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SUBSURFACE GEOLOGY AND OIL AND GAS RESOURCES OF OSAGE COUNTY, OKLAHOMA

PART 8. Parts of Township 20 North, Ranges 9 and 10 East, and Township 21 North, Ranges 8 and 9 East, and all of Township 21 North, Range 10 East

BY

C. T. KIRK, W. R. DILLARD, OTTO LEATHEROCK AND H. D. JENKINS

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FOREWORD

This report on the subsurface geology of Osage County, Okla., describes the structural features, the character of the oil- and gas-producing beds, and the localities where additional oil and gas may be found. It embodies a part of the results of a subsurface geologic investigation of the Osage Indian Reservation, which coincides in area with Osage County. The investigation was conducted by a field party of the Geological Survey of the United States Department of the Interior in 1934 to 1937 and involved the study of the records of about 17,000 wells that have been drilled in Osage County. Funds for the investigation were allotted to the Geological Survey by the Public Works Administration. The primary purpose of the examination was to obtain geologic data for use in the administration of the Indian lands. The results of the inquiry have shown that many localities in Osage County outside the present producing oil fields are worthy of prospecting for oil and gas and that additional oil and gas can be found also by exploring deeply buried beds in old producing fields.

All townships in Osage County that contain many wells are described; the information furnished by such townships is ample for drawing detailed subsurface structure-contour maps. The descriptions of several contiguous townships are combined in separate reports, which are issued as parts of a single bulletin. No edition of the consolidated volume will be published, but the several parts can be bound together if desired.

The subsurface investigation of Osage County was carried on mainly by L. E. Kennedy, W. R. Dillard, H. B. Goodrich, Charles T. Kirk, J. D. McClure, Otto Leatherock, Constance Leatherock, W. E. Shamblin, J. N. Conley, H. D. Jenkins, J. H. Hengst, G. D. Gibson, and N. W. Bass, geologists. The work of each geologist contributed more or less to the results of the investigation in each township. However, the investigations of the individual townships in Osage County were made mainly by various individuals of the group, and their names appear in the township descriptions. In addition to those whose names appear above, valuable assistance in the compilation of information was given by Lucile Linton, S. B. Thomas, R. C. Beckstrom, B. A. Lilienborg, J. G. Dwen, K. H. Johnson, J. G. Beaulieu, C. R. Viers, E. L. Hitt, Grace Clark, R. A. Payne, and J. C. Rollins.

Oil companies and individuals who contributed information are too numerous to acknowledge all by name. Special mention is made, however, of Laughlin-Simmons & Co. and the Indian Territory Illuminating Oil Co. for supplying most of the well elevations used in Osage County; of the Continental Oil Co., Tidal Oil Co., Sinclair Prairie Oil Co., Indian Territory Illuminating Oil Co., Phillips Petroleum Co., W. C. McBride, Inc., The Carter Oil Co., and others for supplying well logs, maps, cuttings, and cores of the producing sands in Osage County.

H. D. Miser, geologist in charge of the section of geology of fuels, supervised the work upon which this report is based. Appreciative acknowledgment is here made of many suggestions made by him during the progress of the investigation and during the preparation of the manuscript. Grateful acknowledgment is due the officers of the Osage Indian Agency at Pawhuska and the late John M. Alden and others in the Tulsa office of the Geological Survey for cooperation and assistance; also Hale B. Soyster and H. I. Smith, of the Geological Survey, for sponsorship and interest in the investigation.

N. W. BASS.

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PLATE 8. Map of parts of T. 20 N., Rs. 9 and 10 E., and T. 21 N., Rs. 8 and 9 E., and all of T. 21 N., R. 10 E., Osage County ---- In pocket

SUBSURFACE GEOLOGY AND OIL AND GAS RESOURCES OF OSAGE COUNTY, OKLAHOMA

Part 8. Parts of Township 20 North, Ranges 9 and 10 East, and Township 21 North, Ranges 8 and 9 East, and all of Township 21 North, Range 10 East

By C. T. KIRK, W. R. DILLARD, OTTO LEATHEROCK, and H. D. JENKINS

ABSTRACT

The area whose subsurface geology and oil and gas resources are described in this report lies along the southern border of Osage County, Okla., and includes parts of T. 20 N., Rs. 9 and 10 E., and of T. 21 N., Rs. 8 and 9 E., and all of T. 21 N., R. 10 E. The towns of Osage and Prue are within the area; Cleveland, which is a mile south of the Arkansas River, is not far beyond its southwestern limit; and Tulsa is 10 miles east of its southeast corner. The production of oil and gas from the many fields in the five townships began as early as 1905, and drilling has continued up to the present. Oil or gas is produced from 13 zones at depths ranging from 250 to 2,600 feet. Of these zones, one is in the Ordovician system, one is at the contact of the Mississippian and the Pennsylvanian series, and all others are in the Pennsylvanian series. The five townships lie within a region that contains many oil and gas fields in the Bartlesville sand; the Red Fork sand is oil-bearing in a narrow belt in T. 21 N., R. 8 E.; and oil and gas are produced in small areas from the Taneha, Skinner, Squirrel, Cleveland, Jones, and Layton sands, the Mussellem and Peoples sand zone, the Okesa, Torpedo, and Clem Creek sand zone, and the Big lime and Peru sand zone.

The rocks dip westward across the five townships at an average rate of about 38 feet to the mile as measured on the top of the Oswego lime. This regional dip is interrupted, however, by many anticlines, domes, synclines, and structural basins. The subsurface crests of most of the domes and anticlines are not directly under the crests as determined on the exposed rocks, and the dips of the deeper rocks are steeper and the structural closures greater in the buried rocks than in the exposed rocks. The exposed rocks are cut by several faults that trend northwest, but the data are insufficient to determine whether the deeply buried rocks, also, are displaced along the faults.

This investigation has shown that there are a few localities not yet completely tested in this part of Osage County that may produce oil and gas and that a few producing oil fields have areas within or adjacent to them that have not been thoroughly prospected. It is pointed out that yields of oil and gas from limy reservoir rocks may be increased by acid treatment and that additional oil may be produced from some of the reservoir sands by repressuring them with gas or flooding them with water.

INTRODUCTION

The subsurface geologic features, the oil- and gas-producing beds, and the areas that are favorable for the discovery of additional oil and gas in parts of T. 20 N., Rs. 9 and 10 E., and T. 21 N., Rs. 8 and 9 E., and all of T. 21 N., R. 10 E., Osage County, Okla., are described in this report, which is the eighth of a series of reports on parts of Osage County. The structure of the buried rocks, the location of producing or abandoned oil and gas wells and dry holes, and the ownership of leases are shown on the accompanying map (pl. 8). The oil- or gas-bearing beds in producing wells and abandoned producers and the deepest beds penetrated in dry holes are shown on the map by colors on the black well symbols. Wells that produced oil or gas from shallow depths and were drilled deeper to test older beds are indicated by special symbols.

All oil- or gas-producing beds in the five townships are described briefly; these beds and all other rocks that have been penetrated by the drill are shown graphically on a generalized columnar section on plate 8. The beds that produce oil or gas are indicated on the columnar section by colors that correspond to the colors on the well symbols on the structure contour map. The thickness of the rock units in southern Osage County varies so greatly that the thickness shown on the columnar section may differ from the true thickness by as much as 50 feet in many localities. The sequence of rocks shown in the columnar section, however, will suffice to identify the rock units in carefully recorded logs of wells drilled in any part of the area. The oil- and gas-producing beds in different parts of the area are listed also in the following table.

Oil- or gas-producing beds in parts of T. 21 N., Rs. 8 and 9 E., part of T. 20 N., R. 10 E., and all of T. 21 N., R. 10 E., Osage County, Okla.

Parts of T. 21 N., R. 8 E.	Part of T. 21 N., R. 9 E.	Part of T. 20 N., R. 10 E.	T. 21 N., R. 10 E.
Okesa, Torpedo, and Clem Creek sand zone.	Okesa, Torpedo, and Clem Creek sand zone.		
Mussellem and Peoples sand zone.	Mussellem and Peoples sand zone.	Mussellem and Peoples sand zone.	Mussellem and Peoples sand zone.
Layton sand.	Layton sand.		
Jones sand.			Jones sand.
	Cleveland sand.		Cleveland sand.
			Big lime and Peru sand zone.
			Squirrel (Prue) sand.
			Skinner sand.
Red Fork (Burbank) sand.	Red Fork (Burbank) sand.		
Bartlesville sand.	Bartlesville sand.	Bartlesville sand.	Bartlesville sand.
		Taneha sand.	
Burgess sand-Mississippi lime zone.	Burgess sand-Mississippi lime zone.	Burgess sand-Mississippi lime zone.	Burgess sand-Mississippi lime zone.
Simpson formation or Siliceous lime.	Simpson formation or Siliceous lime.	Simpson formation or Siliceous lime.	Simpson formation or Siliceous lime.

The exposed rocks in this area, beginning with the oldest, are the uppermost of the Nellie Bly formation, the Dewey limestone, the Ochelata formation, with its Avant limestone member, the Nelagoney formation, and the Elgin sandstone. Their geographic distribution is shown on the State geologic map of Oklahoma by Miser.[1] The attitude of these rocks in T. 21 N., Rs. 8, 9, and 10 E., is shown on an unpublished map prepared by Wood [2] between 1912 and 1917, and their attitude in part of T. 20 N., R. 10 E., is shown on a map prepared by Goldman.[3] In areas for which well logs have furnished little or no information on the attitude of the buried rocks, the structure-contour maps of the exposed rocks prepared by Wood and Goldman were used extensively in drawing the subsurface structure contours on plate 8. Few data on the atttitude of the exposed rocks are available, however, in areas bordering the Arkansas River, where the Pennsylvanian rocks are concealed by Recent deposits of alluvium.

OIL- AND GAS-PRODUCING BEDS

Oil and gas have been produced in parts of T. 20 N., R. 10 E., and T. 21 N., Rs. 8, 9, and 10 E., from 13 zones, ranging from the uppermost part of the Siliceous lime, of Ordovician age, upward to the Okesa, Torpedo, and Clem Creek sand zone, which lies in the upper half of the Ochelata formation of the Pennsylvanian series. The producing zones lie at depths ranging from 250 to about 2,650 feet. The largest initial daily production came from the Siliceous lime and possibly the sand just above it, in the Simpson formation, but the Bartlesville sand is the most persistent oil producer in the area. The Red Fork (Burbank), Cleveland, Jones, Layton, and Squirrel sands and the Burgess sand-Mississippi lime zone and other less productive sands yield oil and gas at some places. The oil- and gas-producing rocks in this area, from the oldest to the youngest, are described briefly on the following pages.

SILICEOUS LIME AND SIMPSON FORMATION

The logs of many of the wells drilled in this region do not show whether the oil or gas reported in the Ordovician beds comes from the Siliceous lime or from the overlying Simpson formation; these beds, therefore, are here grouped as a unit, designated as Simpson formation or Siliceous lime. The Siliceous lime, as shown by deep wells in Osage County, is in places 1,000 feet or more thick, but it is very thin or absent over the crests of some of the sharply folded domes.

[1] Miser, H. D., Geologic map of Oklahoma, U. S. Geol. Survey, 1926.

[2] Wood, R. H., Unpublished map of parts of Hominy quadrangle in Geological Survey files.

[3] Goldman, M. I., in White, David, and others, Structure and oil and gas resources of the Osage Reservation, Okla.: U. S. Geol. Survey Bull. 686, pp. 353–358, pl. 50, 1922.

Abundant evidence in this county and elsewhere in Oklahoma indicates that peaks of pre-Cambrian crystalline rocks underlie many of the steeply folded domes and anticlines at relatively shallow depths, and that Mississippian, Ordovician, and Cambrian beds that are thin or absent on the crests thicken rapidly on the flanks of the domes and anticlines. The Ordovician rocks have a wide range in total thickness in these five townships. For example, granite was found about 40 feet below the base of the Mississippi lime in a well near the crest of the dome in the SW¼ sec. 9, T. 21 N., R. 9 E., whereas in well 34 in the center of the south line of SW¼SE¼ sec. 19, T. 21 N., R. 9 E., low on the north flank of a sharply folded dome, Ordovician beds were penetrated to a depth of more than 400 feet without encountering pre-Cambrian rocks, and on a low dome in the NW¼ sec. 26, T. 21 N., R. 9 E., they were penetrated to a depth of more than 740 feet without encountering pre-Cambrian rocks.

The well logs indicate that the Siliceous lime consists mainly of limestone, with sandstone in a lesser amount. Microscopic examination of well cuttings shows that the upper part of this lime is a finely crystalline brown to white dolomite that commonly contains chert. The lower part of the lime is probably of Cambrian age and the upper part of Ordovician age. Oil and gas have been found in the Siliceous lime in only a few small areas in these five townships, and in all these areas, the oil and gas occur in the uppermost 100 feet of the lime—in most places in the uppermost 5 feet. In some places the oil-bearing zone apparently extends upward into the Simpson formation, which unconformably overlies the Siliceous lime.

The Simpson formation as defined by Luther White,[4] consists of a lower unit of medium to coarse, rounded to angular quartz sand that represents the Burgen sand and is called locally the Hominy sand, a middle unit of interbedded green shale and sand that constitutes the Tyner formation, and an upper unit of sand that represents the Wilcox sand. The Simpson formation is about 100 feet thick but thins northward; it pinches out 20 to 25 miles northeast of these five townships. A northeastward-tapering wedge of the Wilcox sand is present in the southwestern part of these townships but pinches out northeastward along an irregular line that trends north of west from near the middle of the east line of T. 20 N., R. 10 E., to about the northwest corner of T. 21 N., R. 8 E. The Wilcox sand continues to thicken southwestward beyond Osage County, and is about 100 feet thick 20 miles to the southwest. Thus, except in a few localities of small extent, the Tyner formation and the Burgen sand make up the Simpson formation in these five townships.

[4] White, L. H., Subsurface distribution and correlation of the pre-Chattanooga ("Wilcox" sand) series of northeastern Oklahoma: Oklahoma Geol. Survey Bull. 40, vol. 1, pl. 2, pp. 21–40, 1928.

BURGESS SAND-MISSISSIPPI LIME ZONE

Oil is found in many localities in Osage County in the rocks that lie at or near the contact of the Mississippi lime and the overlying Cherokee shale. Sand that is composed of fine to coarse, angular to rounded quartz forms the basal bed of the Cherokee shale in many localities in the southeastern part of the county and lies on chert beds of the uppermost part of the Mississippi lime or is separated from them by a thin bed of shale. This sand is called the Burgess sand, but in many wells beds that are recorded as Burgess sand are actually chert of the underlying Mississippi lime, which in drilling has been crushed into fine angular particles resembling sand grains. Therefore the rocks that are adjacent or nearly adjacent to the contact of the Cherokee shale and the Mississippi lime are referred to herein as the Burgess sand-Mississippi lime zone, because it is impossible to differentiate these two beds in the drillers' logs. However, it has been determined from microscopic examination of drill samples that in many fields in southern Osage County the oil-bearing rocks assigned to this zone occur in the Mississippi lime and are composed of chert and, locally, of chert and limestone. Much of the chert is weathered to a porous white rock, but part of it, light gray in color, appears to be unweathered.

Oil or gas is produced from the Burgess sand-Mississippi lime zone in about 10 wells in these five townships. Five of these wells are in T. 21 N., R. 10 E., two are in T. 21 N., R. 8 E., two are in T. 21 N., R. 9 E., and one is in T. 20 N., R. 10 E. The depth to this zone varies considerably, but in much of the area it is about 2,100 to 2,500 feet.

TANEHA SAND

A local lenticular sand that occurs between the Burgess sand-Mississippi lime zone and the Bartlesville sand is known as the Taneha sand. It appears to be equivalent to the Tucker sand of the oil and gas fields of counties adjacent to Osage County on the south. In T. 20 N., R. 10 E., this sand, where present, ranges in thickness from about 10 to 30 feet and in depth from about 2,000 to 2,400 feet. It is shown in the logs of most of the wells in this township that have been drilled deep enough to penetrate rocks at its horizon, and it yielded oil in six wells in three localities and gas in two wells. The initial daily yield of oil from the Taneha sand ranged from 35 to 100 barrels to the well, and the initial daily yield of gas ranged from 750,000 to 5,000,000 cubic feet to the well.

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BARTLESVILLE SAND

The parts of T. 20 N., Rs. 9 and 10 E., and T. 21 N., Rs. 8 and 9 E., that lie in Osage County and all of T. 21 N. R. 10 E. are wholly within a region in northeastern Oklahoma in which the Bartlesville sand is the main oil- and gas-producing zone in many fields. In these five townships the most productive areas whose oil is derived from the Bartlesville sand are, from east to west, the Madalene anticline and the southern part of the Wildhorse field, in T. 21 N., R. 10 E.; the field in secs. 3, 10, and 11, T. 21 N., R. 9 E; the field in secs. 19, 20, 29, and 30, T. 21 N., R. 9 E., and secs. 12, 13, 24, and 25, T. 21 N., R. 8 E.; and the Boston field, in the northwest corner of T. 21 N., R. 8 E.

In many localities gas occurs in the upper part of the Bartlesville sand, and oil occurs at various depths below the top. Salt water occurs below the oil in many fields; in others the sand is practically free from water. The Bartlesville sand characteristically gives up its oil at a slow rate but yields throughout a long period. Many wells producing oil from the Bartlesville sand in southeastern Osage County have produced for periods ranging from 20 to 30 years. For instance, the first two wells drilled in the SW¼ sec. 20, T. 21 N., R. 9 E., which were completed in 1905 and 1906, are still producing. Recently the pools in the Bartlesville sand have received added attention from the oil operators because of the success of gas-repressuring and water-flooding projects in a few fields in northeastern Oklahoma.

The Bartlesville sand occurs in the lower part of the Cherokee shale, where it lies in thin-edged lenses a few to several hundred acres in extent that attain a maximum thickness of 200 feet. Shale from 50 to 150 feet in thickness commonly separates the Bartlesville sand from the Mississippi lime. Microscopic examination of well samples shows that the Bartlesville sand is composed mainly of fine to medium, subangular quartz grains and minor amounts of other minerals, including mica and feldspar. It is similar in composition and physical character to the Red Fork (Burbank) sand, which occurs somewhat higher in the Cherokee shale and is an important oil producer in T. 21 N., R. 8 E., and farther northwest in western Osage County, Okla., and Cowley, Butler, and Greenwood Counties, Kans. The Bartlesville sand is similar also to the Bluejacket sandstone member of the Cherokee, which crops out in Northeastern Oklahoma and southeastern Kansas and is probably equivalent to a part of the Bartlesville sand.

The subsurface geologic investigation of Osage County has shown that the Bartlesville sand was laid down as a series of beach deposits on the western shore of the Cherokee sea;[5] that the oil-bearing sand

[5] Bass, N. W., Leatherock, Constance, Dillard, W. R., and Kennedy, L. E., Origin and distribution of Bartlesville and Burbank shoestring oil sands in parts of Oklahoma and Kansas: Am. Assoc. Petroleum Geologists Bull., vol. 21, no. 1, pp. 55–56, 1937.

occurs as lens-shaped bodies that are longer than they are wide; and that the lenses of oil-bearing sand are distributed for the most part independently of the structural attitude of the rocks.

RED FORK (BURBANK) SAND

The Red Fork sand lies near the middle of the Cherokee shale, above the Bartlesville sand and below the Pink lime. The Red Fork appears to lie at about the stratigraphic horizon of the Burbank sand of western Osage County and is therefore tentatively correlated with it. The main occurrence of the Red Fork in these five townships is in T. 21 N., R. 8 E., where a narrow oil-bearing lens of this sand extends for several miles northwestward from the south boundary of Osage County in sec. 23. This lens also extends for several miles southeastward from sec. 23 into Pawnee County. The sand lies at a depth of about 2,125 feet and ranges in thickness from a feather edge to 60 feet.

SKINNER SAND

The Skinner sand, which in this area is relatively unimportant as a producer of oil and gas, occurs from 75 to 100 feet below the top of the Cherokee shale and normally about 10 feet below the Verdigris lime.

SQUIRREL (PRUE) SAND

Lenses of sand known as the Squirrel sand, called locally the Prue, occur between the Verdigris lime and the Oswego lime. These lenses are especially abundant in the eastern half of T. 21 N., R. 10 E. Locally they range downward and occupy the position of the Verdigris lime. In the localities in which the Squirrel sand is oil-bearing it is about 5 to 30 feet thick, commonly about 25 feet, and at a depth of 1,600 feet. As a commercially important oil-producing sand, however, it is limited to a group of about 40 wells in secs. 14, 22, and 23 and a few other localities in T. 21 N., R. 10 E.

BIG LIME AND PERU SAND ZONE

The Peru sand lies at the top of the Labette shale, but is present only locally. In some places the Peru sand is in contact with a sandy phase of the Big lime, which overlies it, and in drillers' logs it is impossible to determine the boundary between the two. Therefore, the Big lime and the Peru sand are here considered as a single zone. This zone yields oil in two wells on the Madalene anticline and in one well in sec. 30, T. 21 N., R. 10 E., where it is 20 feet thick and lies at a depth of about 1,550 feet. In localities in which the Big lime phase yields shows of oil and gas, its production could probably be increased by treating it with acid.

JONES AND CLEVELAND SAND

The sequence of rocks that lies between the Big lime and the Checkerboard limestone member of the Coffeyville formation is in part equivalent to the Nowata shale, the Lenapah limestone, and the lower part of the Coffeyville formation. Moreover, because the Big lime is notably thin here, it appears probable that the lowermost part of this sequence may be equivalent to the upper part of the Big lime. The total thickness of the sequence is about 375 feet, and it consists of sandstone and shale and locally a few beds of limestone. One of the limestone beds is recorded about 100 feet above the base of the sequence. This limestone may represent the Lenapah limestone, it may be equivalent to the uppermost part of the Big lime, or it may be merely a local lentil that is not equivalent to either of these. Sandstone occupies much of the middle of the sequence in parts of the area covered by the five townships. It was named the Cleveland sand because wells on the Cleveland town site, which is in T. 21 N., R. 8 E., about a mile south of the Osage County boundary, produced oil from it. The sand attains a maximum thickness of more than 200 feet but in many places is split into two benches by a bed of shale, which locally contains a coal bed. In places where the sand occurs in two benches the upper bench is commonly called the Jones or Dillard sand and the name Cleveland is restricted to the lower bench.

Both the Cleveland and Jones sands yield oil and gas. The Cleveland sand yields them in relatively few wells, which are mainly in two localities—secs. 1 and 2, T. 21 N., R. 9 E., and secs. 4 and 5, T. 21 N., R. 10 E. Depths to the sand range from 1,300 to 1,600 feet. The Jones sand lies at depths of about 1,350 to 1,600 feet and is 20 to 50 feet thick. It yields oil and gas mainly in two fields, one in the northeastern part of T. 21 N., R. 8 E., and the other in the northern part of T. 21 N., R. 10 E.

LAYTON SAND

The Layton sand occurs in the upper part of the Coffeyville formation. In some places it lies immediately below the Hogshooter limestone, and in others it is separated from the limestone by as much as 75 feet or more of shale. Locally, the sand is recorded in the logs as a double unit, separated by shale. It has a maximum thickness of about 60 feet, but locally it is absent. Depths to the sand range from about 900 to 1,200 feet. The Layton sand produces oil and gas in eight localities in T. 21 N., R. 9 E., and in three localities in T. 21 N., R. 8 E.

MUSSELLEM AND PEOPLES SAND ZONE

The Peoples sand, in the uppermost part of the Nellie Bly formation, and the Mussellem sand, in the lowermost part of the Ochelata formation, are difficult to identify in many localities, both because of their

lenticular character and because of the patchy occurrence of the Dewey limestone, which normally lies between the two sands and serves as a general guide in distinguishing one sand from the other. Therefore, these two sands and the Dewey limestone, which constitute a sequence that ranges from 100 to 200 feet in thickness, are treated herein as a single zone. Depths to this zone range from 800 to 1,000 feet. Many logs record shows of oil and gas in the zone, a few wells in secs. 23 and 24, T. 21 N., R. 8 E., produce oil and others in the northern part of T. 20 N., R. 10 E., produce gas from it.

OKESA, TORPEDO, AND CLEM CREEK SAND ZONE

A sequence about 200 feet thick, of sand, shale, red beds, and a few beds of limestone occupies the lower part of the upper half of the Ochelata formation. It includes rocks believed to be equivalent to the Okesa, Torpedo, and Clem Creek sands. This sequence is treated herein as a single zone, because the individual beds cannot be identified in the well logs. The top of the zone is found at depths ranging from 100 to 400 feet. The most notable localities in which these sands yield oil and gas are in the northeastern part of T. 21 N., R. 8 E., and the western part of T. 21 N., R. 9 E. In sec. 30, T. 21 N., R. 9 E., this zone, called the "300-foot sand," is being successfully repressured with air, and in the SE¼ sec. 30 with gas, for increased oil production.

PARTS OF T. 21 N., R. 8 E.

The parts of T. 21 N., R. 8 E., that lie northeast and northwest of the Arkansas River are in south-central Osage County, about 25 miles northwest of Tulsa. The village of Osage is in the Osage County part of the township, and Cleveland is about a mile south of the Osage-Pawnee county boundary. The Osage County parts of the township cover an area of about 12 square miles.

Eight oil- and gas-producing zones are recorded in the well logs of this 12 square miles. Of these zones, the largest producing areas have been developed in the Bartlesville, Red Fork, Layton, and Jones sands. Other zones produce minor amounts of oil and gas in a few localities. Depths to which drilling has been carried to test all of the eight zones range from about 500 feet—the depth to the Okesa, Torpedo, and Clem Creek sand zone—to about 2,900 feet—the depth to the Ordovician rocks.

About 335 wells have been drilled in the Osage County parts of the township. Much drilling was done during 1911 in sec. 24, and during 1912 and 1913 in the N½ sec. 11. Drilling in sec. 6, in the Boston oil field, was begun in 1914, 2 years after oil was first produced in the field by a well in sec. 1, T. 21 N., R. 7 E. Other wells were drilled in 1925 and 1926 in the extreme northeastern part of the township. Mean-

while, during the period 1920 to 1927, drilling had progressed northward through sec. 23, and during the period 1930 to 1934 it progressed still farther northward, into secs. 14 and 11.

The subsurface investigation of the parts of T. 21 N., R. 8 E., that lie in Osage County was conducted in 1935, mainly by Charles T. Kirk. The data on production were compiled in 1938 by Miss Anna L. Weinrich, of the Osage Indian Agency, from records on file at the agency.

STRUCTURE AND DEVELOPMENT

The regional dip of the rocks in T. 21 N., R. 8 E., is westward at the rate of about 30 to 35 feet to the mile, as measured on the top of the Oswego lime. This regional dip is interrupted, however, by several folds and structural terraces. The township lies in a belt of rocks that trends northeastward through western Creek and south-central Osage counties and contains many pronounced folds and faults.[6] The Cushing anticline in western Creek County, 25 miles southwest of T. 21 N., R. 8 E., and the large Cleveland dome in the central part of T. 21 N., R. 8 E., in Pawnee County a short distance south of the Osage County boundary, are well known folds in this belt. The dips on the Oswego lime on local structural features in T. 21 N., R. 8 E., are steeper than the corresponding dips in the exposed rocks, and the crests of the domes in the Oswego lime are not directly below the crests in the exposed rocks.

Oil and gas development in the Osage County parts of this township has gone forward in a total area of about 3 square miles and in many places, although not everywhere, is confined to the upfolds. Many wells have produced oil and gas from the Bartlesville sand on a series of anticlines that trend northward through the eastern part of the township, and on the Boston dome in sec. 6. The Red Fork sand is a prolific source of oil and gas in a narrow belt that trends northwest through secs. 23, 14, 11, and 10. The lenticular Jones sand yields oil and some gas throughout an area about half a square mile in extent in parts of secs. 1, 2, 11, and 12. The Okesa, Torpedo, and Clem Creek sand zone yields oil in many wells in sec. 12.

ANTICLINE MAINLY IN SEC. 12

A prominent anticline that lies mainly in sec. 12 has a structural closure of about 80 feet on the Oswego lime. This anticline includes two domes, each of which has a structural closure of about 50 feet. Less confidence can be placed in the position of the structure contours on this anticline as indicated on plate 8, however, than in the position of other structure contours on that plate, because they are based on

[6] Greene, F. C., Oil and gas in Oklahoma, Geology of Pawnee County; Okla. Geol. Survey, Bull. 40, vol. 3, pp. 176–177, 1930.

meager information only. The logs of many wells were not available; and many of the datum altitudes used in drawing the structure contours were projected from rocks at shallow depths, because many of the wells did not penetrate the Oswego lime, the datum bed on which the contours are drawn.

The exposed rocks in secs. 12 and 13 form a single dome with a structural closure of about 40 feet.[7] The crest of the dome in the exposed rocks is near the center of the NE¼SW¼ sec. 12, and a pronounced structural terrace occupies the center of the E½ sec. 12. It appears not improbable that the southeast one of the two domes on the top of the Oswego lime (pl. 8) is represented in the exposed rocks by the structural terrace and that the northwest dome on the Oswego lime is represented in the exposed rocks by the dome in the NE¼SW¼ sec. 12.

More than 100 wells have been drilled in sec. 12 and the parts of the adjoining sections that lie on the anticline. The main oil-bearing zones are the Bartlesville and Jones sands, and the Okesa, Torpedo, and Clem Creek sand zone. The wells producing from the Bartlesville sand are about 2,275 feet deep, and they produced initially from 25 to 150 barrels of oil a day. The wells producing from the Jones sand are about 1,600 feet deep; they yielded initially from 5 to 100 barrels of oil a day. Oil-bearing Jones sand extends from the crest of the anticline down the west flank to an altitude of 140 feet below that of the crest. The wells that are high on the flank of the anticline had the larger initial yields, however. Four wells in the N¼ sec. 13 on the south nose of the anticline produced initially from 8 to 25 barrels of oil a day from the Layton sand, encountered at a depth of about 1,200 feet. Many wells in the E½ sec. 12 on the crest and east flank of the southeast dome of the anticline produce oil from the Okesa, Torpedo, and Clem Creek sand zone, encountered at depths ranging from 550 to 600 feet, but the initial daily yield of the wells was less than 50 barrels each. This producing area extends eastward into sec. 7, T. 21 N., R. 9 E.

No wells have been drilled on the crests of the domes to a depth sufficient to penetrate the Simpson formation or the upper part of the Siliceous lime. Well 48 in the SW¼SE¼NW¼ sec. 12, in the trough of the saddle between the domes, penetrated a considerable thickness of Ordovician rocks but failed to produce oil or gas, although it yielded shows of oil from the Bartlesville sand and the Burgess sand-Mississippi lime zone. It is not unlikely that additional wells drilled in the NW¼ sec. 12 and the SW¼ sec. 1 would produce oil from the Bartlesville sand, because this area lies between two areas already

[7] Wood, R. H., Unpublished map of parts of the Hominy quadrangle in Geological Survey files.

yielding oil from the Bartlesville—one in secs. 12, 13, and 24 and the other in the NW¼ sec. 1 and the N½ sec. 2.

The total amount of oil produced to the end of 1937 from the anticline that lies mainly in sec. 12 is shown in the following table:

Oil produced from the anticline mainly in sec. 12, T. 21 N., R. 8 E.

Tract	Date of first production	Production to end of 1937 (barrels) [1]
SW¼ sec. 1	Prior to July 1916	196,078
SE¼ sec. 2	do	21,690
NE¼ sec. 11	do	281,980
NW¼ sec. 11	do	[2]
NE¼ sec. 12	do	143,980
NW¼ sec. 12	do	1,631,152
SW¼ sec. 12	do	1,244,471
SE¼ sec. 12	do	648,131
NE¼ sec. 13	do	443,174
NW¼ sec. 13	do	105,305

[1] Does not include amount produced prior to July 1916.
[2] Abandoned.

N½ SEC. 1 AND N½ SEC. 2

The structural nose that plunges south into the northern part of secs. 1 and 2 is on the south flank of an anticline that trends northeastward through sec. 36, T. 22 N., R. 8 E., into secs. 30 and 31, T. 22 N., R. 9 E.[8] This anticline is separated from the anticline in sec. 12, T. 21 N., R 8 E., by a syncline that trends eastward through the S½ sec. 2 and the S½ sec. 1. Many wells in the N½ sec. 1 and the N½ sec. 2, T. 21 N., R. 8 E., and in sec. 35, T. 22 N., R. 8 E., are low on the southwest flank of this anticline and produce oil from the Bartlesville sand. The initial yield of the wells in secs. 1 and 2 ranged from 25 to 150 barrels a day each. Most of the wells were drilled from 1924 to 1926 and are still producing. Two wells in the NE¼ sec. 2 produced from the Layton sand. It appears probable that the producing area in the Bartlesville sand could be extended southward by drilling additional wells in the NW¼ sec. 1 and the NE¼ sec. 2.

The total amount of oil produced in the N½ sec. 1 and the N½ sec. 2 to the end of 1937 is shown in the following table:

Oil produced in N½ sec. 1 and N½ sec. 2, T. 21 N., R. 8 E.

Tract	Date of first production	Production to end of 1937 (barrels)	Remarks
NE¼ sec. 1	October 1924	387	Abandoned in February 1925.
NW¼ sec. 1	April 1925	210,239	
NE¼ sec. 2	March 1924	540,343	
NW¼ sec. 2	May 1926	90,927	
		841,896	

[8] Kirk, C. T., and others, Subsurface geology and oil and gas resources of Osage County, Okla., Part 2, Townships 22 and 23 North, Ranges 8 and 9 East: U. S. Geol. Survey Bull. 900–B, pl. 2.

S½ SEC. 13, E½ SEC. 24, AND NE¼ SEC. 25

A low anticlinal nose plunges northwest through sec. 24 into sec. 13. It appears to be a prong of the prominent dome whose crest is in sec. 30, T. 21 N., R. 9 E., and to lie along the general anticlinal axis of the prominent anticline in sec. 12, T. 21 N., R. 8 E. The Bartlesville sand yields oil in many wells in the S½ sec. 13 and the E½ sec. 24 of this township. This oil-producing area is more or less a continuation of the producing area on the anticline in sec. 12. The sand is a little more than 100 feet thick and lies at a depth of 2,200 to 2,300 feet. The oil wells in the S½ sec. 13 and the E½ sec. 24 yielded initially from 30 to 170 barrels a day each from the Bartlesville sand. Two wells, one in the SE¼ sec. 13 and the other in the NE¼ sec. 24, both low on the anticlinal nose, tested Ordovician beds but failed to produce oil or gas.

The Layton sand which lies at a depth of about 1,125 feet, produces oil in several wells in the NE¼ sec. 25, low on the west flank of the dome whose crest is in sec. 30, T. 21 N., R. 9 E. The initial daily yields of the wells ranged from 5 to 95 barrels. Several of the wells are on a broad sand bar in the Arkansas River known as Turkey Island.

The total amount of oil produced from the S½ sec. 13, E½ sec. 24, and NE¼ sec. 25 to the end of 1937 is shown in the following table:

Oil produced in parts of secs. 13, 24, and 25, T. 21N., R. 8E.

Tract	Date of first production	Production to end of 1937 (barrels)
SW¼ sec. 13	Prior to July 1916	[1] 50,007
SE¼ sec. 13	do	[1] 240,863
NE¼ sec. 24	do	[1] 149,809
SE¼ sec. 24	March 1921	[2] 4,233
NE¼ sec. 25 (part)	December 1920	44,298
		489,210

[1] Does not include amount produced prior to July 1916.
[2] Abandoned in 1934.

RED FORK SAND BELT

The northwest nose of an anticline whose crest is in sec. 35, and therefore outside Osage County, projects northward into sec. 23. The axis of this anticline lies in the general trend of an elongated but open fold that trends northwestward through secs. 14, 11, and 10 and is separated from the anticline by a shallow syncline in the N½ sec. 23. A number of producing oil wells form a narrow belt that occupies the crest of the northern part of the south anticline in sec. 23, whence the belt extends northwestward across the syncline in the N½ sec. 23 and along the crest of the north anticlinal fold in secs. 14, 11, and 10. It extends southeastward, also, from sec. 23, on the Osage

County line, for many miles, but this part of it is broken by several gaps and fails to coincide with the crests of folds, trending instead diagonally across anticlines, synclines, and monoclines. About 50 wells have been drilled in this belt in secs. 23, 14, 11, and 10.

The oil in this narrow belt is obtained from the Red Fork sand at a depth of 2,150 to 2,350 feet. The initial daily yields of the wells in secs. 10, 11, 14, and 23 ranged from 5 to 600 barrels, but there was a wide range in the initial yields of offset wells. The largest initial yields were made by wells near the middle of the E½ sec. 23 and in the NW¼NW¼ sec. 14 and the SW¼ sec. 11. The logs of many dry holes on both sides of the oil-bearing belt record little or no sand at the horizon of the Red Fork sand. It is probable, therefore, that this producing bed is a buried sand bar or other form of shoestring sand similar to those of like age in Kansas [9] and to those in the Burbank oil field,[10] in western Osage County.

The distribution of the producing wells in a shoestring belt indicates that oil-bearing Red Fork sand probably occupies the undrilled gap in the belt in the NE¼SW¼ sec. 14. Also, the northwest extension of the belt probably continues across the NE¼ sec. 10 and sec. 3. Shoestring sand belts commonly contain gaps that are barren of sand and oil, and therefore, if a few dry holes were drilled in the NE¼ sec. 10, they would not necessarily establish that locality as the northwest end of the oil-bearing belt. More likely the belt would be found to continue northwestward beyond the barren gap and across sec. 3.

The total amount of oil produced to the end of 1937 from the Red Fork sand belt is shown in the following table:

Oil produced from the Red Fork sand belt

Tract	Date of first production	Production to end of 1937 (barrels)	Remarks
NE¼ sec. 10	July 1930	10,957	Abandoned in 1932.
SE¼ sec. 10	August 1929	25,486	Abandoned in December 1935.
SW¼ sec. 11	March 1930	149,107	
NW¼ sec. 14	May 1930	101,484	
SW¼ sec. 14	July 1929	4,446	Abandoned in January 1935.
SE¼ sec. 14	March 1927	22,315	Abandoned in September 1937.
NE¼ sec. 23	July 1920	150,440	
NW¼ sec. 23	April 1922	12,681	Abandoned in June 1935.
SW¼ sec. 23 (part)	June 1935	121	Abandoned in September 1935.
SE¼ sec. 23 (part)	November 1919	200,705	Abandoned in September 1924.
		677,742	

[9] Bass, N. W., Origin of the shoestring sands of Greenwood and Butler Counties, Kans.: Kansas Geol. Survey Bull. 23, pp. 63–104, 1936.

[10] Bass, N. W., Leatherock, Constance, Dillard, W. R., and Kennedy, L. E., Origin and distribution of Bartlesville and Burbank shoestring oil sands in parts of Oklahoma and Kansas: Am. Assoc. Petroleum Geologists Bull., vol. 21, no. 1, pp. 55–56, 1937.

BOSTON DOME

A part of the east flank of the Boston dome lies in sec. 6, T. 21 N., R. 8 E., but the crest and main part of the dome are in sec. 1, T. 21 N., R. 7 E.[11] The oil-producing area extends across the part of sec. 6 that lies in Osage County and a short distance into the part that lies in Pawnee County. Of 26 wells that were drilled in the Osage County part of sec. 6, 21 produced oil, 2 produced gas, and 3 were dry. All these wells tested the Bartlesville sand, at a depth of about 2,250 feet, and four wells tested the Ordovician rocks, at a depth of about 2,500 feet. Only two wells produced oil from the Ordovician rocks, and the drillers' logs indicate that the oil in these rocks occurs in the upper part of the Siliceous lime.

The initial daily yields of the wells producing from Bartlesville sand ranged from 45 to 75 barrels. The initial daily yield of one of the wells producing from Ordovician rocks was 50 barrels. The initial daily yields of wells in sec. 6 are small when compared with the yields from wells in sec. 1, T. 21 N., R. 7 E., on the crest of the dome, whose yields ranged from 1,000 to 3,000 barrels a day. It is noteworthy that the two wells that have produced oil from Ordovician rocks are about 30 feet structurally lower than well 6 in the NW¼SW¼NW¼ sec. 6, which produces oil from the Bartlesville sand. Therefore, the deepening of well 6 to the Siliceous lime, before it is abandoned, may be advisable, provided wells that are higher on the dome are not yielding large amounts of water from the Siliceous lime.

The discovery well on the Boston dome was drilled during 1912 in sec. 1, T. 21 N., R. 7 E., and the first well in sec. 6, T. 21 N., R 8 E. was drilled in 1914. Development continued slowly until 1920. The total amount of oil produced from the Osage County part of sec. 6 from July 1916 to the end of 1937 was 1,223,529 barrels. The amount of oil produced prior to July 1916 was not learned.

PART OF T. 20 N., R. 9 E.

An area of about 4 square miles in T. 20 N., R. 9 E., mostly in secs. 1, 2, 3, and 4, lies along the south margin of Osage County. This part of the township is about 16 miles northwest of Tulsa, and the village of Prue is near its center. No oil or gas has been produced from this area, although five wells have been drilled. Of these, four were drilled during 1928 and 1929 near the center of sec. 4, and the other was drilled during 1931 in sec. 1.

[11] Beckwith, H. T., Oklahoma Geol. Survey Bull. 40, vol. 3, pp. 250–252, figs. 51–53, 1930.

STRUCTURE AND DEVELOPMENT

The regional dip of the rocks across the Osage County part of T. 20 N., R. 9 E., is westward at the rate of about 35 feet to the mile as measured on the top of the Oswego lime. The position of the structure contours in this area as shown on plate 8 is speculative, because little information is available concerning it and adjoining areas. River alluvium completely covers this part of the township. The few data available from well logs indicate the presence of an anticlinal nose about a mile wide that projects northward across sec. 4 and of a syncline that extends southeastward though secs. 3 and 2. The syncline contains a relatively flat structural basin in its trough in sec. 3.

One of the wells drilled on the anticlinal nose in sec. 4 penetrated the Bartlesville sand at a depth of 2,145 feet. The Peoples, Layton, Jones, Cleveland, Squirrel, and Skinner sands are also present in the well, but they yielded no oil or gas, according to the log. The other three wells in sec. 4 penetrated the upper 10 to 20 feet of the Mussellem and Peoples sand zone at a depth of about 500 feet. These wells were all reported as dry holes, although the log of one recorded a show of oil in the Mussellem and Peoples sand zone. The dry hole in the SW¼SE¼ sec. 1 penetrated the Burgess sand-Mississippi lime zone at a depth of 2,220 feet. The Layton, Squirrel, Cleveland, Red Fork, and Bartlesville sands are all present in this hole, but, according to the log, they yielded no shows of oil or gas.

PART OF T. 21 N., R. 9 E.

Most of T. 21 N., R. 9 E., lies along the southern margin of Osage County, but about 1½ square miles in its southwest corner lies in Pawnee County. The southeast corner of this township is 20 miles northwest of Tulsa, and its northwest corner is 6 miles south of Hominy. About 360 wells have been drilled in the township, and oil and gas have been found mainly in seven localities, which are widely separated. These localities have a combined area of about 5 square miles.

Eight zones yield oil or gas. The Bartlesville sand is the most widely distributed producing zone in the township. The Okesa, Torpedo, and Clem Creek sand zone, the Layton, Cleveland, and Red Fork sands, the Burgess sand-Mississippi lime zone, and the Ordovician rocks each produce only in small areas.

The first well in T. 21 N., R. 9 E., was drilled in sec. 20 in 1904, according to the logs. After an interval of a few years, development proceeded in secs. 18, 19, 20, 29, and 30 with considerable activity in 1911 and 1912, and has continued to the present time. Most of the recent activity has been in sec. 30. Several wells were

drilled in sec. 2 during 1911, and others in 1917. A few, yielding mostly gas, were drilled in sec. 26 from 1920 to 1924. Twenty or more were drilled in the E½ sec. 10 and the W½ sec. 11 from 1923 to 1926. Several were drilled in sec. 7 from 1926 to 1928. Many were drilled in the SW¼ sec. 9 and in adjoining tracts in 1928. Several were drilled in secs. 27 and 34 in 1933 and 1934. Drilling for oil is still in progress in the Okesa, Torpedo, and Clem Creek sand zone in sec. 27.

The subsurface investigation of T. 21 N., R. 9 E., was conducted in 1935 and 1936, chiefly by H. D. Jenkins and W. R. Dillard. The data on production were compiled in 1938 by Miss Anna L. Weinrich, of the Osage Indian Agency, from records on file at the agency.

STRUCTURE AND DEVELOPMENT

The regional dip of the rocks in T. 21 N., R. 9 E., is westward at an average rate of about 35 feet to the mile as measured on the top of the Oswego line. This regional dip, however, is interrupted by several pronounced domes and synclines. The domes, each of which covers an area of 1 to 4 square miles, appear to have no systematic arrangement. The structural closure on the Oswego lime is less than 100 feet on each of each of the domes.

The folding in the buried rocks (see pl. 8), is considerably steeper than in the exposed rocks. Three normal faults that trend northwestward cut the exposed rocks. One of these extends northwest from the center of sec. 16 to a point near the west quarter corner of sec. 9, one extends northwest from the center of sec. 21 to a point near the east quarter corner of sec. 17 [12] and a third passes through sec. 8. These faults, like many others in this region, are arranged en echelon and occur in several belts that trend slightly east of north from southern Oklahoma to the northern part of Osage County.[13] The available data are inadequate to show definitely whether the deeply buried rocks are also offset by faults, except that the logs of wells in the SW¼ sec. 9 indicate that there has been no displacement in the Oswego lime and other deeply buried rocks in that locality.

Oil is produced on all the domes in T. 21 N., R. 9 E., except two. These domes are in secs. 24 and 26 and produce gas. The oil and gas occur on the crests and flanks of all domes except the one in sec. 10. The crest of that dome is barren, but oil and small amounts of gas are found in the Bartlesville sand on its east, north, and northwest flanks. Oil-producing Bartlesville sand in secs. 18, 19, and 30 occurs not only

[12] Miser, H. D., Geologic map of Oklahoma, U. S. Geol. Survey, 1926.

[13] Fath, A. E., Geology of the Bristow quadrangle, Creek County, Okla.: U. S. Geol. Survey Bull. 759, pp. 35–36, 1925; The origin of the faults, anticlines, and buried "granite ridge" of the northern part of the Mid-Continent oil and gas field, U. S. Geol. Survey Prof. Paper 128, pl. 12, 1920.

on the crests of the main domes in secs. 19 and 30, but it also extends nearly two miles northwest of the crests. Here the most prolific wells in the Bartlesville sand are about 40 feet structurally below the crest of the dome in sec. 30. It is noteworthy that the oil-producing body of Layton sand in secs. 20 and 29 is narrow and elongated northeastward and that the sand is oil-bearing only on the northeast flank of the dome. The Layton sand did not produce oil on the highest parts of the dome in sec. 30. The distribution of the oil and gas deposits in T. 21 N., R. 9 E., suggests that the occurrences of the oil and gas, in general, are controlled somewhat by the large upfolds but that the local occurrences on these major upfolds are controlled by the lenticular character of the reservoir beds.

DOMES IN SECS. 18, 19, 20, 29, AND 30

A complex group of five domes occupies parts of secs. 18, 19, 20, 29, and 30. These domes have structural closures ranging from about 20 to 60 feet as measured on the top of the Oswego lime. The crest of the most prominent one in the group is in the NE¼ sec. 30 (See pl. 8), about 1,300 feet northwest of its crest in the exposed rocks.[14] The relatively small domes whose crests are in the SW¼ sec. 20 and the NW¼ sec. 29 underlie a shallow syncline in the exposed rocks, and they are more than half a mile west and southwest of a dome whose crest in the exposed rocks is near the southeast corner of sec. 20. The dome in the exposed rocks near the southeast corner of sec. 20 is so far removed from the subsurface domes that it may not represent an upward reflection of them. It is possible that the surface dome in the SE¼ sec. 20 is underlain by a subsurface one, but this is only hypothetical, and therefore no subsurface dome is shown on plate 8.

Oil is produced in secs. 18, 19, 20, 29, and 30 from three zones—from the Bartlesville sand at a depth of about 2,200 feet, from the Layton sand at a depth of about 1,100 feet, and from the Okesa, Torpedo, and Clem Creek sand zone at a depth of about 300 feet. Only a few wells produce oil from the Burgess sand-Mississippi lime zone. Ordovician rocks have been tested in five wells, two of which penetrated several hundred feet into these rocks but failed to produce oil or gas in a commercial amount. One of these wells, however (No. 31 in the NE¼ sec. 30), had a good show of oil in the Ordovician rocks.

Some of the wells in secs. 18, 19, 20, 29, and 30 were drilled as early as 1904, but most of them were drilled from 1910 to 1912. About 1935 several shallow wells were drilled in the central part of sec. 30 to test the Okesa, Torpedo, and Clem Creek sand zone for oil and one deep well (No. 31) was drilled in 1935.

[14] Wood, R. H., Unpublished map of parts of the Hominy quadrangle in Geological Survey files.

The initial daily yields of wells in the Bartlesville sand ranged from 5 to 4,000 barrels of oil, though the initial yield of many of them was only a few hundred barrels. The initial daily yields of wells in the Layton sand ranged from 7 to 48 barrels, and the yields of those in the Okesa, Torpedo, and Clem Creek sand zone, from about 25 to 100 barrels. The oil-bearing part of the Okesa, Torpedo, and Clem Creek sand zone is being repressured with gas in part of the field and with air in another part, and the wells are responding to these operations with increased yields.

The total amount of oil produced from secs. 18, 19, 20, 29, and 30 from July 1916 to the end of 1937 is shown in the following table:

Oil produced from secs. 18, 19, 20, 29, and 30, T. 21 N., R. 9 E.

Tract	Date of first production	Production to end of 1937 (barrels)
SW¼ sec. 18	Prior to July 1916	[1] [2] 55,286
NE¼ sec. 19	do	[1] 46,947
NW¼ sec. 19	do	[1] 51,244
SW¼ sec. 19	do	[1] 37,908
SE¼ sec. 19	do	[1] 166,593
SW¼ sec. 20	do	[1] 237,496
NW¼ sec. 29	do	[2] 402,367
NE¼ sec. 30	do	[1] 1,122,185
NW¼ sec. 30 (part)	do	[1] 247,776
SE¼ sec. 30 (part)	October 1934	155,043
SW¼ sec. 30 (part)	March 1923	83,755
		2,606,600

[1] Does not include amount produced prior to July 1916.
[2] Abandoned in February 1933.

DOME IN SECS. 8, 9, 16, AND 17

One of the steepest upfolds in T. 21 N., R. 9 E., lies in parts of secs. 8, 9, 16, and 17. The lowest closing structure contour on the top of the Oswego lime (pl. 8) includes an area of about 300 acres, and its structural closure is more than 60 feet. The structural closure of the dome is but little more than 10 feet in the exposed rocks,[15] and the crest of the dome in the exposed rocks lies about 1,200 feet northeast of its crest in the Oswego lime. This dome is similar in shape and size to another dome 1½ miles to the east, and the two rise above the crest of an east-west anticline whose total structural closure on the Oswego lime exceeds 100 feet. A fault along which the exposed rocks have a vertical displacement of less than 10 feet trends northwest from the center of sec. 16, across the dome in the SW¼ sec. 9, to a point about 200 feet east of the west quarter corner of sec. 9.[16] The logs of wells near this fault indicate that it disappears at shallow depth. Another fault, along which the exposed rocks

[15] Wood, R. H., Unpublished map of parts of the Hominy quadrangle in Geological Survey files.
[16] Idem.

have a vertical displacement of about 20 feet, trends northwest from the center of sec. 21 to a point a few hundred feet west of the east quarter corner of sec. 17; and a third fault passes through sec. 8.[17] It appears probable that these two latter faults, also, cut only the rocks that lie at shallow depth. Well 2, near the center of the SW¼ sec. 9, encountered granite at a depth of 2,575 feet, about 40 feet below the base of the Mississippi lime, and, according to the driller's log, penetrated 92 feet of the granite. Well 34 in the SW¼SE¼ sec. 19 and well 21 of the SE¼SW¼ sec. 20 each reached a depth of more than 440 feet below the base of the Mississippi lime without encountering granite. These findings indicate that the dome in sec. 9 overlies a peak of pre-Cambrian rocks on whose slopes the Ordovician and Cambrian rocks increase in thickness at short distances away from the crest.

Of the 50 wells drilled on the dome, 27 produced oil and 1 produced gas from the Okesa, Torpedo, and Clem Creek sand zone at a depth of about 250 feet. Three produced gas and 2 produced oil from the Bartlesville sand at a depth of about 2,200 feet. Four produced oil from the Red Fork sand at a depth of about 2,000 feet. One well produced oil and one produced gas from the Layton sand at 1,100 feet. Most of the wells that produce from the Okesa, Torpedo, and Clem Creek sand zone were drilled in 1928, but wells are still being drilled to this zone. Gas pressure is being applied to the oil-bearing part of the Okesa, Torpedo, and Clem Creek sand zone through several input wells in the SW¼ sec. 9 and the NE¼ sec. 17.

Seven wells on the dome tested the Ordovician rocks, but none of them produced oil or gas.

The total amount of oil produced in secs. 8, 9, 16, and 17 to the end of 1937 is shown in the following table:

Oil produced from secs. 8, 9, 16, and 17, T. 21 N., R. 9 E.

Tract	Date of first production	Production to end of 1937 (barrels)
SW¼ sec. 9	June 1918	144,710
NE¼ sec. 16	January 1929	40,797
NW¼ sec. 16	October 1928	61,395
NE¼ sec. 17	August 1922	27,809
		274,711

DOME IN SECS. 2, 3, 10, 11, 14, AND 15

A steeply folded dome whose crest is in the SE¼ sec. 10 occupies parts of secs. 2, 3, 10, 11, 14, and 15. Its lowest closing contour on the Oswego lime includes nearly 300 acres, and its structural closure

[17] Miser, H. D., Geologic map of Oklahoma, U. S. Geol. Survey, 1926.

is more than 60 feet. The structural closure of this dome in the exposed rocks is a little more than 30 feet,[18] and its crest on the exposed rocks is about 400 feet southeast of its crest on the Oswego lime. The dome forms the eastern part of a large upfold that trends east-west through the north half of T. 21 N., R. 9 E., and includes the dome whose crest is in sec. 9.

On the dome just described 45 wells have been drilled. Those drilled near the crest did not produce. Oil was found in many wells, however, in the Bartlesville sand on the east, north, and northwest flanks of the dome, and gas was found in the same bed in three wells on the north flank. The initial daily yields of the oil wells ranged from 7 to 150 barrels, and the initial daily yields of the gas wells ranged from 500,000 to 10,000,000 cubic feet. The depth to the Bartlesville sand is about 2,250 feet. The wells on the northwest flank of the dome were drilled in 1920, and those on the east flank were drilled from 1923 to 1925. The Okesa, Torpedo, and Clem Creek sand zone, which yields oil on the dome in sec. 9, lies at depths of 200 to 400 feet on the dome in sec. 10, where it is barren of oil. It is possible, of course, that this zone and the Bartlesville sand will prove to be oil-bearing on the crest and south flank of the dome, where no wells have been drilled.

The total amount of oil produced to the end of 1937 from the above-described dome is shown in the following table:

Oil produced from the dome in secs. 2, 3, 10, 11, 14, and 15, T. 21 N., R. 9 E.

Tract	Date of first production	Production to end of 1937 (barrels)
SE¼ sec. 3	April 1924	109,814
NE¼ sec. 10	January 1922	281,087
NW¼ sec. 10	August 1919	10,699
SW¼ sec. 10	June 1920	37,281
SE¼ sec. 10	November 1924	271,838
NW¼ sec. 11	January 1923	124,362
SW¼ sec. 11	July 1923	208,776
NW¼ sec. 14	March 1926	12,110
NE¼ sec. 15	1927	8,160
		1,064,127

DOME IN SEC. 2

An oval-shaped dome, with a structural closure of about 30 feet on the top of the Oswego lime, occupies much of sec. 2 and a part of sec. 1 and extends northward into the S½ sec. 35 and the S½ sec. 36, T. 22 N., R. 9 E. This dome is reflected in the exposed rocks[19] but its crest on the Oswego lime is about 700 feet northwest of its crest in the

[18] Wood, R. H., op. cit.

[19] Wood, R. H., Unpublished map of parts of the Hominy quadrangle, in Geological Survey files.

exposed rocks. Twenty-three wells have been drilled on the part of this dome that is in T. 21 N., R. 9 E., most of them during the period 1914 to 1918. Eight of these produced oil and one produced gas from the Cleveland sand at depths ranging from 1,350 to 1,450 feet, and one produced oil and two produced gas from the Bartlesville sand at a depth of about 2,150 feet. The initial daily yields of most of the oil wells were less than 50 barrels; the initial daily yields of the gas wells ranged from 4½ to 9 million cubic feet.

Inasmuch as the Ordovician rocks have not been penetrated on the crest of the dome it would be advisable to drill here to test these beds. The Siliceous lime would be encountered at a depth of 2,750 to 2,800 feet.

The total amount of oil produced to the end of 1937 on the dome in sec. 2 is shown in the following table:

Oil produced from the dome in sec. 2, T. 21 N., R. 9 E.

Tract	Date of first production	Production to end of 1937 (barrels)
NW¼ sec. 1	Prior to July 1916	[1] 19,639
NE¼ sec. 2	do	[1] 25,805
NW¼ sec. 2	do	[1] 56,393
SE¼ sec. 2	January 1919	[2] 16,849
		118,686

[1] Does not include amount produced prior to July 1916.
[2] Abandoned in March 1929.

DOMES IN SECS. 24 AND 25

The two domes in secs. 24 and 25, T. 21 N., R. 9 E., extend eastward into the western part of T. 21 N., R. 10 E. The main dome, whose crest is in the NE¼ sec. 24, T. 21 N., R. 9 E., has a structural closure on the top of the Oswego lime of about 60 feet. The small dome, whose crest is in the NE¼ sec. 25, has a structural closure of about 20 feet and appears to be a local feature on the south flank of the main dome. The structural closure in the exposed rocks of the main dome is about 40 feet and its crest in the exposed rocks is in the SE¼ sec. 24,[20] about 1,800 feet south and a short distance west of its crest on the Oswego lime.

Of 12 wells drilled in secs. 24 and 25, 6 produced gas from the Bartlesville sand, at a depth of about 2,100 feet. Most of the wells were drilled in 1925 and 1926, and they produced initially from 7 to 17 million cubic feet of gas a day. Well 1 in the northeast corner of

[20] Wood, R. H., op. cit.

sec. 25 produced both gas and oil from the Bartlesville sand. From November 1925 to February 1927 this well produced a total of 1,435 barrels of oil. Well 1 in the NE¼SE¼SE¼ sec. 25 low on the south flank of the southeast dome began producing oil in January 1929 and by the end of 1937 had produced a total of 17,228 barrels. This well produces from the Bartlesville sand, and additional wells drilled near it would probably also obtain oil from the same bed. Two wells in sec. 24 on the main dome tested the Siliceous lime at a depth of about 2,700 feet but found no oil or gas, and a well in the SE¼SE¼ sec. 24, in the saddle between the two domes, stopped in the Simpson formation.

OHIO-OSAGE OIL AND GAS FIELD

The Ohio-Osage oil and gas field in secs. 22, 26, 27, and 34 includes two small domes, each of which has a closure of less than 20 feet on the top of the Oswego lime. The crest of one of these domes is in the NW¼NW¼ sec. 26, and the crest of the other is in the NE¼NW¼ sec. 34. The domes are minor structural features on a southwestward-plunging anticlinal nose that extends from the NE¼ sec. 26 to the SE¼ sec. 33 and seem to bear no relation to the attitude of the exposed rocks.[21] Several wells on the northeast dome produced gas and a few produced oil from the Bartlesville sand at a depth of about 2,250 feet, and several wells on the southwest dome produced oil from the Layton sand at a depth of about 1,100 feet. The initial daily yields of the gas wells ranged from 1½ to 5½ million cubic feet each. The initial daily yields of the oil wells producing from the Bartlesville sand ranged from 8 to 10 barrels each, and the initial daily yield of those producing from the Layton sand was about 30 barrels each. The yield of the wells producing from the Layton sand to the end of 1937 was about 1,700 barrels to the acre.

Two wells on the northeast dome tested the Ordovician rocks. One of these penetrated 575 feet into the Siliceous lime. Two dry holes on the southwest dome were drilled into the upper part of the Mississippi lime. Most of the wells on the northeast dome were drilled from 1920 to 1924, and most of those on the southwest dome were drilled in 1933 and 1934. The well in the northeast corner of sec. 33, however, was drilled in 1906. A few of the wells in the W½ sec. 27 were drilled in 1938.

[21] Wood, R. H., Unpublished map of parts of the Hominy quadrangle in Geological Survey files.

The total amount of oil produced from this field to the end of 1937 is shown in the following table:

Oil produced in the Ohio-Osage field

Tract	Date of first production	Production to end of 1937 (barrels)	Remarks
SW¼ sec. 26	April 1920	1,580	Abandoned in March 1921.
SE¼ sec. 27	April 1933	8,465	
SW¼ sec. 27	May 1933	66,835	
NE¼ sec. 27	January 1922	2,819	Abandoned in March 1923.
NW¼ sec. 27	May 1937	284	
NE¼ sec. 34	August 1933	3,347	
NW¼ sec. 34	May 1933	34,815	
		118,145	

SEC. 7

A small area in the NW¼ sec. 7 yields oil from the Okesa, Torpedo, and Clem Creek sand zone at a depth of about 500 feet. The rocks are structurally lower in this area than anywhere else in the township. Of the 17 wells drilled here, 9 had an average initial daily yield of about 45 barrels. The field was developed from 1926 to 1931, and a total of 118,927 barrels of oil had been produced by the end of 1937.

PART OF T. 20 N., R. 10 E.

About three-fourths of T. 20 N., R. 10 E., lies in Osage County, east and north of the Arkansas River. The southeast corner of the township is about 10 miles west of Tulsa.

The Taneha sand has yielded oil in 6 wells in three localities in this area and gas from 2 wells in two localities, and the Mussellem and Peoples sand zone has yielded gas in 10 wells in secs. 4 and 9. The Bartlesville sand yields gas in 3 wells in widely separated localities; the Burgess sand-Mississippi lime zone has yielded a few barrels of oil in 1 well and gas in 1 well; and the Ordovician rocks have yielded oil in 1 well and gas in 1 well. Drilling depths to all five of these producing zones range from about 300 to 2,750 feet.

In all, about 75 wells have been drilled in the Osage County part of T. 20 N., R. 10 E., of which about 25 penetrated the Burgess sand-Mississippi lime zone and about 15 others reached the Ordovician rocks. Of the total number of wells, 25 have produced oil or gas. Some development took place in sec. 36 in 1915 and 1916; one well was drilled during 1916 in sec. 26; one was drilled during 1916 and two others during 1918 in secs. 4 and 13. Some wells were drilled from 1925 to 1927 in the southwestern part of the township, and a few were drilled at about the same time in the northeastern part. Several wells were drilled during 1929 in secs. 4 and 9, two were drilled during 1934 and 1936 in sec. 2, and two were drilled during 1936 in sec. 8.

The subsurface investigation of T. 20 N., R. 10 E., was conducted mainly by W. R. Dillard and Otto Leatherock in 1935 and 1936. The data on production were compiled by Miss Anna L. Weinrich, of the Osage Indian Agency, from records on file at the agency.

STRUCTURE AND DEVELOPMENT

The regional dip of the rocks in T. 20 N., R. 10 E., is westward at an average rate of about 45 feet to the mile as measured on the top of the Oswego lime. This dip is modified somewhat by several anticlinal noses and synclines and one low dome. The Osage County part of this township has fewer local structural features than most of the other townships that lie wholly or partly in southeastern Osage County. The positions of the structure contours shown on plate 8 in much of this area are speculative, because only a few control points on the datum bed are known; the contours were interpreted largely from Goldman's [22] structure contour map of the exposed rocks.

The exposed rocks are cut by two faults that trend northwest in the E½E½ sec. 13, and by three faults that trend northwest in secs. 35 and 36. The vertical displacement along each fault is only a few feet. The data are insufficient to determine whether the deeply buried rocks are displaced.

DOME IN SECS. 1 AND 2

On a low dome in secs. 1 and 2 oil is produced from the Taneha sand in two wells at a depth of about 2,130 feet, and gas is produced from the Bartlesville sand in one well at a depth of 1,970 feet. The initial daily yield of one of the oil wells was 35 barrels, and that of the other was 100 barrels; the initial daily yield of the gas well was 5 million cubic feet. The total yield of gas was not learned, but the yield of oil in the NE¼ sec. 2 from August 1927 to the end of 1937 was 55,819 barrels, and the total yield in the SE¼ sec. 2 from June 1928 to the end of 1937 was 56,534 barrels.

Additional wells on the dome might obtain oil from the Taneha sand, and others might obtain gas from the Bartlesville sand. As the dome lies in a region that yields oil from Ordovician rocks, one of the wells now producing from the Taneha sand should be deepened to the Siliceous lime before it is abandoned, or a well should be drilled into this lime in the southwest corner of the SE¼NE¼ sec. 2.

ANTICLINAL NOSE IN SECS. 4, 8, AND 9

An anticlinal nose projects southwestward from the Prue dome, whose crest is in sec. 34, T. 21 N., R. 10 E. The axis of the nose

[22] Goldman, M. I., in White, David, and others, Structure and oil and gas resources of the Osage Reservation, Okla.: U. S. Geol. Survey Bull. 686, pl. 50, 1922.

extends southwestward across sec. 4, the NW¼NW¼ sec. 9, and the NE¼ sec. 8, T. 20 N., R. 10 E. Several wells in the SW¼ sec. 4 and the NW¼ sec. 9 on the nose yield gas from the Mussellem and Peoples sand zone. The sand is from 5 to 40 feet thick and lies at depths ranging from 280 to 420 feet. The initial daily yields of the gas wells ranged from 125,000 to 4,000,000 cubic feet.

Well 114 in the NW¼ sec. 9 produced initially 75 barrels of oil a day, but there is considerable doubt as to the real identity of the zone yielding this oil, although it is shown on plate 8 as the Mussellem and Peoples sand zone. The well penetrated the Burgess sand-Mississippi lime zone but was plugged back to a shallower depth. It produced a total of 5,172 barrels from May 1929 to March 1936, when it was abandoned. Well 120, now abandoned, produced gas from the Mussellem and Peoples sand zone in the SE¼NW¼SW¼ sec. 4 on the anticlinal nose and also tested the Ordovician rocks, but they yielded neither oil nor gas. Several wells tested the Burgess sand-Mississippi lime zone, but without success.

ANTICLINAL NOSE IN SECS. 23 AND 24

Well 92 in the NW¼SE¼SE¼ sec. 23 produced gas from the Bartlesville sand at a depth of about 2,100 feet. Its initial daily yield was 5½ million cubic feet. The well is on an anticlinal nose that trends northwest through the S½ sec. 24 and through sec. 23. Well 1 in the southwest corner of the NW¼ sec. 24, low on the northeast flank of the nose, produced intially 2½ million cubic feet of gas from Ordovician rocks at a depth of about 2,500 feet. Four other wells, all of which are low on the flanks of the fold, tested the Ordovician rocks, but found neither oil nor gas.

ANTICLINAL NOSE IN SECS. 27, 28, AND 29

A low anticlinal nose trends southwest through secs. 27, 28, and 29 (pl. 8). Gas is produced in three wells in widely separated localities on the nose, and oil is produced in one well. Well 1 in the northwest corner of the SW¼ sec. 27 produced initially 8,300,000 cubic feet of gas a day from the Burgess sand-Mississippi lime zone at a depth of 2,380 feet. Well 109 near the center of the NE¼ sec. 28 produced initially 750,000 cubic feet a day from the Taneha sand at a depth of 2,315 feet. Well 1 in the northeast corner of the SE¼ sec. 29 produced initially 23½ million cubic feet of gas from the Bartlesville sand at a depth of 2,150 feet. Well 1 in the southwest corner of the NW¼ sec. 28 produced initially 20 barrels of oil a day from the Taneha sand after finding water in the Ordovician rocks. The well was completed in January 1926 and had produced a total of 30,436 barrels by the end of 1937. Two other wells in sec. 28, on the anticlinal nose found water in the Ordovician rocks.

DOME IN SECS. 32 AND 33

The north flank of a dome whose crest is in T. 19 N., R. 10 E., occupies parts of secs. 32 and 33, T. 20 N., R. 10 E. Two dry holes and a well that produced oil for about 1½ years were drilled on the flank of the dome in secs. 32 and 33. The well yielded initially 150 barrels of oil a day from the lower part of the Simpson formation at a depth of 2,605 feet. The total yield from the well from January 1926 to June 1927 was 3,784 barrels.

SEC. 34

Three wells near the center of sec. 34 produced oil from the Taneha sand at a depth of about 2,225 feet. The initial daily yields of the wells ranged from 22 to 65 barrels. One of them was deepened into the Ordovician rocks and one tested the Burgess sand-Mississippi lime zone without discovering oil or gas. The total amount of oil produced to the end of 1937 is shown in the following table:

Oil produced in sec. 34, T. 20 N., R. 10 E.

Tract	Date of first production	Production to end of 1937 (barrels)	Remarks
NE¼ sec. 34	December 1929	2,638	Abandoned in May 1933.
NW¼ sec. 34	June 1930	22,162	
SE¼ sec. 34	July 1929	4,735	Abandoned in September 1933.
		29,535	

SEC. 36

Well 217 in the NE¼SE¼NW¼ sec. 36 produced initially 5 million cubic feet of gas a day from the Taneha sand at a depth of 1,995 feet. Several dry holes were drilled in the S½S½ sec. 25 and in sec. 36. The well in the southwest corner of sec. 36 is reported to have had an initial yield of 10 barrels of oil a day from the Burgess sand-Mississippi lime zone, but the total amount it has produced is not known.

T. 21 N., R. 10 E.

T. 21 N., R. 10 E., is in southeastern Osage County, and its southeast corner is 11 miles northwest of Tulsa. About 350 wells have been drilled in the 6 principal oil and gas fields of the township. These 6 fields occupy a total area of about 4 square miles.

Nine zones yield oil or gas in T. 21 N., R. 10 E. Of these, the Cleveland sand is a prolific producer of oil in the Wildhorse field at a depth of 1,100 to 1,300 feet; the Bartlesville sand yields oil or gas in many localities and is particularly productive on the Madalene anticline at a depth of about 1,900 feet; the Squirrel (Prue) sand has proved profitable at a depth of 1,500 to 1,600 feet in about 40 wells; and Ordovician rocks have yielded oil at high initial rates at a depth

of 2,300 to 2,400 feet in several wells on the East Madalene dome and the South Wildhorse anticline.

Development of the oil and gas resources of T. 21 N., R. 10 E., began as early as 1910 on the Prue dome; most of the wells in the Wildhorse field were drilled from 1915 to 1920; those on the Madalene anticline from 1917 to 1919, but a few from 1924 to 1926; most of those on the East Madalene dome, in 1923 to 1925; most of those on the South Wildhorse anticline, from 1925 to 1931; and most of those in secs. 19, 30, and 31, from 1928 to 1930. Several localities that appear favorable for further development are described in connection with the detailed descriptions of the different structural features in this township.

The subsurface investigation of T. 21 N., R. 10 E., was conducted in 1935, mainly by W. R. Dillard and Otto Leatherock. The data on production were compiled in 1938 by Miss Anna L. Weinrich, of the Osage Indian Agency, from records on file at the agency.

STRUCTURE AND DEVELOPMENT

The regional dip of the rocks in T. 21 N., R. 10 E., is slightly south of west at an average rate of about 45 feet to the mile as measured on the top of the Oswego lime. This general attitude of the rocks, however, is interrupted by several prominent anticlines and synclines, which are shown on plate 8. The nine or more major folds include a part of the large Wildhorse anticline, which lies mainly in T. 22 N., R. 10 E., the South Wildhorse and Madalene anticlines, and the East Madalene and Prue domes. The Prue and East Madalene domes and the South Wildhorse anticline form an irregular northward-trending anticlinal belt. This belt is bordered on the east by a relatively deep syncline that trends northeastward through secs. 35, 26, 24, and 13 and farther northward merges wtih the structural basin whose center is in the NW¼ sec. 12. A broad syncline extends northeastward from the NW¼ sec. 30 through secs. 19, 20, 21, and 22. Another deep syncline plunges southwest from the northeast corner of sec. 3 across secs. 3, 4, and 9 into the SE¼ sec. 8, where it changes its course and passes northwestward through secs. 8, 7, and 6.

The distribution of the wells indicates that the accumulations of oil and gas in this township are controlled by the local upfolds, because most of the oil and gas fields are on domes and anticlines. On the other hand, the occurrence of oil in the Squirrel sand low on the west flank of the East Madalene dome is doubtless controlled by the character and thickness of the reservoir sand rather than by its attitude.

Anticlines and other structural features as mapped on a subsurface datum or key bed in this region commonly do not agree in horizontal position with the same features as mapped on the exposed rocks, and

the variation in position may amount to some hundreds or even thousands of feet. Steeper dips are noticeable at depth on a given anticline; thus a subsurface dome may be smaller and more difficult to locate in the Ordovician rocks than in the exposed rocks.

MADALENE ANTICLINE

The Madalene anticline occupies parts of secs. 16, 17, and 18. It plunges westward and has three subsidiary domes, all of low structural relief. About 70 wells were drilled on this anticline some 20 years ago, of which at least 40 are still producing oil or gas. The oil and gas in all the wells except two are derived mainly from the Bartlesville sand. Well 2 in the NW¼SW¼ sec. 16 produces oil from the Mussellem and Peoples sand zone as well as from the Bartlesville sand; and well 6 in the SW¼NW¼ sec. 17 produces oil from the Squirrel sand as well as from the Bartlesville, but the color overprint symbol for only the Bartlesville is shown on these wells on plate 8. The Peru sand produced initially 50 barrels of oil a day from well 2, in the SW¼NE¼ sec. 17.

The Bartlesville sand lies at a depth of about 2,000 feet. This bed is lenticular and ranges from about 35 to 130 feet in thickness. The initial daily yields of the Bartlesville sand ranged from 10 to 220 barrels of oil, and the average initial daily yield was about 50 barrels. The logs of some wells record water in the lower part of the sand. Twelve wells on the anticline penetrated the Burgess sand-Mississippi lime zone and 7 wells were drilled into Ordovician rocks. None of these produced oil or gas, although several had shows of oil. Several of the wells that reach Ordovician rocks are low on the flanks of the anticline but 2 that are on or near its crest constitute valid tests. No well, however, has tested the Ordovician rocks on the main dome, whose crest is near the center of the W½NW¼ sec. 17.

The total amount of oil produced to the end of 1937 from the Madalene anticline is shown in the following table:

Oil produced from the Madalene anticline

Tract	Date of first production	Production to end of 1937 (barrels)	Remarks
NE¼ sec. 16	May 1919	4,693	Abandoned in September 1921.
NW¼ sec. 16	November 1918	351,204	Abandoned in March 1930.
SE¼ sec. 16	do	27,980	Abandoned in March 1930.
SW¼ sec. 16	May 1917	252,149	
SE¼ sec. 17	May 1918	117,398	
NW¼ sec. 17	August 1919	202,984	
SE¼ sec. 17	September 1917	380,129	
SW¼ sec. 17	August 1917	259,127	
NE¼ sec. 18	July 1924	98,619	
SE¼ sec. 18	January 1921	22,087	Abandoned in June 1928.
		1,716,370	

SOUTHERN PART OF THE WILDHORSE FIELD

Most of the Wildhorse anticline and oil field lies in T. 22 N., R. 10 E., and is described in an earlier report on that township.[23] The southern flank of the anticline extends into secs. 3, 4, and 5, T. 21 N., R. 10 E., where many wells produce from the Bartlesville sand and many others from the Cleveland sand. Several of the wells are structurally more than 60 feet lower than the lowest closing contour of the main anticline. The average initial yield of wells producing from the Bartlesville sand was about 50 barrels of oil a day, and that of wells producing from the Cleveland sand was about 40 barrels. The Cleveland sand lies at a depth of about 1,200 feet, and the Bartlesville sand at a depth of about 1,900 feet. Only one well produces oil from the Jones sand.

Of the five wells that penetrated rocks below the Bartlesville sand, well 17 in the SW¼NW¼ sec. 4, and well 3, in the NE¼NE¼ sec. 5, produced small amounts of oil from the Burgess sand-Mississippi lime zone. Well 1, in the northwest corner of the SE¼ sec. 4, and well 22 in the southwest corner of the NE¼ sec. 5, are low on the south flank of the anticline and, therefore, are poorly situated for testing the Ordovician rocks.

The total amount of oil produced to the end of 1937 in secs. 3, 4, and 5 is shown in the following table:

Oil produced from the Wildhorse anticline in secs. 3, 4, and 5, T. 21 N., R. 10 E.

Tract	Date of first production	Production to end of 1937 (barrels)	Remarks
NW¼ sec. 3	July 1920	185	Abandoned in March 1921.
SW¼ sec. 3	May 1920	29,777	
NE¼ sec. 4	April 1918	159,331	
NW¼ sec. 4	Prior to July 1916	[1] 1,246,925	
SW¼ sec. 4	October 1917	1,295,265	
NE¼ sec. 5	Prior to July 1916	[1] 1,145,917	
NW¼ sec. 5	November 1918	24,520	Abandoned in October 1928.
SE¼ sec. 5	September 1917	20,004	Abandoned in October 1919.
		3,921,924	

[1] Does not include amount produced prior to July 1916.

SOUTH WILDHORSE ANTICLINE

The South Wildhorse anticline lies mainly in secs. 2, 10, and 11, and its crest is in the NW¼ sec. 11. The structural closure on the anticline is about 35 feet on the top of the Oswego lime and about half as large in the exposed rocks. The crest of the anticline in the exposed rocks[24] is near the center of the west line of the SW¼ sec.

[23] Bass, N. W., Kennedy, L. E., Dillard, W. R., Leatherock, Otto, and Hengst, J. H., Subsurface geology and oil and gas resources of Osage County, Okla.: U. S. Geol. Survey Bull. 900–A, pp. 8 and 9, 1938.

[24] Wood, R. H., Unpublished map of parts of the Hominy quadrangle in Geological Survey files.

11, about half a mile southwest of its position in the Oswego lime (pl. 8). On the South Wildhorse anticline 14 wells, two of which have been abandoned, have produced oil; 12 wells, 7 of which have been abandoned, have produced gas; and 5 wells were completed as dry holes.

Oil and gas have been produced on the anticline from six zones, of which the Siliceous lime has yielded the most oil. Gas was found in a few wells in the Squirrel and Bartlesville sands, and water was found in a few in the lower part of the Bartlesville sand. The initial daily yield of well 694 in the NW¼SW¼ sec. 11 was 7¾ million cubic feet of gas. Well 2 in the SE¼SW¼NW¼ sec. 11 produced initially 18 million cubic feet of gas a day from the Bartlesville sand but was not completed as a gas well. The initial daily yields of most of the other gas wells ranged from 250,000 to 2,500,000 cubic feet a day. The Burgess sand-Mississippi lime zone yielded oil in three wells, two of which are in sec. 11, near the crest of the anticline, and one in the southeast corner of the NE¼ sec. 10, on the west flank. The Skinner sand yielded oil in one well in sec. 10, low on the west flank of the anticline. The Mussellem and Peoples sand zone yields gas in one well in the southeast corner of the SW¼ sec. 2, near the crest of the fold. The total amount of oil produced to the end of 1937 from the South Wildhorse anticline is shown in the following table:

Oil produced from the South Wildhorse anticline

Tract	Date of first production	Production to end of 1937 (barrels)	Remarks
NE¼ sec. 10	September 1925	48,202	Abandoned in November 1929.
SE¼ sec. 10	May 1926	52,355	
NW¼ sec. 11	July 1925	179,340	
SW¼ sec. 11	September 1925	116,814	
		396,711	

EAST MADALENE DOME

Oil is produced in two small tracts on the East Madalene dome, whose crest is mostly in the SE¼ sec. 14. Gas is produced on one of the tracts. Eleven wells near the crest of the dome, four of which are now abandoned, have produced oil from Ordovician rocks at a depth of about 2,400 feet. One of these wells yielded initially 350 barrels a day, but most of the others yielded less than 50 barrels a day. The Bartlesville sand yielded gas in two wells near the crest of the dome and in three wells in the N½ sec. 14, on the northwest flank of the dome, at a depth of about 1,900 feet. The initial daily yields of the gas wells ranged from 250,000 to 5,000,000 cubic feet. The Bartlesville sand also yielded oil, at the initial daily rate of 14 barrels, from a well completed in 1936 in the NE¼ sec. 14. Gas was found here in the Bartlesville

sand as early as 1917, and drilling for oil in the Ordovician rocks began in 1924 and continued into 1928. Unless the existing wells in the NE¼ sec. 23 should produce large amounts of water, it appears probable that drilling to the Ordovician rocks in the northwest corner of the SE¼NE¼ sec. 23, would provide an additional producing well, inasmuch as wells in the NE¼NE¼ sec. 23 had large initial yields.

One of the most consistently producing oil areas yet discovered in T. 21 N., R. 10 E., lies in the SW¼ sec. 14, the W½ sec. 23, and the E½ sec. 22, low on the west and southwest flanks of the East Madalene dome. The rocks here evidently have no eastward structural closure, but the well logs show that the oil-bearing Squirrel sand, which is about 25 feet thick and porous, changes toward the east to nonporous sandy shale. Therefore, the east margin of the oil reservoir appears to be indicated by a change from porous to nonporous sediments. The depth to the Squirrel sand is about 1,600 feet. The initial yields of the wells ranged from 8 to 700 barrels of oil a day. Six wells near the margin of the oil-producing area tested Ordovician rocks. Dry holes have defined the limits of the producing area in the Squirrel sand except on the west.

A small dome that has a closure of less than 20 feet on the top of the Oswego lime (pl. 8) lies in the NW¼ sec. 14, on the northwest flank of the East Madalene dome and on the structural ridge that connects that dome with the South Wildhorse anticline. A deep test well, drilled on the dome in 1925, yielded a show of gas from the Squirrel sand at a depth of 1,600 feet. It was abandoned as a dry hole, however, at a total depth of 2,520 feet, after penetrating rocks that probably belong to the Siliceuos lime. Two wells nearby produced initially 500,000 and 1,500,000 cubic feet of gas a day. One of them produced from the Squirrel sand, and the other from the Bartlesville sand.

The total amount of oil produced to the end of 1937 from the East Madalene dome is shown in the following table:

Oil produced from the East Madalene dome

Tract	Date of first production	Production to end of 1937 (barrels)	Remarks
SW¼ sec. 13	April 1918	17,038	Abandoned in September 1924.
NE¼ sec. 14	April 1937	1,058	
NW¼ sec. 14	November 1925	206	Abandoned in April 1927.
SW¼ sec. 14	September 1924	193,908	
SE¼ sec. 14	May 1924	43,246	
NE¼ sec. 22	April 1924	121,303	
SE¼ sec. 22	August 1927	3,905	
NE¼ sec. 23	May 1920	131,790	
NW¼ sec. 23	July 1923	936,638	
SW¼ sec. 23	January 1924	8,737	
		1,456,771	

PRUE DOME

The Prue dome is a fold of irregular shape that occupies parts of secs. 26, 27, and 28 as well as parts of secs. 33, 34, and 35, T. 21 N., R. 10 E. Its structural closure on the top of the Oswego lime is about 30 feet. The exposed rocks are structurally highest near the center of the NW¼SE¼ sec. 27.[25]

About 30 wells, each of which produces either oil or gas, have been drilled on the Prue dome. About half of these produce from the Squirrel sand and the other half from the Bartlesville sand. The average initial daily yield of the gas wells was 6 million cubic feet, and the maximum initial yield of a single well was 14 million cubic feet. The average initial daily yield of the oil wells was about 35 barrels, and the maximum daily yield of a single well was 150 barrels. The depth to the top of the Squirrel sand ranges from 1,500 to 1,600 feet, and the depth to the top of the Bartlesville sand from 1,900 to 2,000 feet. Ordovician rocks were tested in three wells on the dome but failed to yield oil or gas. The wide distribution of wells that produce oil from the Bartlesville sand indicates that additional producers could be obtained from this sand in areas lying between the present producing wells.

The total amount of oil produced to the end of 1937 from the Prue dome is shown in the following table:

Oil produced from the Prue dome

Tract	Date of first production	Production to end of 1937 (barrels)	Remarks
NW¼ sec. 27	March 1928	15,235	
SW¼ sec. 27	February 1926	47,985	
SE¼ sec. 27	April 1926	11,846	Abandoned in December 1933.
SW¼ sec. 28	January 1925	5,048	
SE¼ sec. 28	January 1927	23,515	
NE¼ sec. 33	August 1927	51,383	
SE¼ sec. 33	January 1922	4,219	Abandoned in December 1935.
NE¼ sec. 34	January 1920	10,492	Do.
NW¼ sec. 34	August 1920	11,626	Abandoned in November 1937.
SW¼ sec. 34	January 1921	54,082	Abandoned in May 1935.
		235,431	

SECS. 19, 30, AND 31

The W½ sec. 19 contains the eastern part of a dome whose crest is in sec. 24, T. 21 N., R. 9 E. Four gas wells in sec. 19 had initial daily yields of 4½, 8, 16, and 25 million cubic feet of gas from the Bartlesville sand. The sand is about 100 feet in thickness and lies at a depth of about 2,100 feet. Two dry holes low on the flanks of the dome tested the Ordovician rocks.

[25] Wood R. H., op. cit.

Several wells in the S½ sec. 30 and one well in the NW¼NE¼ sec. 31 produced oil or gas from the Bartlesville sand at a depth of about 2,000 feet. One well in the SW¼ sec. 30 produced oil at an initial daily rate of 115 barrels from the Big lime and Peru sand zone at a depth of about 1,550 feet. The wells are on an anticlinal nose that plunges southwestward through sec. 30 into the N½ sec. 31. The initial daily yields of the oil wells ranged from 15 to 115 barrels, and the initial daily yields of the gas wells ranged from 1½ to 6½ million cubic feet.

The total amount of oil produced to the end of 1937 from the wells in secs. 30 and 31 is shown in the following table:

Oil produced in secs. 30 and 31, T. 21 N., R. 10 E.

Tract	Date of first production	Production to end of 1937 (barrels)	Remarks
NW¼ sec. 30	December 1925	1,682	Abandoned May 1927.
SW¼ sec. 30	June 1928	16,036	
SE¼ sec. 30	February 1929	77,591	
NE¼ sec. 31	March 1929	12,522	
		107,831	

E½ SEC. 26 AND W½ SEC. 25

Several wells on an anticlinal nose in the E½ sec. 26 (pl. 8) produce oil from the Bartlesville sand, and one well in the southwest corner sec. 25 produces oil from the Burgess sand-Mississippi lime zone. The Bartlesville sand is encountered at a depth of about 1,950 feet, and the Burgess sand-Mississippi lime zone at a depth of about 2,200 feet. The initial daily yields of most of the wells were less than 50 barrels. The well in the southwest corner of sec. 25 began producing oil in May 1933 and had yielded a total of 5,726 barrels by the end of 1937. The total yield from the wells in the SE¼ sec. 26 from May 1933 to the end of 1937 was 5,647 barrels.

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