper or first sand zone and oil shows in the lower zone. The age of the Layton series is Conemaugh and correlates with the upper Kansas City formation of the Kansas section. The Layton has a thickness of about 500 feet.

CHECKERBOARD LIMESTONE

Below the Layton series is the Checkerboard limestone in the Oklahoma City area. Gould[8] describes the Checkerboard as a member of the Coffeyville formation lying near the base, having a thickness of 2½ to 3 feet thick, fine grained, and fossiliferous. In Oklahoma County the lithology and microfossil evidences are the same, but position and thickness are different. Bush believes that the Checkerboard limestone is placed just as correctly there (as is known in the Oklahoma City field) as anywhere lower. Several Oklahoma City geologists believe it is lower in the section some 200 feet, because it fits in better with a section traced from the northern part of the State. It is essentially a limestone, light gray, medium crystalline to a buff, finely crystalline, and slightly porous. The upper limestone is about 60 feet thick under which is a shale ten feet thick. Below the shale is another limestone, dark, dense, and intercalated with dark gray shale. The lower limestone member has a thickness of 20 feet and the approximate total thickness of the Checkerboard limestone is therefore 90 feet. It is of Conemaugh age and correlates with the lower part of the Kansas City formation in the Kansas section.

UNCORRELATED BEDS

Below the Checkerboard limestone and above the Oswego limestone are a group of shales with a few thin limestone and sandstone

8. Gould, Chas. N., Index to the stratigraphy of Oklahoma: Oklahoma Geol. Survey Bull. 35, p. 73, 1925.

members. The shales are dark gray in color. The interval between the base of the Checkerboard limestone and the base of the Oswego limestone correlates with the Marmaton formation of the Kansas section. A closer subdivision of this section is very difficult to make at this time. Bush suggests in his original log of the Oklahoma City area that approximately 150 feet below the base of the Checkerboard (composed chiefly of shale with several thin bedded limestones) occurs what should be called the Coffeyville formation, and the remaining 550 feet of dark shales should be referred to as the Nowata shale.[9] However, the Coffeyville formation, as described by Gould at its type locality, has the Checkerboard limestone near the base of the formation.[10] It will be very difficult to correlate these beds with other sections due to additions or thickening of members such as are described above. The Marmation formation is Allegheny in age.

OSWEGO LIMESTONE

Below the uncorrelated section occurs the Oswego limestone which has, at the top, a limestone member which is dark in color and finely crystalline. In the middle portion the Oswego limestone has a thin, dark shale member. At the base occurs a dense fossiliferous limestone. The Oswego has a thickness of about 40 feet. It is known as the Fort Scott limestone at the base of the Marmaton group in the Kansas section. It is of Allegheny age.

CHEROKEE SHALE

Below the Oswego limestone is the Cherokee shale which is mostly dark shale, and has a varying thickness according to its relation to structure. Near the top of the formation is an oil-stained, subangular, loosely bonded, micaceous sandstone which is known as the "Prue sand" in the Oklahoma City area. Near the base are several thin limestone shells which are light gray in color, dense to coarsely crystalline, and dolomitic, with some included sand. The Cherokee shale is the basal formation of the Pennsylvanian, and it corresponds to late Pottsville and early Allegheny time. It has a thickness of 100 to 300 feet and correlates with the Cherokee shales of the Kansas section.

"DETRITAL ZONE"

At the base of the Pennsylvanian rocks is a large unconformity which indicates that at some time later than Mayes the whole area (around Oklahoma City) was uplifted and remained a positive element while erosion truncated the Mayes limestone, Woodford, Hunton, Sylvan, Viola, Simpson, and approximately 300 feet of Arbuckle limestone before invasion by the Pennsylvanian sea. A sheet of detrital material of varying thickness was spread over the truncated sediments. The detritus is composed almost wholly of reworked Simpson material.

9. Bush, F. A., personal communication.
10. Gould, Chas. N., Index to the stratigraphy of Oklahoma: Oklahoma Geol. Survey Bull. 35, p. 72, 1925.

The zone shows no bedding and is poorly sorted as to size and character of material. The term "detrital zone" was started and is current in the Oklahoma City pool. It should no doubt receive a name just as the Sylamore sandstone (also called Misener sand) in northeastern Oklahoma. The nature of deposition and stratigraphic relation of the Sylamore sandstone are somewhat analagous to the "detrital zone".

MISSISSIPPIAN

MAYES LIMESTONE

Mississippian rocks are found in several wells off the Oklahoma City structure. They are not present on structure due to their removal by erosion. In the Slick-Banta No. 1 well a thickness of about 22 feet of Mayes limestone was found. It is a gray cherty limestone, of Chester age or older, and correlates with the lower part of the Caney shale. The Cherokee shales lie unconformably on this Mayes section.

WOODFORD SHALE

Below the Mayes is found the Woodford which is primarily a black shale with several interstratified chert beds and disseminated pyritic material. In the Martin well, sec. 13, T. 13 N., R. 1 W., it has a thickness of 42 feet. It is probably basal Mississippian in age and is generally correlated with the Chattanooga shale.

DEVONIAN-SILURIAN

HUNTON FORMATION

The Hunton limestone is found below the Woodford, but it is not differentiated into its members in wells in this area. In the Martin well, sec. 13, T. 13 N., R. 1 W., it had a thickness of 70 feet. At the top it is a buff-colored, dense, weathered limestone, which grades into a white, dense limestone with coarse calcite crystals near the middle. It becomes finely crystalline and at the base it is white and pink, coarsely crystalline, and marly. In the Slick-Prairie-Phillips No. 1 Sudik, sec. 8, T. 10 N., R. 2 W., there are 300 feet of Hunton limestone. In the Prairie-Slick No. 1 Banta, sec. 18, T. 11 N., R. 2 W. there are 350 feet of Hunton. In age the Hunton limestone may represent Alexandrian and Niagaran of Silurian and Helderbergian time of Devonian.

ORDOVICIAN

SYLVAN SHALE

Underlying the Hunton is the Sylvan which is a light green and gray in color, flaky, splintery, soft shale containing graptolites. In the Martin well, sec. 13, T. 13 N., R. 1 W., there are 95 feet of Sylvan; in the Sudik well, sec. 8, T. 10 N., R. 2 W., 130 feet. In age it is Richmond time of the Ordovician. However some consider the Richmond to be the lower part of the Silurian system.

VIOLA LIMESTONE

Below the Sylvan shale is the Viola limestone which has a thickness of 0 to 40 feet. It is white to pink in color, coarsely crystalline, and contains few fossils. Fanny C. Edson[11] states that the Viola limestone in the Mid-Continent region has two members, the upper one a coarsely crystalline limestone which she calls Richmond bed, and a lower bed, buff and dense, which she calls lithographic bed of probable Black River age.

Underlying the coarsely crystalline limestone is a light gray to drab dense limestone which is considered to be the top of the Simpson in this area. This dense limestone is also called the top of the Simpson in Seminole County.[12]

White[13] states that the Viola limestone observed in east-central Oklahoma is the Richmond phase of the Viola limestone of the Arbuckle Mountains and correlates with the Fernvale limestone of Arkansas.

Whether the dense limestone is a member of the Viola is questionable and either interpretation may be correct. It is considered the top of the Simpson by most of the men working in the Oklahoma City area.

In the Arbuckle Mountains, the Fernvale phase of the Viola is separated from the Simpson by 500 to 600 feet of middle Viola limestone. This horizon is not present in Oklahoma County, probably due to erosion.

SIMPSON FORMATION

The Simpson formation underlies the Viola limestone unconformably and has a total thickness of 813 feet in the Martin well in sec. 13, T. 13 N., R. 1 W., this being the only well going through the entire section of Simpson.

The Simpson has recently been subdivided into several divisions by Decker and Merritt,[14] in the Arbuckle Mountains. The writer has divided the Simpson formation in Oklahoma County into three parts for convenience in description and cross-sections:

3. Upper Simpson (all Simpson above Wilcox)
2. Wilcox sand horizon
1. Lower Simpson (all Simpson below Wilcox)

The upper Simpson is 72 feet thick in the Martin well, sec. 13, T. 13 N., R. 1 W., and is composed of a dense lithographic limestone member at the top 30 feet thick and probably correlative with the dense

11. Edson, Fanny C., Ordovician correlation in Oklahoma: Bull. Amer. Assn. Pet. Geol. Vol. 11, pp. 968-970, 1927.
12. Levorsen, A. I., Geology of Seminole County, Oklahoma: Geol. Survey Bull. 40-BB, p. 25, 1928.
13. White, L. H., op. cit. p. 18.
14. Decker, Chas. E., and Merritt, C. A., Subdivisions of the Simpson formation: Oklahoma Geol. Survey, mimeographed pamphlet.

limestone member of the Seminole section. The remaining 42 feet of alternating limestone and dolomite cannot be as readily correlated with the Seminole section. The dolomite is buff in color and dense. Near the base of the upper Simpson is a thin bed of white dense chert. In the Sudik well, sec. 8, T. 10 N., R. 2 W., a thickness of 200 feet of upper Simpson is found which shows the extent of lateral gradation and southward divergence of the Simpson section as compared with the Martin well.[15] The age of the Simpson above the Wilcox (upper Simpson) is Black River.

The second division or Wilcox sand horizon has a thickness of 250 feet in the Martin well and is composed of sand, white in color, loosely bonded with frosted, rounded, and subangular grains. There are a few thin pyrite seams disseminated in the sand section. However, in the Sinclair School Land 67, sec. 36, T. 11 N., R. 3 W. No. 1, the Wilcox is not found as an entire sand body but has thin green shales interbedded through it. The age of the Wilcox is basal Black River (Ordovician).[16]

The Wilcox sand horizon has been proved productive of oil in the south end of the Oklahoma City pool and probably will be found productive elsewhere in the county.

The third division or lower Simpson has a thickness of 489 feet in the Martin well. The upper portion is sandy with interbedded bright green splintery shale beds, and a little dolomite. Under this occurs a series alternating maroon and green, soft splintery shales including some rounded and frosted sand, and intercalated with thin sand shells. This is probably the Tyner member as described by Weirich.[17] The Tyner correlates with the McLish division of the Simpson and is upper Chazy in age.[18] Below this is a sand 45 feet thick, white in color, subangular, and frosted which may be the Burgen sandstone. The Burgen sandstone occurs at the base of the McLish division of the Simpson and is Chazy in age.[19] Below the sandstone is a broken series of sandstone, dark green shale, sucrose dolomite, and limestone. This series has a thickness of 110 feet in the Martin well. A sandstone having a thickness of 55 feet occurs below the broken series. The sand is white in color, rounded, frosted, subangular, loosely cemented, poorly assorted, and has a little dolomite. The broken series and this sandstone probably belong to the Oil Creek division of the Simpson formation, the age of the Oil Creek being lower Chazy, as proposed by Decker and Merritt.[20]

15. Weirich, T. E., Features of the Simpson formation: Oil and Gas Journal, April 24, 1930.
16. Decker, C. E., and Merritt, C. A., Correlation table of formations of the Simpson group: Oklahoma Geol. Survey, mimeograph pamphlet.
17. Weirch, T. E., op. cit.
18. Decker, C. E., and Merritt, C. A., op. cit.
19. Decker, C. E., and Merritt, C. A., op. cit.
20. Decker, C. E., and Merritt, C. A., op. cit.

The attempted subdivision of the lower Simpson is from the Martin well in sec. 13, T. 13 N., R. 1 W., which went through a complete section of the Simpson and into the Arbuckle. A finer division in the Oklahoma City field would be difficult, due to an incomplete section and changes in lithology. Therefore, the writer has made the general subdivision "lower Simpson" which is merely indicative of position in reference to the Wilcox sand.

ARBUCKLE LIMESTONE

The Arbuckle limestone which lies below the Simpson formation is composed essentially of dolomite, light brown to buff in color, highly porous, coarsely sucrose, massive, and intersected by many small fissures. As found exposed in the Arbuckle Mountains the Arbuckle limestone has a measured thickness of 7,872 feet.[21] The Arbuckle limestone is probably thinner in the Oklahoma City area due to erosion.

In the Arbuckle Mountains the upper part of the Arbuckle is limestone while the lower part is dolomitic. This leads to the question as to what part of the Arbuckle is found below the Simpson in the Oklahoma City field. White[23] indicates a considerable truncation of the Arbuckle in northern Oklahoma. However, at the present time there are not enough deep wells between the Arbuckle Mountains and the Oklahoma City field to definitely correlate the Arbuckle limestone which is found in this county. The age of the Arbuckle limestone, according to Ulrich[24] is upper Cambrian and lower Ordovican.

GEOLOGIC HISTORY

During lower and middle Cambrian time, Oklahoma was undergoing erosion and the area must have been low and relatively peneplained. Deposits of residual material resulted from erosion of igneous bedrock. As upper Cambrian seas invaded Oklahoma, they came primarily by the way of the Sonoric embayment from the southwest across Texas and joined the Ouachitaic embayment from the east and probably covered the entire State.[25] Wilson also suggests that the clastic sediments of the Reagan sandstone were the first deposits formed as the invading sea worked over the residual material of the igneous bedrock and that the seas cleared and the Arbuckle limestone was then laid down.

At the close of the Arbuckle limestone deposition, there was a complete emergence and the seas next invaded from the east through the Ouachitaic embayment.[26] This places an unconformity between the

21. Decker, C. E., and Merritt, C. A., Physical characteristics of the Arbuckle limestone: Oklahoma Geol. Survey Cir. 15, p. 15, 1928.
22. White, Luther H., Subsurface distribution and correlation of the pre-Chattanooga ("Wilcox" sand) series of northeastern Oklahoma: Oklahoma Geol. Survey Bull. 40-B, p. 11, 1926.
23. White, Luther H., op. cit., p. 11.
24. Ulrich, E. O., Revision of Paleozoic systems: Bull. Geol. Soc. America, vol. 22, pl. 27, p. 608, 1911.
25. Goull, Chas. N., and Wilson, R. A., Upper Paleozoics of Oklahoma: Oklahoma Geol. Survey Bull. 41, p. 34, 1927.
26. Gould, Chas. N., and Wilson, R. A., op. cit.

top of the Arbuckle limestone and the Simpson formation. The erosion taking place during this unconformity would account for the drainage channel or sink hole that is found in the Arbuckle limestone in the Gildden No. 1, and No. 2 wells in sec. 13, T. 11 N., R. 3 W., which reached the top of the Arbuckle some 400 feet lower than in the north, south, and east offsets. (See figure 7, page 32.)

Evidence that erosion removed some of the Arbuckle limestone is found in the northeastern part of Oklahoma. Following deposition of the Arbuckle limestone and previous to early Simpson time, the Ozark area was uplifted and subjected to erosion. The beds were truncated more to the north than to the south.[27]

Morgan discovered evidence of this period of erosion in studying the Simpson formation in the Stonewall quadrangle. Describing the thickness and character of the Simpson, he states,[28]

> The absence of the lower portion of the Simpson formation to the north and the more clastic nature of subsequent portions of the formation in that direction, suggest an Ordovician land mass to the north of the Arbuckle area over which the Simpson sea gradually encroached.

The highly porous upper part of the Arbuckle limestone also suggests that it was exposed to weathering.

Following deposition and erosion of the Arbuckle limestone the advance of the Simpson sea, with minor oscillations, from the east through the Ouachitaic embayment deposited the lower Simpson, Wilcox, and upper Simpson. Weirich[29] suggests that during Tyner time (lower Simpson) subaerial conditions controlled deposition and that the presence of maroon shales suggests a possible unconformity existing in the middle of the Tyner. At the end of deposition of the upper Simpson a retreat of the sea resulted in the erosion of a part of the upper Simpson. This break is not very clearly defined in the Oklahoma City area, a difference in thickness of upper Simpson in the Martin well, sec. 13, T. 13 N., R. 1 W., as compared with the much greater thickness in the Sudik well, sec. 8, T. 10 N., R. 2 W., might indicate the break. In the Seminole area Levorsen states:[30]

> Locally the Viola limestone is apparently conformable on the underlying Simpson formation but over broad areas it overlaps the entire middle and lower Viola and the upper Simpson section.

The Richmond sea next invaded Oklahoma, coming from the southeast, and it was during this time that the maximum Richmond invasion of North America occurred. This invasion caused deposition of the

27. White, Luther H., Op. cit., p. 11.
28. Morgan, Geo. D., Geology of the Stonewall quadrangle; Bureau of Geol. Bull. 2, p. 26, 1924.
29. Weirch, T. E., op. cit. p. 112.
30. Levorsen, A. I., Geology of Seminole County: Oklahoma Geol. Survey Bull. 40-BB, p. 24, 1928.

coarsely crystalline Viola member which is at the top and called the Richmond bed by Edson.[31] The sea also deposited the Sylvan shale, which is conformable with the Viola limestone throughout the state. White[32] suggests that the upper part of the Viola limestone, being so much more widespread than the lower and thicker portions of the formation, and conformity of the Viola-Sylvan contact, indicate that the Ordovician-Silurian boundary should be placed below Richmond.

A deepening of the Sylvan sea caused deposition of the Hunton limestone. In Oklahoma County, so far as known, the Hunton overlies the Sylvan conformably; but some wells in the future will probably discover Sylvan in contact with Pennsylvanian, because in the Oklahoma City area there are formations both above and below the Sylvan that have unconformable contact with Pennsylvanian rocks. However, this unconformity would not indicate that the Hunton limestone was laid down unconformably on Sylvan, but that after conformable deposition., erosion truncated the Hunton down to the Sylvan. At the end of Hunton time the sea retreated to the northeast and the Hunton limestone was exposed to erosion. The amount eroded is variable; in the Slick-Banta No. 1 well in sec. 18, T. 11 N., R. 2 W., there is 350 feet, while in the Martin well in sec. 13, T. 13 N., R. 1 W., there is 65 feet of Hunton limestone. This period of erosion lasted until lower Mississippian time when seas coming from the northeast deposited Woodford shale and the overlying Mayes limestone. Whether the Mayes is conformable on Woodford is questionable. The Mayes limestone which is correlated with the base of the Caney shale is the uppermost Mississippian formation found in the county. At the close of Mayes limestone deposition the Oklahoma City area was uplifted and subjected to erosion sufficient to expose the Arbuckle limestone, or until the invasion of the Cherokee sea. All of the State except the southeastern part became elevated during upper Mississippian or at the end of Caney time. The gentle downwarping in the southeast due to the Ouachitaic embayment and relative elevation of the rest of the State, exposed a large part of Oklahoma to erosion. The great unconformity in the Oklahoma City area was the result of this widespread erosion at the close of the Mississippian.

This uncomformity represents a time interval from post-Mayes to early Pennsylvanian. The unconformity is very marked in the Oklahoma City area due to erosion debris left on the eroded surface This represents, in part, what has been called "detrital zone" in the Oklahoma City field. A thin blanket of this detrital material is found in contact with the Arbuckle, Simpson, Viola, Hunton, and with Mayes. The material was derived chiefly from the Simpson formation.

Contemporaneous with uplift or soon after a large normal fault with its axis trending approximately N. 35° W. occurred. A line

31. Edson, Fanny Carter, Ordovician correlation in Oklahoma: Bull. Am. Assn. Petr. Geol., Vol. 11, pp. 968-970, 1927.
32. White, Luther H., op. cit., p. 18.

drawn through the northwest corner of sec. 18, T. 11 N., R. 2 W. and continued through the southeast corner of sec. 10, T. 11 N., R. 2 W. will approximate the strike of this fault. (see fig. 7).

The fault is found in subsurface correlation and does not find expression at the surface, but passes into a fold and is reflected as a steep east dip. The Prairie-Slick Hiddleston No. 2 penetrated the top of the Hunton at -5,433 feet while one location south the Shell Petty No. 3 found the top of the Arbuckle at -4,863 feet, giving the Hunton an average thickness of 150 feet (it varies from 50 to 350 feet) and the section below the Hunton to the top of the Arbuckle a thickness of 950 feet (taken from the Martin well) would give a throw of 1,700 to 1,800 feet. Another contact which shows the fault clearly is the Slick Banta No. 1 in sec. 18, T. 11 N., R. 2 W., which had the top of the Hunton at -5,531 feet and the I. T. I. O. Farley No. 3 which is 1,220 feet west and 660 feet south had the top of the Arbuckle at -4,805. This comparison gives a throw of about 1,800 feet. The length or extent of the fault is not now known, but it is at least 2½ miles long and probably longer. (see fig. 7).

The upthrow of the fault raised the west side and allowed erosion to act rapidly whereas the east side was relatively much lower and suffered little or no erosion. This erosion removed the Mayes, Woodford, Hunton, Sylvan, Viola, Simpson, and about 300 feet of Arbuckle limestone. By projecting the Arbuckle limestone, it is estimated. that 300 feet was removed.

The early Pennsylvanian seas which deposited the Wapanucka limestone and upper Caney did not invade Oklahoma County for they were too far south. The Hunton arch and Ozark arch further restricted the lower Pennsylvanian seas to the southeast during Atoka, Hartshorne-McAlester-Winslow time.[33]

A complete submergence of the Ozark arch at the close of Winslow time began the Cherokee, or Pennsylvanian, sediments in Oklahoma County.

A series of minor oscillations throughout the remainder of the Pennsylvanian deposition may have caused minor unconformities but the Pennsylvanian sea as a whole remained over Oklahoma County until middle Wabaunsee time when a great area in southeastern Oklahoma, Arkansas, and northwest Louisiana was uplifted, causing a recession of the Pennsylvanian sea to the west and south.[34] This allowed rapid erosion and deposition of large quantities of clastic sediments on the northwest flank known generally as the red beds. It was during this time that the Pontotoc, Stillwater, Wellington, and Garber formations

33. Dott, Robert H., Pennsylvanian paleography: Oklahoma Geol. Survey, Bull. 40-J, 1927.
34. Anderson, G. E., Geology of Cleveland and McClain counties: Oklahoma Geol. Survey Bull. 40-N, p. 16, 1927.

were deposited.[35] In the sea to the west and north their marine equivalents are interfingered with the red beds during minor oscillations of sea. The Hennessey shale was then deposited over the Garber and this was followed by deposition of the Duncan sandstone. The Duncan was the last Permian bed to be deposited in Oklahoma County. Part of the Wellington, all of the Garber, and Hennessey, and part of the Duncan are found outcropping in the county and overlying each other to the west. After the Permian deposition in the county, elevation and erosion has been taking place from Permian to Recent.

STRUCTURE

Surface Structure

Structurally, the surface formations in Oklahoma County form a gentle west-dipping monocline. The formations become progressively younger to the west, all of them being apparently conformable. The strike of the Permian surface formations is slightly west of north, and the beds have a normal west dip of 30 to 35 feet per mile.

This west-dipping monocline, as a whole, is quite uniform. However, there are irregularities which may cover an area of several miles. The arching or flexure of the Garber sandstone south of Oklahoma City shows an abnormality in the occurrence of an east dip. Taking a point on top of the Garber approximately 7 miles east of the Oklahoma City structure, the elevation is 1,200 feet. Going west, the top of the Garber at the highest point on structure should be (using normal west dip of 30 to 35 feet per mile) 230 feet below surface. On top of the structure the top of the Garber, however, is found at an elevation of 1,325 feet, which, in elevation, is 125 feet higher than the top of the

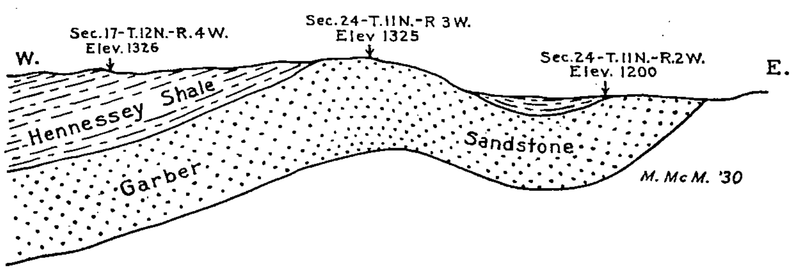

Figure 3. Generalized cross-section showing the arching of the Garber sandstone from east to west across the Oklahoma City field.

Garber 7 miles to the east. This 125 feet plus 230 feet that should be allowed for a normal west dip, gives the Garber an arching of 360 feet. Going north and west to the Bethany well, sec. 17, T. 12 N., R. 4 W.

35. Idem.

the top of the Garber was reported some 200 feet below surface and the elevation approximately the same as on the Oklahoma City structure. This would represent a normal west dip. (see fig. 3).

The arching south of Oklahoma City shows 120 feet of closure on the Garber sandstone at the surface. (see fig. 4). This fold may be classed as a dome and is the only one which has been proved in the county.

There are other surface and subsurface structures reported in the county, but data on these are still held confidential by the oil companies.

A subsurface fault striking in a northwest-southeast direction on the east side of the Oklahoma City structure finds no surface expression as a fault, but the fault is reflected in a steepening of the east dip on the surface structure (note steepening on surface structure, fig. 4).

The beds that are used as key beds in maping surface structure in the county are the massive sandstone at the top of the Garber, and the three sandstone members in the base of the Hennessey (described under Surface Formations). These beds seem to maintain a fairly constant interval and can be traced from the northern part to the southern part of the county.

Subsurface Structure

The subsurface structure may best be discussed if divided into two parts, early Paleozoic and late Paleozoic; the former to include all sediments up to Pennsylvanian and the latter to include Pennsylvanian and Permian.

LATE PALEOZOIC STRUCTURE

The Permian and Pennsylvanian rocks that are found below the surface dip west at approximately 50 feet per mile. The entire Pennsylvanian section reflects the surface structure the same as the surface, but shows more closure than the surface beds. (Note structure maps on Pawhuska formation and Checkerboard limestone, figs. 5 and 6.)

EARLY PALEOZOIC STRUCTURE

In general, the members of early Paleozoic formations are parallel and reflect the structure nearly the same as the Pennsylvanian-Permian section. The thickening of the Simpson to the south and variable thickness of the Hunton would tend toward divergence. Also the complete removal of all the early Paleozoic sediments down to the Arbuckle limestone gives a convergence.

The total structural relief of the Arbuckle limestone in Oklahoma County can not be determined accurately at this time due to lack of data. However, the estimated relief is about 2,400 feet. A structural contour map on the Arbuckle is shown in figure 7.

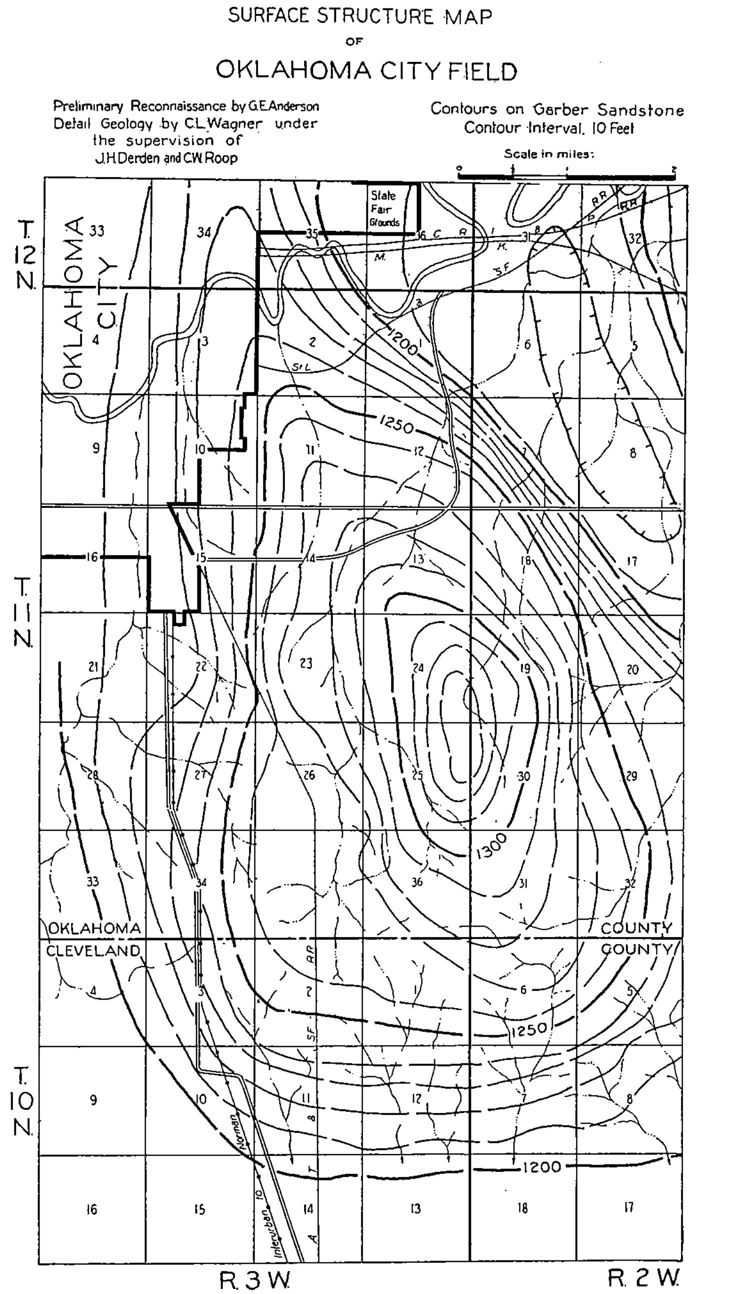

Figure 4. Surface map of Oklahoma City field. Contours on the Garber sandstone. Contour interval, 10 feet. Map used through courtesy of I. T. I. O., R. J Riggs, Chief Geologist.

Origin of Oklahoma City Structure

The rocks thus far found in Oklahoma County are of sedimentary origin. However their original attitude has been changed and, through deep well records, some idea of the geological history is derived. The present structure of the Oklahoma City pool is believed to have developed in the following manner.

The first determinable structural movement that affected the region probably came at the close of Mayes time when the Oklahoma City area was uplifted. During or immediately following this uplift, base leveling occurred and the formations were eroded from the structurally high area. This truncation included Mayes, Woodford, Hunton, Sylvan, Viola, Simpson, and approximately 300 feet of Arbuckle limestone. These truncated surfaces, excluding the Arbuckle limestone, are found successively underneath the Pennsylvanian formations on the flanks of the field with a covering of the detrital material. During or immediately following this post-Mayes uplift, a large normal fault was developed on the east side of the structure causing the downthrow side (east side) to retain a full section while the upthrow side was exposed and truncated. As the erosion neared base level the Cherokee sea advanced, depositing material first on the flanks, and then over the crest, giving a much thicker section on the margins of the structure.

Another structural movement of major importance that is evidenced by subsurface records is between Oswego and Checkerboard times. Contouring the top of the Oswego limestone there is an offset of 400 feet in wells 660 feet apart (Slick-Hiddleston No. 2, and Shell, Petty No. 3). Although this was not as great as the first one, it tends to show that the structural high was not derived by a single uplift.

The Oklahoma City structure shows a decrease in closure progressively higher in the section, so that at the surface a closure of about 125 feet is found as compared to the 450 feet (and probably more) of known closure on the Arbuckle limestone.

There was perhaps much post-Permian deformation, but it probably was not as great a deformation as that which occurred at the close of the Mississippian or in early Pennsylvanian.

DEVELOPMENT

Oklahoma City Field

The first and most prolific oil horizon found in the Oklahoma City pool was the Arbuckle limestone. Production is generally found at different horizons in the upper 400 feet of the formation. Production comes chiefly from a porous dolomite found at approximately 6,000 to 6,500 feet in depth.

Above the Arbuckle limestone and on the flanks, production is found in the sand horizons of the lower Simpson. These wells, while

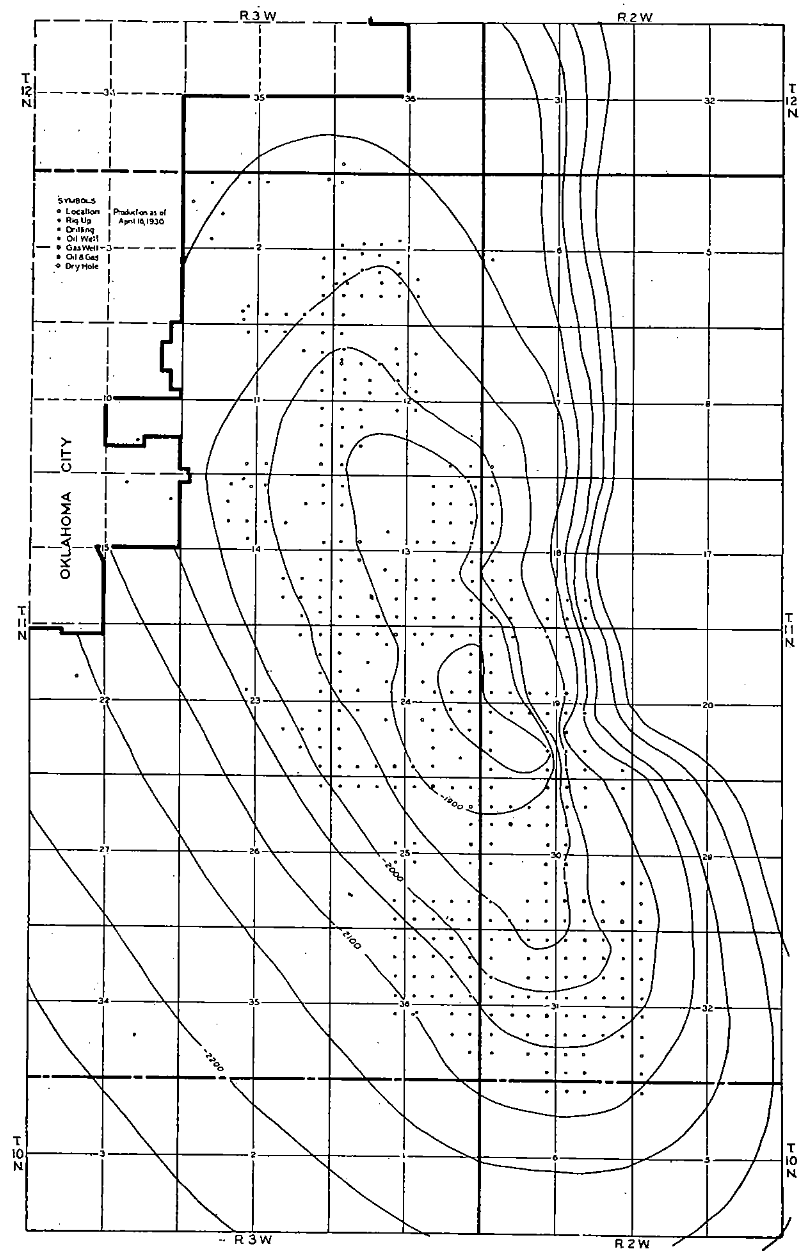

Figure 5. Subsurface map of the Oklahoma City field. Contours on top of the Pawhuska limestone. Contour interval, 50 feet.

not quite as large in their flush production, do not show water as do the wells in the Arbuckle limestone.

Above the lower Simpson production still farther out on the flanks of the structure production is found in the Wilcox sand horizon. As yet, only a few wells are completed in this sand, but these have been very prolific.

The above three horizons are the chief producers in the field and most wells are drilled to one or more of these horizons.

There are a few shallow horizons that are productive of oil and gas.

A good show of oil was found in several wells at approximately 6,250 feet in the Prue sand.

Gas was found in considerable abundance at 5,500 feet in an oolitic limestone below the Checkerboard limestone.

In the Checkerboard lime, found at 5,200 feet, a trace of oil and 1,000,000 cubic feet of gas were found. This productive horizon was found in several wells.

Gas is found in both the upper and lower parts of the Layton series, which is encountered at approximately 4,700 feet in depth. The upper Layton sand produced 47 million cubic feet of gas in the discovery well. The I. T. I. O.-Foster Trosper No. 1 well tested 200 barrels per day in the Layton.

Above the Layton, gas is found in both upper and lower parts of the Tonkawa series. This series is found at approximately 4,200 feet.

In the Hoover series, which is above the Tonkawa, the I. T. I. O.-Foster Oklahoma City No. 1, found 25,000,000 cubic feet of gas in the lower part of the series. The Hoover series is found at approximately 3,600 feet.

In addition to these oil and gas horizons, numerous shows are found in the shallower horizons but are not commercial.

DRILLING AND PRODUCTION METHODS

The first few shallow wells in the county were drilled with cable tools. Later the rotary was used down to the Arbuckle limestone where it was standardized and the wells drilled in with cable tools. This change always caused a great amount of trouble and expense and the chances for fishing jobs increased due to drilling into high pressure gas zone. Now the general practice is to drill the wells complete with rotary tools.

Three strings of casing are generally used. The surface pipe (15½-inch) is cemented at 200 to 300 feet with 400 to 600 sacks of

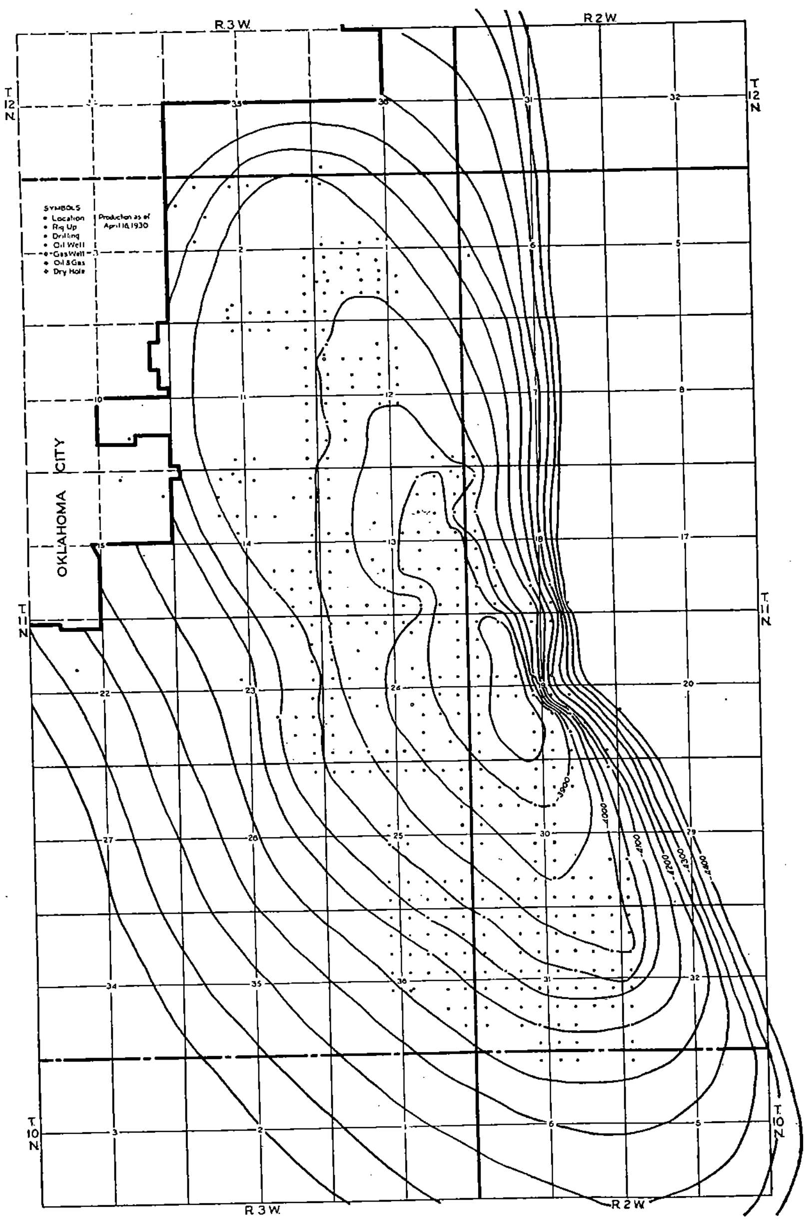

Figure 6. Subsurface map of the Oklahoma City field. Contours on top of the Checkerboard limestone. Contour interval, 50 feet.

cement, cementing to the surface. The 9 5/8-inch is then carried to the Checkerboard limestone, or 5,200 feet, and is cemented with 1,500 sacks of cement. The hole is generally completed with 7-inch casing which is cemented on top of the producing horizon (6,000 to 6,400 feet in depth) with 250 sacks of cement. The cement is allowed to set for 7 days and then the plug is drilled out. The drilling in continues with 3½-inch drill pipe and rotary bit. Rotary mud averaging 10 to 12 pounds per gallon is generally used at this depth. The hole is then bailed to test. If the well shows oil while bailing, the tools are pulled out and the well is allowed to flow to clean itself. If nothing shows, the well is drilled deeper. Most of the wells in the field flow natural due to the enormous gas pressure. The gas in the field ranges from 20,000,000 to 100,000,000 cu. ft. per day with rock pressure averaging 2,300 pounds. The oil wells range from 10,000 to 40,000 barrels per day. The oil flow from the wells goes to separators, then to tanks. A few wells have been put on gas lift.

GENERAL COST OF DRILLING AND EQUIPMENT

1. The general contract price for drilling is $11.00 per foot.

2. An amount of 48,000,000 to 52,000,000 cu. ft. of gas is needed to complete an average well.

3. Approximately 150,000 barrels of water are used in each well. More water is used in the upper part of the hole, where drilling speed is more rapid, than in the lower part.

4. Two slush ponds are needed, which are generally 90 feet long, 20 feet wide, and 6 feet deep.

5. Surface equipment includes four 125 horsepower steam boilers which have a working pressure of 250 to 300 pounds.
Slush pumps are of duplex steam driven type.

6. Lease equipment, camps, roads, and general miscellaneous material which must be charged to each well.

The total cost of drilling and completing a well averages $155,000.00. Average drilling time (including drilling in) is 114 days.

The wells in the Oklahoma City pool are, with few exceptions, drilled one well to ten acres, with a spacing of 660 feet, or 330 feet from property lines.

FUTURE OUTLOOK

At the present time there are numerous wildcat wells being drilled throughout the county which will assure Oklahoma County of receiving a complete test for oil and gas production.

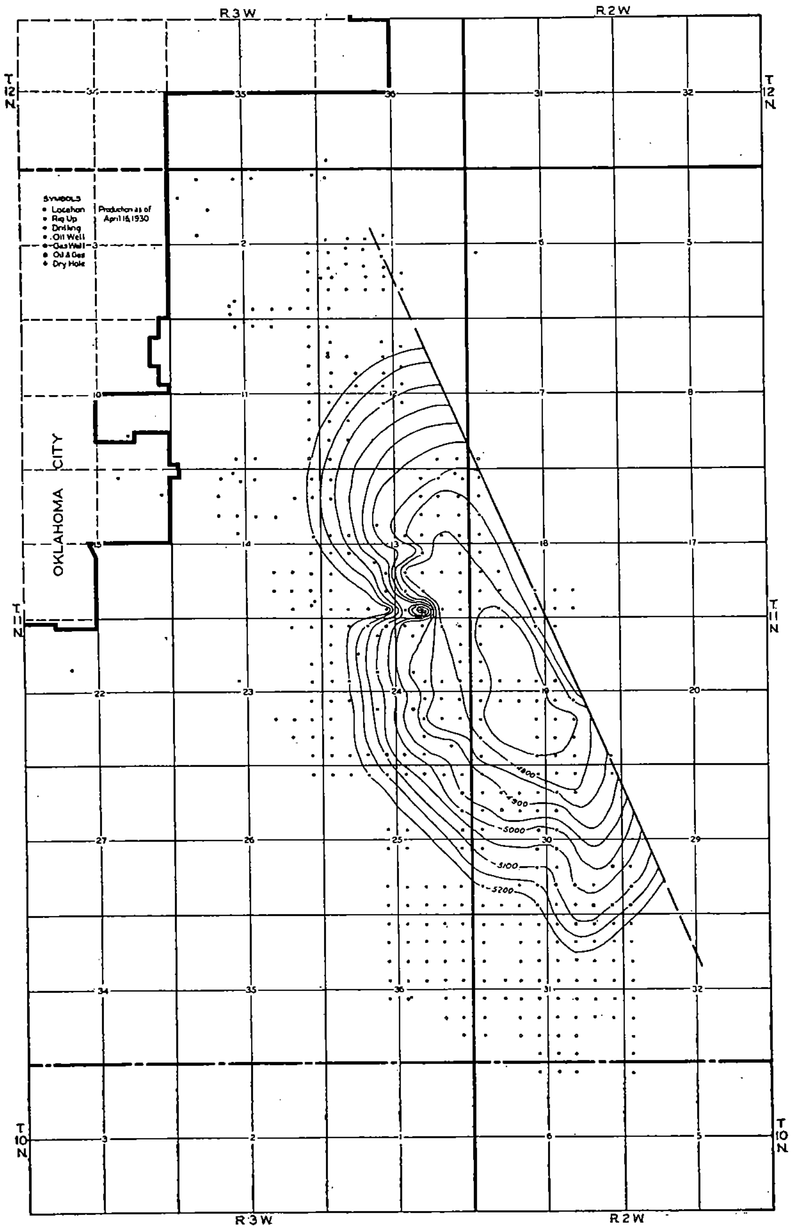

Figure 7. Subsurface map of the Oklahoma City field. Contours on top of the Arbuckle limestone. Contour interval, 50 feet.