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**COWLEY COUNTY OIL AND GAS RESOURCES**

by

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COWLEY COUNTY OIL AND GAS RESOURCES  
By Raymond C. Moore, State Geologist.

INTRODUCTION

For very many years Cowley County has been viewed by oil operators and by geologists as important prospective oil and gas territory. Much time and a very large amount of capital have been expended in testing various parts of the county, but except for a little gas and some relatively unimportant findings of oil, the results until recently have been decidedly disappointing. At the present time, the county seems prepared to take its proper place among the important producers in the Mid-Continent field.

The following general account of some of the geologic features which are involved in the exploration and in the future development of Cowley County oil and gas has been prepared at the request of Mr. Alfred Hill. Since the writer was for a number of years a resident of Arkansas City, he is somewhat familiar with the surrounding territory and has, therefore, had in a measure a special interest in the geological problems and in the vicissitudes of oil and gas development of the region. Because of the special importance of Cowley County and adjoining territory in Kansas as prospective oil producing land, the State Geological Survey has looked forward to the opportunity of undertaking field examination of this region and the preparation of a detailed geological bulletin, to appear among the series of scientific publications issued by the Survey. It is regrettable that on account of an apathetic attitude on the part of the Kansas Legislature toward such scientific investigations of our state natural resources, the necessary funds for this and similar work in other parts of the state have not, even though they are small,

been made available. This account, therefore, is based on such general information which is at the writer's disposal, supplemented in particular by data on the Rainbow bend oil field, prepared by Mr. D. R. Snow and Mr. D. P. Dean, of the Waite-Phillips Company. To these gentlemen, to Mr. M. W. Baden and to other geologists who have assisted in supplying information concerning parts of Cowley County, the writer is indebted.

#### SURFACE FEATURES OF COWLEY COUNTY.

Like adjoining parts of Kansas and Oklahoma, the surface of Cowley County is <sup>^</sup>rather gently rolling plain. In places, however, especially in the eastern part of the county and along parts of the valleys of the Walnut and the Arkansas, there are steep, abrupt slopes. To the geologist it is evident that the surface topography is very intimately related to the geology of the region; that is, each hard rock formation produces a distinct bench or platform which is terminated at the outcrop of the rocks by a more or less steep escarpment. The soft rocks produce gently rolling country or form slopes beneath the hard rocks. This feature, which is illustrated in figure 1, is of obvious importance to the geologist who is studying the position and structure of the rocks with reference to possible deposits of oil beneath the surface.

The valleys of Arkansas River, of the Walnut and of a number of smaller streams are floored by accumulations of river sand, gravel and alluvium so that a flat plain of variable width, lacking hard rock exposures, occurs along each of these streams.

#### GEOLOGY OF COWLEY COUNTY.

The rock formations which are exposed at the surface in Cowley County consist of light colored, fine grained, hard limestones some of them containing much hard, flinty chert, and of more or less sandy

variously colored shale. These rock formations appear to be essentially horizontal, but measurement shows that they are actually inclined at a very slight angle westward so that the lowermost, oldest rocks appear at the surface near the east border of the county and the highest, youngest beds along the west margin. This gentle westward dip is present throughout eastern and central Kansas and Oklahoma, and, as shown clearly in figure 4, is responsible for the occurrence at increasingly greater depths westward of the oil and gas formations which occur relatively near the surface in the southeastern shallow oil fields of Kansas.

All of the surface rocks in Cowley County, west of the prominent line of hills which extend southward through Grand Summit and Hoosier in the eastern part of the county, belong to the so-called Permian division of geologic history and they were formed at the bottom of a shallow sea which extended over this country some seventy or seventy-five million years ago. Many of the formations contain abundant fossil marine shells. In the easternmost part of the county are several square miles in which the uppermost rocks of Pennsylvanian age occur. The great coal measures division which also contains most of the oil and gas in the Mid-Continent field. The distribution of the main rock divisions in Cowley County is shown in the geologic map, figure 2.

In the course of prospecting with the drill, a well in the southeast part of the county may start in the upper part of the Pennsylvanian. or if farther west, a gradually increasing thickness of the Permian rocks must be penetrated before the Pennsylvanian beds are reached. The total thickness of the Pennsylvanian ranges from about 2500 to 2900 feet, and like the Permian consists of alternating limestones,

shale and sand. From the last, has been obtained in various places the gas which has been produced near Arkansas City, Winfield and in some other parts of the county. The oil at Rainbow Bend is derived from a sand apparently equivalent to the well known Burbank sand of Osage County, Oklahoma which lies at the very base of the Pennsylvanian series. Beneath the Pennsylvanian is a very massive, thick, rather hard limestone with a thickness of about 300 to 350 feet. This so-called Mississippi lime belongs to the Mississippian geological division and is commonly readily recognized in drilling. Beneath it, there is in many places a bed of bituminous black shale with which are local deposits of porous quartz sandstone which may contain commercial accumulations of oil. The rocks below the Mississippi lime and the black shale where that is present belong to the Ordovician period. At its top, there is in some places a formation consisting of greenish shale and sand which may be productive of oil. This horizon is commonly designated the Wilcox sand by the operators. Beneath this sand, or in places directly below the Mississippi lime, is a very thick formation of limestone and dolomite containing more or less flint and quartz which is commonly designated the Ordovician siliceous lime. The upper part of this formation contains oil in a number of places. The production at Graham is reported to come from this horizon.

The ~~rough~~<sup>like</sup> layers which compose the plains of Kansas and Oklahoma may not inaptly be compared to the pages of a book or a magazine which has been gently bent so that the pages are not absolutely horizontal.

In drilling through these layers, starting at any given one of them, the thickness of the underlying beds down to the bottom-most layer should be readily computed. In the eastern part of Kansas and Oklahoma the older rocks regularly and usually underlie the upper series, but across central Kansas, from north to south, drilling has discovered a strongly elevated part of the igneous rock floor on which the sedimentary layers rest. The

*so-called granite ridge* *the*  
Along the flanks of this buried ridge of granite, various older rocks, including the Mississippi lime and the underlying formations, are more or less elevated and parts of them were evidently weathered and removed by erosion before the deposition of the now overlying Pennsylvanian and Permian rocks. This is evidenced by the manner in which the drill passes from the lowermost Pennsylvanian rocks into Mississippian or directly into various formations of the Ordovician *in places*. Farther north in Kansas, one may drill from the Pennsylvanian directly into the granite, neither Mississippi lime or Ordovician rocks being present. This granite ridge is responsible also for a *belt* of rather pronounced anticlinal folding which extends most of the distance across the state. The rocks layers above the granite are gently arched over it, *and* this structure is responsible for the large accumulations of oil which have been developed in recent years in Butler County, in the Eldorado, Augusta and Douglas pools. Southward from Butler County, the crest of this buried range of granite hills appears to become lower and lower so that the thickness of the overlying sedimentary rocks is greater and the probability of encountering the granite in deep wells is less. Only one well in this south central portion of the state has encountered the granite, the so-called Oxford well in Sumner County, just west of the Cowley County line, the granite here being encountered at 2230 feet below sea level. ~~The~~ The oil and gas of Cowley County, as in other parts of the Mid-Continent field, are obtained from the more porous rock formations in which minute spaces between the grains or small cavities in the rocks permit reservoir storage for these fluids. Most common of these oil containing rocks are sandstones, but in some places, weathered parts of limestones also yield commercial amounts of oil. In Cowley County while some gas and a very little oil has been obtained from sands in the middle and upper part of the Pennsylvanian, the chief oil producing horizons are

in the basal part of this rock series. The sand which yields the oil at Rainbow Bend occurs at the very bottom of the Pennsylvanian and the sand appears to rest directly on the underlying Mississippi limestone. The sands at this horizon appear to be rather notably lenticular and their distribution appears to be controlled to a very considerable extent by irregularities in the surface of the Mississippi lime. This irregular distribution is chiefly responsible for the great difficulty which has been experienced in locating productive fields in the county; much deep drilling having been done before the prolific producing lenses were discovered. Because of the very irregular character of these sands also it is very probable that there are very valuable undiscovered pools within the county. As has been found in some of the counties farther east, such good paying sands may be found in places where dry holes have been drilled on every side.

In addition to the sand at the base of the Pennsylvanian, the weathered portion of the underlying Mississippi lime is in places an important possible container of oil. This is especially true in some of the districts east of Cowley County but it also may be found here.

So-called second break pay occurs from 300 to 350 feet below the top of the massive Mississippi limestone and is an important producing horizon in various Oklahoma fields and in parts of Kansas. Geologically, this zone of deeper production will occur at two or three porous formations as indicated above, the sand at the base of the Chatanooga black shale, the sandy zones in the Ordovician Tyner formation, (the so-called Wilcox pay) or in the porous weathered upper part of the Ordovician siliceous lime. These rocks have been identified in the well logs and in study of the cuttings from various wells in western Cowley County and eastern Sumner County, but in some places the rocks between the Mississippi lime and the Ordovician siliceous lime are missing and the drill passes directly from the one limestone into the

other. Deep production in the Graham pool northeast of Rainbow Bend appears to come from the upper part of the Ordovician siliceous lime.

#### Structure.

As has been indicated, the general slope of the rock formations in Kansas and northern Oklahoma is gently westward, the inclination of the rock layers amounting to a very few feet per mile. In places there are interruptions of this regional slope of the rocks in the form of anticlinal arches or domes or in minor and rather local deviations in <sup>dip</sup> depth which produce terraces or noses. <sup>" " by the last)</sup> The structure contour lines representing equal elevations on a selected rock formation are deflected in a more or less pronounced degree from a general north-south trend. In the eastern part of Cowley County, there is a rather pronounced anticline with axis trending northeast southwest, in the vicinity of the town of Dexter. This fold extends many miles northeastward and is one of the most pronounced structural features in this part of the state. <sup>At</sup> Rainbow Bend, a thin surface limestone shows a not very prominent anticlinal structure in which there appears to be a southeast dip of about 20 feet in approximately 3/4 of a mile. Drilling which has been done in this region indicates a much more prominent anticlinal fold in the rocks which are deeply buried but it is noteworthy that all of the production appears to lie on the southeast flank of the anti<sup>ti</sup>line and that a dry hole has been drilled near the crest of the fold. The controlling factor in the distribution of the production here is the extent of the sand body which rests apparely <sup>nt</sup> on this flank of the fold. In the central and eastern parts of Cowley County, the limestone beds at the surface permit fairly detailed mapping of the rock structure, but in the western part of the county and in Sumner County, the lack of hard limestones or other rocks which can be followed readily at the surface makes exploration very difficult. Shallow test drilling to some determinable hard rock formation has been resorted to in order to secure necessary information concerning

the position and character of these folds in the rocks.

*Oil & Gas Production.*  
A map showing the distribution of the main Cowley County oil and gas production with relation to the fields north in Butler County and south in Kay County, Oklahoma is shown in Fig. 5. This map, prepared by Messrs D. R. Snow and D. P. Dean, geologists of the Waite-Phillips Co., and by them kindly made available to the writer, shows also the general structure of the top of the Mississippi lime in central western Cowley County and the east border of Sumner County. This map shows an interesting alignment of the new fields in western Cowley County and the well known Blackwell field of Oklahoma. The general direction of the axis of the folding and of the field paralleling the discovered trend in the main granite ridge which appears to lie a short distance farther west.

The Rainbow Bend field, a structure and production map for which prepared by Messrs Snow and Dean is shown in Fig. 6, is the most important commercial field which has so far been discovered in Cowley County. Discovered in December 1923, it has already produced more than 2,000,000 barrels of high grade 41 gravity oil. Thirty one wells have been completed with an average daily <sup>initial</sup> production of over 1,000 barrels per well without shooting and the field is now making around 12,500,000 barrels of oil daily. Some 28 wells are now drilling. Because the entire area of production is controlled by a single organization, there has been an absence of competitive drilling and it is probable that the oil which is beneath the ground will be produced much more economically than in cases where a mad rush to secure the oil results in over drilling; except for this condition in the Rainbow Bend field, a very much higher daily production would doubtless have been obtained and would now be obtainable. The sand from which the oil comes occurs about 3200 feet below the surface. # As has been noted previously, there is not very much surface evidence of the folding which is present in the Rainbow Bend area. Credit for the first observation of the structure

appears to be due Mr. Martin W. Baden of Winfield who mapped the area and secured leases. A test was arranged which eventually found the pay sand and was completed as a 350 barrel flowing well. As shown by the subsurface map on the top of the Mississippi lime, Fig. 6, there appears to be a rather pronounced dome in the deep rocks, the sand from which the oil is obtained lying chiefly on the southeast flanks of this limestone arch. A dry hole on the Patterson farm in the NE $\frac{1}{4}$  of Sec. 1, T. 33 S., R. 3 E. showed that the sand was absent in this part of the field. The Mississippi limestone is notably thinner near the crest of the fold than on the flanks, indicating that there was more or less erosion of this formation before the accumulation of the sand in which the oil occurs and of younger rocks which overlie it. It may be noted here that in addition to the main producing sand at Rainbow Bend a higher sandy formation is a spotted producer in this field. This upper sand is apparently the main producer in the Slick pool, six miles farther north. It is a part of the Kansas City formation and appears to be equivalent to the <sup>Layton</sup> Laton sand of Oklahoma and the Stokes sand of Eldorado. The main producing sand at Rainbow Bend occupies a position which is practically identical with that of the Burbank sand in the productive Osage County, Oklahoma producing area. However, because it is by no means certain that this sand is continuous with the Burbank sand, it has seemed best to term the producing sand in Cowley County the Rainbow Bend sand. Up to the present time, approximately 640 acres has been proved in the Rainbow Bend area as productive of oil. The per acre yield will probably be about 12,000 barrels, <sup>which is</sup> This considerably larger than the average yield per acre in the Burbank field. As proven area increases, the estimate per acre will probably be reduced on account of poorer production at the edges of the field and the relief of gas pressure through present producing wells.

A casing head gasoline plant recently completed is producing approximately 15,000 gallons per day. There is approximately 25,000,000 cu. ft. of casing head gas available from the Rainbow Bend sand at present. The average yield per thousand cubic feet of gas is about 2 gallons of grade double A gasoline,

and it is estimated that the plant can be operated at a capacity of 30,000 gallons per day for two and half years from the gas of the present proven area before production is decreased from diminished gas. The value of the casing head gasoline production is estimated at approximately 25% of the oil production.

In the Graham district a short distance northeast of the Rainbow Bend field, there appears to be another small high point in the Mississippi lime, as shown by the map, Fig. 6. In this field, the main producing zone is in the top of the Ordovician siliceous lime beneath the Mississippian limestone. The higher sands are not important here for the higher sands are not developed. The wells which so far have been drilled are less productive than those at Rainbow Bend and the future limits of the field and importance of the production have not been determined.

One of the important recent developments is the discovery of oil in the Slick pool, west of Winfield. The oil here comes from <sup>a</sup>the sand considerably above the base of the Pennsylvanian at a depth of about <sup>2550</sup>25 to 50 feet from the surface.