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OIL AND GAS IN OKLAHOMA

GEOLOGY OF WAGONER COUNTY

By
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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.

Mr. Philip Boyle, the author of this chapter on Wagoner County, is very familiar with the peculiar structural conditions governing oil and gas accumulation, having spent the last two years in this county. This report, with the accompanying maps and cross-sections will be of value in developing new areas in the county.

CHAS. N. GOULD,
Director

May, 1927.

OIL AND GAS IN OKLAHOMA

WAGONER COUNTY

By

J. Philip Boyle

INTRODUCTION

GENERAL STATEMENT

In the history of geological work, for the purpose of locating oil and gas pools, no intensive consecutive study seems to have been made of the agencies governing the accumulation of oil in Wagoner County until two years ago, when the author commenced doing work over the entire county to determine these facts. The result of the last two years work convinced the author that oil production occurring in Wagoner County is closely related to the folding, faulting and settling which occurred during and after the disturbance which caused the Seneca and other small parallel faults, and that there occurs in Wagoner County general lines of production governed by long sharp anticlinal folds. The sands producing oil and gas in the county are called by any name which happens to occur to the operator and as the majority of operators in Wagoner County have received very little help from a geological standpoint, the author is writing this report with the purpose of familiarizing the operator with the producing horizons and why they produce.

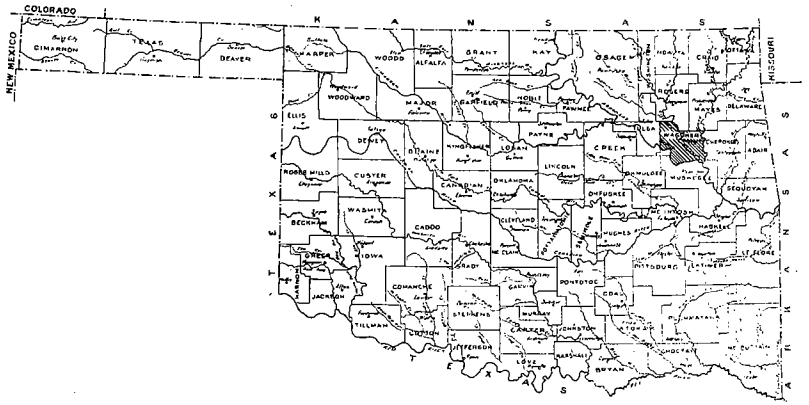

Figure 1.—Index map of Oklahoma showing area covered by this report.

ACKNOWLEDGMENTS

In gathering information for this report, written references on this county were found to be meager. The most useful printed information was obtained from the U. S. Geological Survey maps and those of the Oklahoma Geological Survey. The author is indebted to Luther H. White for valuable information concerning distribution of the formations below the Mississippi limestone, and to Roger W. Sawyer for samples and general information concerning the county.

Mr. Oliver A. Sewell and other local operators were very kind in giving practical information and saving samples from wells.

HISTORY OF DEVELOPMENT

Oil development in Wagoner County progressed from the west side of the county toward the east. (Plate I). The year 1914 seems to have ushered in the discoverey of oil in commercial quantities in the county. Following the initial discovery, the years 1915 and 1916 brought development in T. 17 N., Rs. 15-16 E., to the extent that the large pools such as the Stone Bluff area and the pools in T. 17 N., R. 15 E., were brought in with initial wells of from 10 to 1,500 barrels. From 1916 to the present date, operations have spread over practically the entire county with the result that three distinct producing horizons have been proved in the greater part of the county.

LOCATION

Wagoner County lies in the northeastern part of Oklahoma, and extends from Tps. 15-19 N., Rs. 15-20 E., inclusive. It includes eleven entire townships and parts of ten others. It is very irregular in shape because some of the boundary lines are streams. The approximate area of the county is 580 square miles.

TOPOGRAPHY

The entire county slopes from the north and west to the south and east. The maximum relief of the entire county is approximately 460 feet and lies within the sandstone hills region, with the exception of the extreme northeastern part, which is in the Ozark plateau. The greater part of the surface of the county is a level plain. In the extreme western part the sandstone formations have been cut by stream erosion, forming eastward facing hills which are quickly recognized by their covering of scrub oak vegetation.

The country adjacent to the Grand River has been cut by a number of small streams, forming hills of considerable size. The point attaining the highest elevation is in T. 16 N., R. 14 E., with an elevation of 960 feet, and the lowest point is approximately 500 feet, and marks the point where the Arkansas River flows out of the county. The Arkansas River and its tributaries drain the entire county. Next in size to the Arkansas River is the Verdigris River, which drains

two-thirds of the county and the Grand River which drains the extreme eastern part of the county. The streams have reached the stage where they form meandering channels, and a great many oxbow conditions occur in their broad valleys.

STRATIGRAPHY

SURFACE GEOLOGY

The rocks exposed on the surface of Wagoner County belong chiefly to the Pennsylvanian series and the subdivisions of the Pennsylvanian rocks exposed are the Morrow, Winslow, and Fort Scott formations, and a narrow exposure of the Labette shales.

RECENT OR PLEISTOCENE SEDIMENTS

Stratigraphic Column

		Feet	
Recent	Sand and gravel	5 to 80	
Pleistocene	Sandy clays Clays	10 to 80	
Pennsylvanian	Labette shale	40	Exposed
	Fort Scott	60	
	Winslow	750	
	Morrow		
	Unconformity		
Mississippian	Pitkin lime		
	Lyons-Quinn		
	Lower Mississippi lime		
	Unconformity		
Devonian	Chattanooga shale		
	Unconformity		
Ordovician	Viola limestone		
	Wilcox sand		Upper Tyner sand
	Tyner series		Green shales
	Burgen		Lower Tyner sand
Cambro-Ordovician	Turkey Mountain sand Arbuckle limestone		

Deposited unconformably upon the eroded surface of the Winslow formation in Wagoner County are two horizons of sediments of Recent or Pleistocene age. These sediments are of sub-areal character and represent a flood plain condition of two cycles of erosion by the Arkansas River. The younger formation consists of unconsolidated clays, sands and gravels deposited in the present flood plain of the Arkansas River. These beds, where present, contain numerous pieces

of chert derived from the Winslow formation. Farmers along the Arkansas River bottoms derive their water supply from this formation by sinking sand points.

Approximately 70 feet above the present flood plain of the Arkansas River occurred an earlier cycle of erosion, during the latter part of which the Arkansas River deposited over the area west of Coweta and in the vincinity of Red Bird unconsolidated clays with a maximum thickness of 40 feet. These clays differ from the younger formation by being of more uniform texture, and containing fewer gravels. These late sediments were deposited, after the structural disturbances occurred which caused the Seneca fault, and conceal on the surface some structures now producing oil and gas.

LABETTE SHALE

The Labette shale overlies the Fort Scott formation in Wagoner County, and is exposed over a small area with an approximate thickness of 60 feet just east of Broken Arrow. The Labette formation consists of thin shales with an occasional heavy sandstone.

FORT SCOTT FORMATION

The Fort Scott formation overlies the Winslow but a very small portion of it remains. It is exposed only over a small area in the northwestern corner of the county and is made up of several limestone members, separated by shales. Its probable total thickness as exposed in Wagoner County does not exceed 60 feet.

WINSLOW FORMATION

The Winslow formation is exposed over almost the entire county. It consists of blue and black shales, clay, sandy shale, brown sandstone, occasional beds of chert and thin lenses of coal. The sandstone varies in character from hard thin-bedded to massive. The sandstone is more or less equally divided between the upper part of the formation and the lower. The upper sandstones go to make up some of the bald hills noticeable in the county.

In some restricted areas the hard, thin-bedded sandstones become interspersed with calcareous nodules, in places grading into pure limestone lenses. The clays and shales make up most of the valleys throughout the county. The thickness of the whole formation exposed is approxiately 750 feet. This formation is equivalent of the Cherokee formation to the northwest.

MORROW FORMATION

The Morrow formation, the lowest of the group, consists of limestone and shales with local beds of thin sandstone. The limestone predominates in the lower part of the formation, while the upper part consists mostly of a thin series of sandstones. This formation is exposed along the Grand River in the eastern part of the county.

SUBSURFACE GEOLOGY

The subsurface geology of Wagoner County from the standpoint of oil and gas production may be divided into two distinct divisions —those horizons containing sands occurring above the Mississippi limestone and those occurring between the Chattanooga shale and the top of the Arbuckle limestone. The first sands occurring in the upper division are those of Dutcher age which are reached at a depth of from 200 to 1,400 feet, depending upon the geographic location, and how the area being drilled is located structurally. These sands are not continuous throughout the county, or even through a township They lens in and out either being replaced by the shales, or taking the place of shale intervals.

These sands are often very hard on the axes of folds; sometimes to such an extent that a large shot is necessary to obtain production. The cement in these sands varies from a small content of iron to a high content of calcium carbonate. Initial production in these sands varies from very small wells up to wells producing as high as 1,500 barrels per day.

MISSISSIPPI LIMESTONE

The Mississippi limestone is from 200 to 450 feet thick and throughout Wagoner County contains a shale break in the center. The top part of the limestone represents the Pitkin limestone, the top of which has a very irregular surface. In the depressions of these irregularitites there sometimes occurs a sand probably the equivalent of the Burgess sand found north of Tulsa. This sand has been found to produce oil or gas in commercial quantities only in very rare instances. The shale break in the Mississippi lime occasionally carries a sand which sometimes produces small quantities of gas. The Mississippi lime is variable both in interval and texture and ranges in color from gray-white to black. It lies directly upon the Chattanooga shale where the Chattanooga is present.

CHATTANOOGA SHALE

The Chattanooga shale which directly underlies the Mississippi lime is Devonian in age and is found throughout almost the entire county with an approximate thickness of 60 feet, where drilling records are available to a sufficient depth. This shale varies from soft to very hard, and is usually a dark brown to black color.

VIOLA LIMESTONE

The Viola limestone occurs over a small area in the southern part of Wagoner County (See Fig. 2). This limestone, white to gray in color, varies from 5 to 20 feet in thickness and is hard to chalky

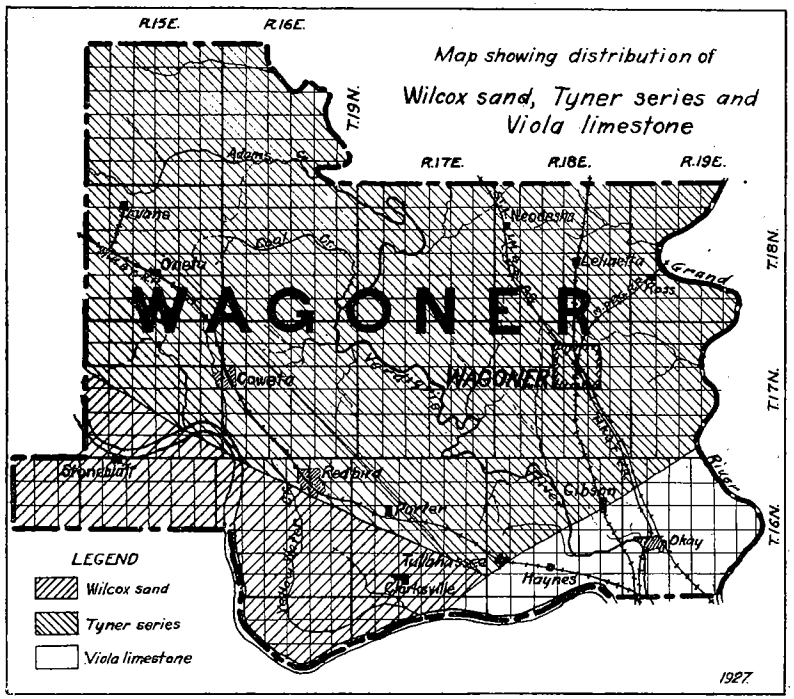

Figure 2.—Map showing distribution of Wilcox sand, Tyner series and Viola limestone.

in texture. It is often called the "white" or "buttermilk" lime by drillers. It occurs just below the Chattanooga shale and lies upon the Wilcox sand where the Wilcox is present. The shore line of deposition of the Viola is very irregular and scattered lenses of this formation occur as far north as Coweta. The main body of Viola limestone thins out with the Wilcox sand.

WILCOX SAND

The Wilcox sand is present in a very small area in Wagoner County, south of the M. K. & T. Railroad. Where present it directly underlies the Chattanooga shale and is a coarse, white to brown sandstone and is an important producing horizon. The normal dip is to the southwest at the rate of approximately 20 feet per mile. The Wilcox shore line crosses Wagoner County in an irregular direction following approximately the right of way of the M. K. & T. Railroad from Broken Arrow to Muskogee.

TYNER SERIES

The Tyner series of Ordovician age underlies the Wilcox sand when that sand is present and directly underlies the Chattanooga shale when the Wilcox sand is not present. This series is found in drilling records throughout practcially all of Wagoner County and is principally recognizable by its light green color. It has a variable interval ranging from 40 to 200 feet in thickness and varies in texture from pure clay shale to sand shale. Two distinct sand horizons occur in this formation throughout Wagoner County and the author has subdivided these formations into the upper Tyner and the lower Tyner sands. Both of these sands are commercially productive of oil and gas and are usually referred to by local operators as the "Wilcox sand." The upper Tyner sand is usually encountered directly under the Chattanooga shale. It varies from nothing to 45 feet in thickness. The lower Tyner sand is encountered at the base of the green shale series and varies in thickness from 10 to 85 feet, usually white to light green in color and very soft. Sands of the Tyner series are easily identified by their characteristic green specks of shale.

BURGEN SANDSTONE

The Burgen sandstone of Ordovician age, deposited in early Ordovician times and found over the entire county, is a clean white sandstone varying from 10 to 40 feet in thickness. It became important as a producing horizon in 1925 when R. W. Sawyer and the Newman Corporation opened a gas field in this sand in T. 17 N., R. 16 E. Structures in this sand conform to those in the Tyner series.

TURKEY MOUNTAIN SAND

At the top of the Arbuckle (siliceous) limestone occurs a sandy horizon sometimes productive of gas in Wagoner County and nearly always referred to by the local operaters as the Turkey Mountain" sand. This horizon is encountered by drilling everywhere in the county where the top of the Arbuckle limestone happens to be sandy in texture.

ARBUCKLE LIMESTONE

The Arbuckle limestone directly underlies the Burgen sandstone and is found throughout the county in drilling records of sufficient depth to encounter this horizon. The top of this limestone is usually grayish in color and is often logged in drilling records as gray sand. The Arbuckle limestone, from a standpoint of oil and gas development, is an important horizon in this county insofar as it marks the limit of depth at which known oil producing horizons may be encountered. The author does not recommend that any wells be drilled deeper than the top of this limestone.

STRUCTURE

The structure of Wagoner County, from a standpoint of oil and gas may be divided into two horizons; that of the Mississippian and Pennsylvanian in the upper division, and that of the formations

lying below the Mississippi lime in the lower division. The surface structure of Wagoner County in general is that of a westward dipping monocline, while that of the lower division is a southwestern dipping monocline. These general dips were disturbed in late Pennsylvanian and early Cretaceous times, causing minor folds and faults which are directly related to the accumulation of oil and gas in this county.

MAJOR FOLDS

The major fold or structural disturbance which at the time of the uplift, or later, directly or indirectly, caused most of the oil producing structures in Wagoner County, is the Seneca fault. This fault originated in late Pennsylvanian time, and resulted in the fracturing of all the sedimentary rocks along its axis, to the extent that a throw as much as 300 feet is developed in places. It further resulted in parallel faulting due to settling and lateral adjustment after the occurrence of the major fault. The Seneca fault crosses the county in a northeast-southwest direction along an approximate line drawn from the southwestern corner of T. 17 N., R. 16 E., to a point where Bull Creek empties into the Verdigris River. This major fault disturbed the normal dip to such an extent that some anticlines were formed which attained a maximum crest 800 feet above the synclines. Following this disturbance of the sediments, the natural process of settling and cross-folding progressed to the extent that most of the structures now producing oil and gas were formed.

PENNSYLVANIAN SURFACE TYPES

Coweta Gas Field

The Coweta gas field located in W.½ sec. 17, and E.½ sec. 18, T. 17 N., R. 16 E. is a typical gas producing structure of this county. It produces from a sand of the Dutcher series with an initial production of from one to six million cubic feet of gas per well. This small anticlinal dome has a complete closure of 40 feet and a direct east dip of at least 70 feet. It resulted from the drag of a small fault running north and south through the eastern half of sec. 17, and is one of the two typical Pennsylvanian type structures in the county.

Figure 3 represents a structural map of sec. 32, T. 18 N., R. 16 E. based on the outcropping beds of this area. The fault along the axis of this structure parallels the Seneca fault and is the top of a hogback anticline running through this section, having the same axis as the fault. The west limb of this anticline dips 750 feet in one mile to the west and 350 feet in one-fourth mile to the east. The cross-section of the producing horizon shown in the figure is drawn to scale and is based upon subsurface data obtained from wells located in the northeastern corner of this section. This cross-section shows the width of the producing area and the effect fault-

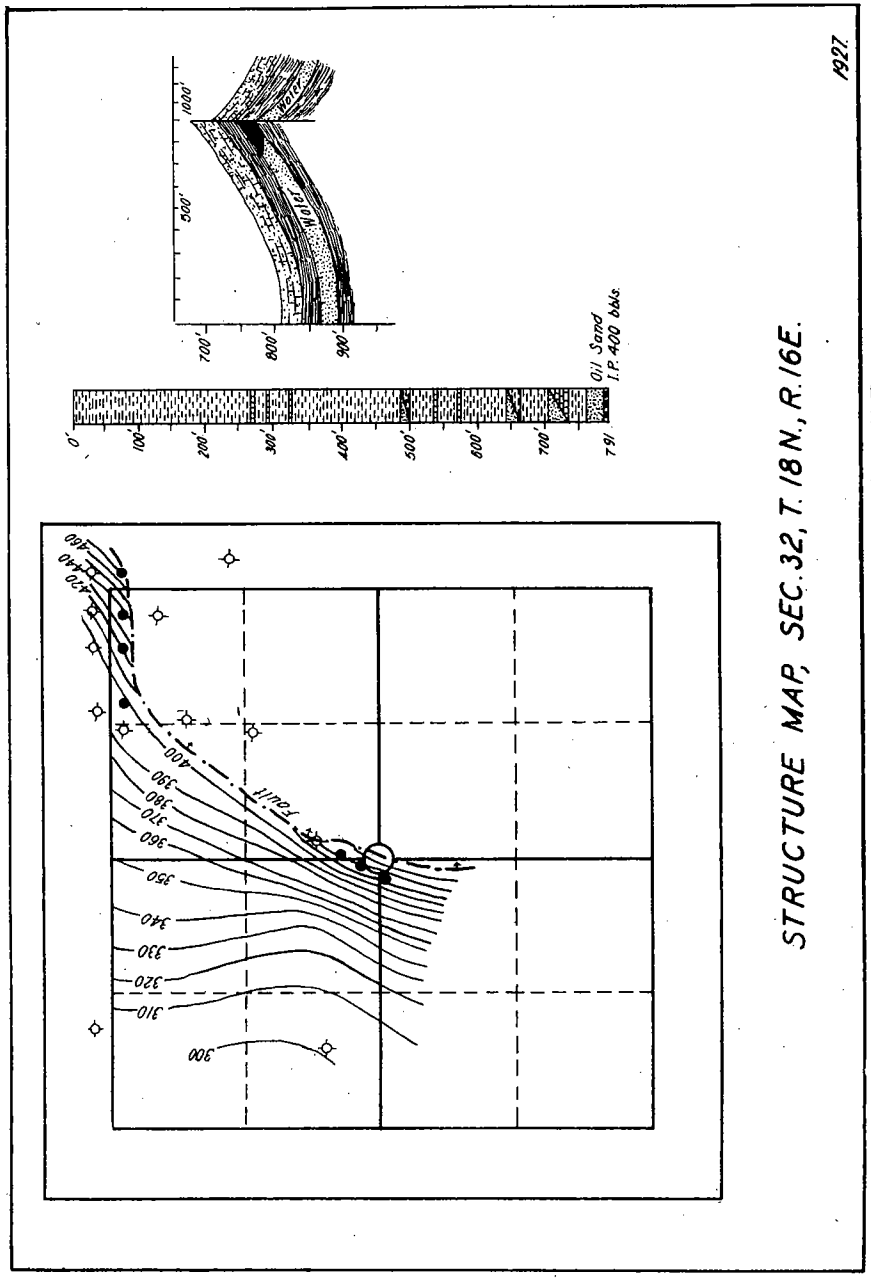

Figure 3.—Structure map, sec. 32, T. 18 N., R. 16 E.

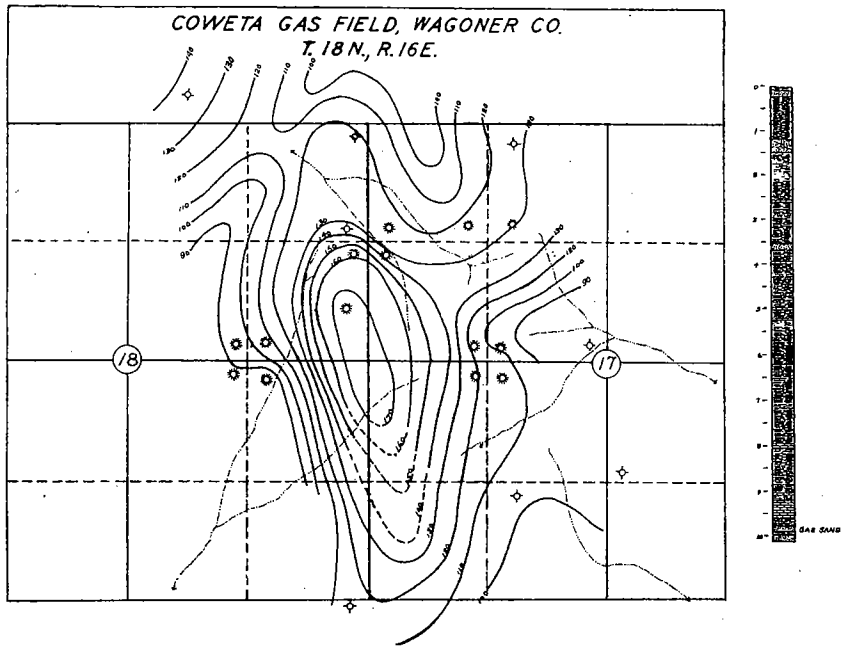

Figure 4.—Contour map of the Coweta gas field.

ing has had upon the accumulation of oil in this structure. This structure shows a characteristic condition occurring in Wagoner County where a meandering fault line is the direct and most important agency in the accumulation of oil in commercial quantities.

COWETA OIL FIELD

The Coweta oil field, located in T. 17 N., R. 16 E., is primarily due to the Seneca fault. Large wells were obtained along its axis along the upthrow side of this fault. The production in the Coweta field is obtained from the sand horizons of the Dutcher series. Production is not coming from one structure, but a series of small structures of types ranging from the meandering fault line to the small dome type.

Pennsylvanian surface structures are very often difficult for the field geologist to locate, because in the producing areas of Wagoner County, more often than not, the structures occur in the valleys and the only outcropping formations are soft clays or shales supporting neither topographic nor structural indications of pools.

PENNSYLVANIAN SUBSURFACE TYPES

The structures occurring in the subsurface of the Pennsylvanian formations are usually reflected at the surface, but due to surface conditions are not always workable by the geologist. The sharp hogback folds and faults to which all Pennsylvanian structures are closely related apparently gain in intensity with depth. In the southwest corner of the county, these sharp folds very likely cause normal domes and anticlines in the surface beds in the area of Stone Bluff due to the fact that the section increases considerably in thickness.

Subsurface geology in Wagoner County is much more dependable than surface geology. The axes of fold shift with depth and in structures where the oil accumulated near or against the footwall of the fault. The exact position of this plane is not always determinable, and sometimes shows an apparent producing area on top, so that a well located upon surface geology might miss production in the formations below. These conditions are important both in the upper and lower producing horizons.

ORDOVICIAN STRUCTURAL TYPES

The Ordovician formations directly underlying the Chattanooga shale constitute the lower division of sand horizons from which oil and gas are being produced. These formations are made up of sand, very thin limestone and light green shales. At the top of this series occurs the Wilcox sand, which is in place south of the M. K. & T. Railroad only (See Fig. 2), with the exception of some of the deep synclines and re-entrants of Ordovician time, giving the shore line of the Wilcox sand a rather meandering edge.

The upper Tyner sand occurs where the Wilcox is not present, production from which apparently has the same relationship to structure as the Wilcox sand. Occurring in the lower part of the Ordovician series is the lower Tyner sand, with the same producing relationship to structure as the upper Tyner. The large type of producing structures in the Ordovician series nearly always reflect on the surface as some type of structural high, but cannot be mapped accurately on the surface. Many of the small dome type of structures do not show at all on the surface and are very small in area.

Figure 5 shows a small producing dome in the Tyner sand. This structure does not show at all on the surface, but has a complete closure of at least 30 feet, and a direct east dip of 50 feet. The green shale seems to have been cut away on the top of this fold and replaced by a coarse sand very similar to eroded Wilcox. As no samples are obtainable, this re-deposited sand may be either Wilcox or Tyner. The entire area of this pool does not cover over 30 acres. There are numerous small pools of this type producing in the county, and as one location in the wrong direction means a dry hole, this type of folding has influenced the operator to believe

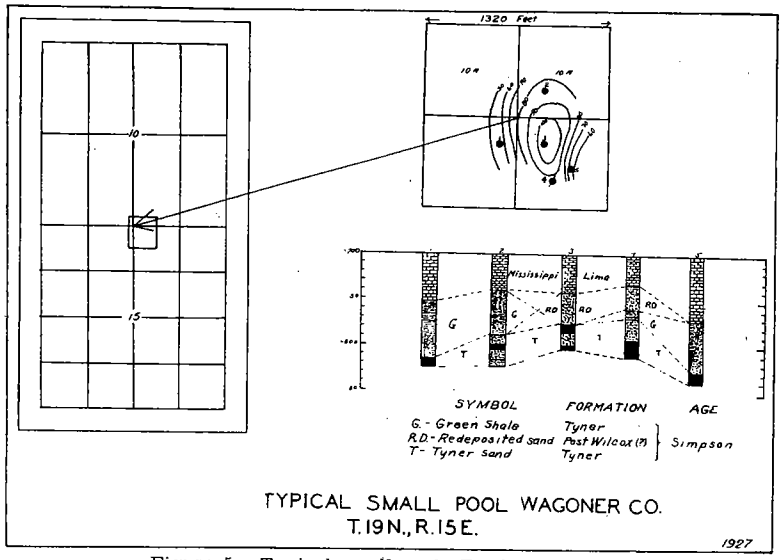

Figure 5.—Typical small pool (T. 19 N., R. 15 E.).

that a spotted lenticular condition governs the accumulation of oil more than a structural condition. However, this idea is erroneous and these small producing areas are due to small-scale domes.

The large faults, some of which show on the surface, and some of which occur only in the Ordovician beds form the closure on the east side of the structure and are consequently the direct agency in the accumulation of oil.

Figure 6 is a subsurface map based on a producing horizon of the lower Tyner sand. This structure shows on the surface, but the surface reflects very poorly the conditions below the Mississippi lime. The cross-section A-A shows the lower section of the logs of wells drawn to scale. The fault which causes the trap for the accumulation of oil in this structure does not show in the Mississippi lime and is a characteristic condition on structures now producing from the Ordovician series. Near this area is a new gas field producing from the Burgen sandstone which occurs under the first lime below the Tyner series. The Burgen is a white, clean sand, very porous in character, and produces from structural types analagous to those in the Tyner series. This sandstone is found nearly everywhere in Wagoner County and is often referred to by the local operator as the "Turkey Mountain" or Wilcox sand.

FUTURE OIL AND GAS DEVELOPMENT

New small pools of oil and gas will be discovered for years to come in Wagoner County. Throughout the county, especially west of the Verdigris River, occur many small structures of both Pennsylvanian and Ordovician types, which as yet, have never been tested.

The future production of oil and gas will depend largely upon the exploration of sands in the Tyner series and the Burgen sandstone. A test well drilled in this county for either oil or gas is not complete until it has reached the top of the Arbuckle limestone.

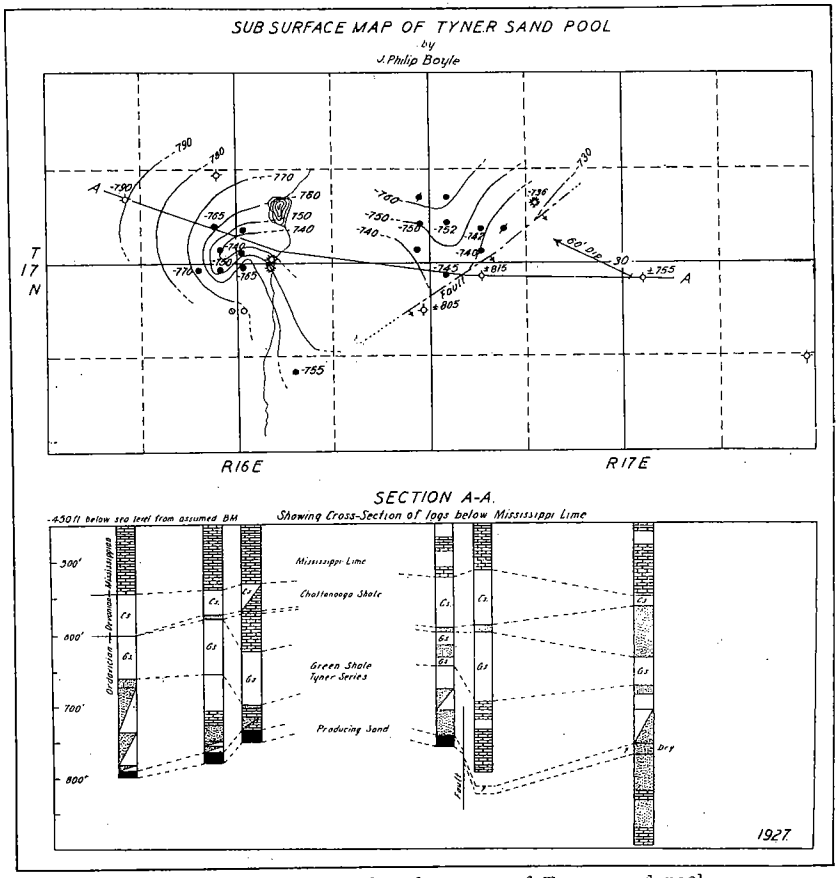

Figure 6.—Subsurface map of Tyner sand pool.

The author does not believe that any large pools will be discovered in the future, due to the small structural types characteristic of this area.

CONCLUSIONS

All of Wagoner County may be considered very probable oil and gas territory west of a line drawn north and south through the town of Wagoner. The author considers geological data very valuable to the operator and with the exception of the silted areas along the river bottoms, practically all of Wagoner County can be either mapped on the surface or subsurface, and by these methods the larger types of structures discovered.