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

PART 2. Townships 22 and 23 North Ranges 8 and 9 East

BY

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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 from 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., Tide Water Associated 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 the 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, Foster Morrell, 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.

CONTENTS

ILLUSTRATION

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

Part 2. Townships 22 and 23 North, Ranges 8 and 9 East

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ABSTRACT

The four townships—Tps. 22 and 23 N., Rs. 8 and 9 E.—whose subsurface geology and oil and gas resources are described in this report, lie in southeastern Osage County, Okla., 20 miles northwest of Tulsa. Hominy is near the middle of the area, and Cleveland is a mile south of the area. This part of Osage County contains many producing oil fields, some of which are 20 years old. Such well-known oil fields as the Pettit, Hominy, East Hominy, and Osage-Hominy, and a part of the Boston occur in these townships. About 900 wells, which include oil wells, gas wells, and dry holes, have been drilled in the four townships. Additional wells were being drilled in 1937. Oil or gas has been produced from 15 beds of sandstone, limestone, and dolomite, which lie at depths ranging from 200 to about 2,900 feet. All except two of the oil- and gas-producing beds are in the Pennsylvanian series; one is in the Mississippian series and one is in the Ordovician system. The oil- and gas-bearing beds in the Ordovician system, however, range through a relatively thick sequence of rocks. The main Ordovician producing beds consist of cherty dolomite and dolomite in the uppermost 50 feet of the Siliceous lime, but some oil and gas are found also in the beds of sandstone in the overlying Simpson formation.

Tps. 22 and 23 N., Rs. 8 and 9 E., are in the midst of a region that includes most of northeastern Oklahoma in which the rocks dip westward at an average rate of about 40 feet to the mile. The regional dip is not uniform, however, but is interrupted by local folds. The most prominent local structural features are domes that are of small areal extent but have relatively steep dips. Most of the domes have structural closures of less than 100 feet on the Oswego lime (pl. 2). There appears to be no very systematic arrangement of the domes, but the steeply folded and gently folded areas in these townships and the surrounding region appear to be aligned in poorly defined belts. A belt that contains many steeply folded domes extends northeastward from the vicinity of Cushing, Okla., through the western part of Tps. 22 and 23 N., Rs. 8 and 9 E., to the vicinity of Pawhuska in central Osage County. This belt is flanked on the east and the west by belts of country that are essentially devoid of steeply folded domes.

The folds in the exposed rocks conform in general shape and position to the subsurface folds, but few of the crests of domes in the exposed rocks lie directly above the crests of domes in the buried rocks, and the structural relief increases with depth. The exposed rocks are cut by many short normal faults which

trend northwestward and are arranged in a narrow belt that trends northward through the westernmost part of Tps. 22 and 23 N., R. 8 E.[1] The individual faults within the belt are arranged en echelon. In few places does the displacement of exposed beds exceed 50 feet. The data are too meager to determine whether the deeply buried rocks also are faulted.

The oil and gas deposits in Ordovician beds and in the Mississippi lime, and to a less extent in several oil- and gas-bearing beds, are concentrated in the structurally high part of the domes and anticlines. The occurrence of oil and gas in the Bartlesville and Layton sands and probably in several other sands is controlled primarily by the distribution of the sand beds, which characteristically occur as lenses of small extent.

The investigation has shown that there are several areas in Tps. 22 and 23 N., Rs. 8 and 9 E., that are prospectively valuable for oil and gas but have not been tested; that several producing oil fields probably contain oil and gas in other beds both shallower and deeper than those already developed; that the continuance of the practice of treating limy reservoir beds with acid will result in increased yields of oil and gas; and that additional oil will eventually be produced by water-flooding several of the oil-producing sands, including the Okesa, Bartlesville, and other sands.

INTRODUCTION

The subsurface structural features, the oil- and gas-producing beds, and the areas that are favorable for the discovery of additional oil and gas in Tps. 22 and 23 N., Rs. 8 and 9 E., Osage County, Okla., are described in this report, which is the second of a series of reports covering parts of Osage County. The structure of the buried rocks, the oil and gas wells, abandoned wells and dry holes, and the ownership of leases are shown on the accompanying map (pl. 2). The oil- or gas-bearing beds in each well, producing or abandoned, and the deepest rocks penetrated in dry holes are shown on the map by color tints over the black well symbols. Wells that produced oil or gas from shallow beds and were drilled deeper to test older rocks are indicated by special symbols.

All beds penetrated by the drill in Tps. 22 and 23 N., Rs. 8 and 9 E., are shown graphically on a generalized columnar section on plate 2. The beds that produce oil or gas are indicated on the columnar section by colored solid circles. The colors on the columnar section correspond to the color overprint on the wells shown on the structure-contour map. The oil- and gas-producing beds in each of the four townships are shown also in the following table:

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

Oil- or gas- producing beds in Tps. 22 and 23 N., Rs. 8 and 9 E., Osage County, Okla.

T. 22 N., R. 8 E.	T. 23 N., R. 8 E.	T. 22 N., R. 9 E.	T. 23 N., R. 9 E.
Cochahee sand.	Revard.		Bigheart sand.
Okesa and Torpedo sands.	Okesa and Torpedo sands.	Okesa and Torpedo sands.	Okesa and Torpedo sands.
	Mussellem and Peoples sands.	Mussellem and Peoples sands.	Mussellem and Peoples sands.
Layton sand.	Layton sand.	Layton sand.	Layton sand.
		Jones sand.	
Cleveland sand.	Cleveland sand.	Cleveland sand.	
Oswego lime.	Oswego lime.		
	Squirrel sand.		
Skinner sand.	Skinner sand.	Skinner sand.	
Bartlesville sand.	Bartlesville sand.	Bartlesville sand.	Bartlesville 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, which belong to the Nelagoney, Elgin sandstone, Pawhuska, and Buck Creek formations of the Pennsylvanian series are shown on the State geologic map of Oklahoma.[2] The attitude of the exposed rocks in Tps. 22 and 23 N., Rs. 8 and 9 E., is shown on an unpublished map prepared by Wood[3] between 1912 and 1917. Wood's map was used extensively in the drawing of the structure contours on plate 2.

OIL- AND GAS-PRODUCING BEDS

Oil or gas has been produced in Tps. 22 and 23 N., Rs. 8 and 9 E., from 15 beds ranging from the uppermost part of the Siliceous lime of Ordovician age upward to the Cochahee sandstone member of the Nelagoney formation of the Pennsylvanian series. Wells that produce oil from the Siliceous lime have yielded the largest flows of all wells in the area. The Bartlesville sand and the Mississippi lime are important oil-producing beds. Because of its shallow depth (450 to 500 feet) the Okesa sand is relatively important as an oil producer in T. 23 N., R. 9 E. The oil- or gas-producing beds, from oldest to youngest, are described briefly on the following pages.

SILICEOUS LIME AND SIMPSON FORMATION

Oil and gas occur in the Siliceous lime and the Simpson formation, but mainly in the Siliceous lime, in several localities in Tps. 22 and 23 N., Rs. 8 and 9 E. The Hominy field on the Hominy dome in T. 22 N., Rs. 8 and 9 E., and the Pettit field on the Pettit dome in T. 23 N., R. 8 E., are two important oil fields that have produced much oil from these beds. The upper part of the Siliceous lime and the Simpson formation as defined by Luther White[4] belong to the Ordovician

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

[3] Wood, R. H., Unpublished map of parts of the Hominy quadrangle, in U. S. Geol. Survey files.

[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, pp. 24 (table), 29–32, 1928.

system. The Simpson formation is separated from the underlying Siliceous lime by an unconformity, but in most wells it is impossible to differentiate them without examining the drill samples with a microscope. Only a few microscopic examinations of drill samples of these beds were made by the writers, but the results of examinations made in some of the fields by geologists of oil companies were furnished by the oil companies. However, in many wells whose only records are the drillers' logs, a precise separation of the Siliceous lime and the Simpson formation was not made.

The Siliceous lime is a better oil producer in Tps. 22 and 23 N., Rs. 8 and 9 E., than the Simpson formation. Oil wells with initial daily yields of 3,000 to 8,000 barrels from the Siliceous lime are not uncommon, although most wells yield initially only a few hundred barrels. The Siliceous lime contains oil in the higher parts of steeply folded domes. The oil is closely associated with salt water, and the producing wells commonly yield much water. Nearly everywhere that wells penetrated the upper part of the Siliceous lime without obtaining oil they found "a hole full of water." The gravity of the oil in the Siliceous lime in southern Osage County ranges from 37° to 41°, A. P. I. scale.

The oil-bearing portion of the Siliceous lime in most places is confined to the uppermost 2 to 50 feet. The reservoir beds commonly are finely crystalline dolomite that contains some chert. In many fields the uppermost beds of the formation are weathered. The oil-bearing beds in different fields, although near the upper boundary of the Siliceous lime, probably occur at different stratigraphic positions, owing to the fact that the Siliceous lime was folded and eroded prior to the deposition of the Simpson formation.[5] Deep wells in Osage County indicate that the Siliceous lime is commonly 1,000 feet or more thick, but on sharply arched domes it is very thin and locally is absent from the tops of some peaks of pre-Cambrian crystalline rock. For example, in the SE¼ sec. 25, T. 23 N., R. 8 E., the Mississippi lime lies on pre-Cambrian red granite and Ordovician beds are confined to the flanks of the dome. The comparatively shallow depth of the pre-Cambrian rocks in the SW¼ sec. 9, T. 23 N., R. 8 E., and in the NW¼ sec. 14, T. 22 N., R. 8 E., also suggests that the Siliceous lime is thin over all sharply folded domes in this region.

In this part of Osage County the Simpson formation represents a thin northward-tapering wedge of a sequence of beds that is thick south of Osage County. The wedge has a maximum thickness of about 175 feet in T. 22 N., R. 8 E. The Simpson formation in this area consists of alternating beds of green shale and sandstone and locally of red shale or dolomite in the upper part and of beds of sand-

[5] White, L. H., op. cit., pp. 27-28.

stone in the lower part. The upper shaly part is called by White [6] the "Tyner formation," and the lower sandstone unit, the "Burgen sand." In the samples from the few wells examined the beds of sandstone in the Simpson formation consist of fine to medium and coarse, subround to subangular quartz grains. The shale beds are mostly light green.

The lower sandstone of the Simpson formation is known locally as the Hominy sand. It was named from the Hominy field, in T. 22 N., Rs. 8 and 9 E., because at the time of the early development of the field it was believed that this sand was the main oil-producing bed. Later, however, through microscopic examination of well samples, oil company geologists learned that most of the oil was found in the underlying Siliceous lime.[7] However, the name "Hominy sand" has continued to be applied locally to beds of sandstone in the lower part of the Simpson formation. White states that in many places the Hominy sand is so tightly cemented that it is virtually a quartzite and is, therefore, a poor reservoir for oil. However, the sand yields oil in several places and yields gas in some places in Tps. 22 and 23 N., Rs. 8 and 9 E. Many wells find water in the upper part of the Simpson formation and oil or gas in the lower part. Many such wells obtain much additional oil after being drilled deeper into the uppermost beds of the Siliceous lime.

BURGESS SAND-MISSISSIPPI LIME ZONE

Beds that occur at or near the contact of the Mississippi lime and the Cherokee shale yield oil and gas. The Burgess sand occurs locally at the base of the Cherokee shale, overlying the uppermost chert beds of the Mississippi lime. The chert is crushed during drilling into fine angular particles that resemble the sand grains and has been recorded as sand in the logs of many wells. Therefore, it is impossible to distinguish accurately the contact of the Burgess sand and the Mississippi lime as recorded in the drillers' logs. However, in Tps. 22 and 23 N., Rs. 8 and 9 E., the important oil- and gas-bearing beds occur in the Mississippi lime, from a few feet to about 60 feet below its top. The logs of many wells and cuttings from a few wells indicate that the Burgess sand is a thin bed composed of a mixture of fine to coarse, angular to rounded quartz sand and weathered bone-white chert, which is underlain by weathered and fresh light-colored chert of the Mississippi lime. Aside from beds of weathered and unweathered chert, the uppermost part of the Mississippi lime contains beds of light-gray and dark-gray crystalline limestone and cherty limestone.

[6] White, L. H., op. cit., pp. 30-31.
[7] White, L. H., op. cit., pp. 29-30.

The Osage-Hominy oil field in the northwestern part of T. 23 N., R. 8 E., is the largest area that produces oil from these beds. Here the oil is found in two to four beds that occur from 10 to 60 feet below the top of the Mississippi lime. A few wells found small amounts of gas in beds reported as sand at the contact of the Cherokee shale and the Mississippi lime. Several wells in widely separated localities in Tps. 22 and 23 N., Rs. 8 and 9 E., found shows of oil and gas from 110 to 130 feet below the top of the Mississippi lime. These shows might be important because in T. 22 N., R. 10 E., oil wells with large initial yields but short lives have been completed in beds that are from 30 to 75 feet below the top of the Mississippi lime. Locally in Osage County limestone is associated with the chert in the Mississippi lime reservoir beds, and in such areas acid treatment of the beds has resulted in increased yields of oil.

BARTLESVILLE SAND

The Bartlesville sand is the most important oil-producing bed in southeastern Osage County and throughout much of the oil-bearing portion of northeastern Oklahoma. The East Hominy field, on the East Hominy anticline in T. 22 N., R. 9 E., and the North Manion field, on the North Manion anticline in T. 23 N., R. 8 E., are the principal areas producing oil from the Bartlesville sand in Tps. 22 and 23 N., Rs. 8 and 9 E., but there are several other small oil-producing tracts. The Bartlesville sand occurs as lenses in the lower part of the Cherokee shale. It is not present over the entire area, but in most places where it is fairly thick and free from many shale beds it yields oil and gas.

Microscopic examination of well samples shows that the sand is composed mainly of quartz and minor amounts of other minerals, including mica and feldspar; the sand grains are subangular and of fine and medium size. It is similar in composition and physical character to the Burbank (Red Fork) sand, which occurs somewhat higher in the Cherokee shale than the Bartlesville sand and is an important oil producer in western Osage County, Okla., and Cowley, Butler, and Greenwood Counties, Kans. The Bartlesville sand is similar in character also to the Bluejacket sandstone member of the Cherokee, which crops out in northeastern Oklahoma and southeastern Kansas and is probably equivalent to a portion of the Bartlesville sand.

The Bartlesville sand body in the East Hominy field is about 100 feet below the Pink lime, which is a persistent thin bed in the Cherokee shale in this part of Osage County. The sand body in the North Manion field is from 70 to 90 feet below the Pink lime. The Inola (?) lime is recorded immediately above the Bartlesville sand or separated

from it by a shale bed that is 10 to 25 feet thick, as shown by the logs of many wells in the North Manion field. The Inola (?) lime is recorded in only a few well logs in the East Hominy field. In the eastern part of Tps. 22 and 23 N., R. 9 E., the Bartlesville sand is separated from the Mississippi lime below by a shale bed about 50 feet thick, but in much of these four townships the sand lies only 10 to 25 feet above the Mississippi lime and locally lies directly on it. The part of the Cherokee shale that is above the position of the Bartlesville sand has a fairly constant thickness in this area.

In northeastern Oklahoma the Bartlesville sand occupies a large area that includes much of the southeastern third of Osage County.[8] Much of the northern two-thirds of T. 22 N., R. 8 E., and the western third of T. 23 N., R. 8 E., lie west of and outside the Bartlesville sand area, but these parts of the townships contain a few relatively small tracts of the Bartlesville sand. The east half of T. 23 N., R. 9 E., contains no oil fields in the Bartlesville sand, although it is surrounded by large tracts of oil-producing Bartlesville sand. In most of the wells in the east half of T. 23 N., R. 9 E., the Bartlesville sand was found, and in several wells it yielded shows of oil and gas.

A microscopic examination of cuttings of several wells in Tps. 22 and 23 N., Rs. 8 and 9 E., was made in connection with a special study of the Bartlesville and Burbank sands throughout parts of northeastern Oklahoma, including Osage County, and southeastern Kansas. Briefly, this investigation showed that the Bartlesville sand was deposited as a series of beach deposits on the western shore of the Cherokee sea;[9] that the oil-bearing sand occurs as lens-shaped bodies longer than they are wide; and that the distribution of the lenses of oil-bearing sand is independent of the attitude of the beds. Therefore, in searching for new oil pools in the Bartlesville sand, it is not necessary to locate test wells on domes or anticlines. Plate 2 shows that most of the oil wells in the Bartlesville sand in Tps. 22 and 23 N., Rs. 8 and 9 E., are on anticlines. Exceptions, however, such as the wells in the W½ sec. 22, T. 22 N., R. 9 E., southeast of the East Hominy anticline, show that the distribution of the oil-bearing sand in parts of these four townships is like the distribution of the sand elsewhere in northeastern Oklahoma and is independent of the attitude of the beds.

In many localities gas occurs in the upper part of the Bartlesville sand, and oil occurs at varying positions below the top. Salt water

[8] Bass, N. W., Kennedy, L. E., Dillard, W. R., and Leatherock, Constance, Subsurface geology of Osage County, Okla., United States Department of the Interior Press Memorandum 105368, pl. 3 B, Jan. 1936; 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., fig. 1, p. 32, 1937.

[9] Bass, N. W., Leatherock, Constance, Dillard, W. R., 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 below the oil in many fields; but in others the sand is practically free from water.

The Bartlesville sand characteristically gives up its oil at a slow rate but yields oil throughout a long period of time. Many wells in northeastern Oklahoma have produced oil from the Bartlesville sand for 20 to 30 years. Recently the Bartlesville sand oil pools have received added attention because of the successful operation of gas-repressuring and water-flooding projects in a few fields in northeastern Oklahoma.

RED FORK (BURBANK) SAND

Several logs of wells, most of which are in T. 22 N., R. 8 E., record a bed of sand between the positions of the Bartlesville sand and the Pink lime. A few logs report shows of oil and gas in the sand, but no wells in Tps. 22 and 23 N., Rs. 8 and 9 E., produce oil or gas from this bed. The sand is believed to be equivalent to the Burbank sand of western Osage County and to the Red Fork sand, which produces oil near Tulsa. The Red Fork (Burbank) sand is similar in composition, physical character, and mode of occurrence to the Bartlesville sand. Like the Bartlesville sand, it occurs in elongated lenses and contains oil or gas both on and off of structural upfolds. The large Naval Reserve field of T. 24 N., R. 7 E., whose oil is derived from this sand, is only 3½ miles west of the northwest corner of T. 23 N., R. 8 E., and a long narrow lens of this sand yields oil in T. 21 N., R. 8 E., only 1½ miles south of the south boundary of T. 22 N., R. 8 E. It is not unreasonable, therefore, to expect that similar bodies of sand are to be found in T. 22 N., R. 8 E.

SKINNER SAND

The logs of a few wells record a bed of sand 5 to 25 feet thick about 100 feet below the top of the Cherokee shale. The sand is near the middle of a shale bed that is about 100 feet thick and lies below the thin Verdigris lime and above the Pink lime. All beds of sandstone that occur at this general stratigraphic position are commonly called the Skinner sand. This sand produces oil in a few wells in widely separated localities in Tps. 22 and 23 N., Rs. 8 and 9 E. The logs of most wells that are outside the small areas that produce oil from this bed record shale at the position of the Skinner sand.

SQUIRREL SAND

Relatively few well logs in Tps. 22 and 23 N., Rs. 8 and 9 E., record beds of sand in the uppermost part of the Cherokee shale, between the Verdigris lime and the Oswego lime. The sand is known as the Squirrel sand and yields oil and gas in several places in Osage County. It

yields oil in several wells in sec. 8, T. 23 N., R. 8 E., in the Osage-Hominy field. Sand is recorded at this position in the logs of wells in sec. 5 of this township and in the Pettit oil field in secs. 20 and 29. Elsewhere in Tps. 22 and 23 N., Rs. 8 and 9 E., only an occasional well log shows sand at this position. In the oil-producing area in sec. 8, T. 23 N., R. 8 E., the Squirrel sand actually occupies the position of the Verdigris lime, which is not recorded here, as well as the position of beds above and below the Verdigris lime.

OSWEGO LIME AND BIG LIME

The Oswego lime is recorded in the well logs as limestone 50 to 75 feet thick. More than half of the logs record a bed of shale, 10 to 20 feet thick, from 10 to 25 feet above the base of the formation. A few logs record a bed of sandstone in the upper part, and a few record other thin beds of shale. Shows of oil and gas are relatively common in the Oswego lime, but in Tps. 22 and 23 N., Rs. 8 and 9 E., it has not been an important producer until recently, when the Pure Oil Co. and Sinclair Prairie Oil Co. began acid treatment of these beds in wells in sec. 5, T. 23 N., R. 8 E., in the Osage-Hominy field. Wells here that initially had small daily yields have been made to produce from 500 to 700 barrels of oil a day by acid treatment. No doubt the logs of other wells in this part of Osage County should be examined for shows of oil and gas in the Oswego lime. Many wells that yielded shows of oil amounting to several barrels a day, from the Oswego lime probably could be converted into profitable producers by the use of acid.

The Big lime produces no oil or gas in Tps. 22 and 23 N., Rs. 8 and 9 E., but, like the Oswego lime, it has yielded shows of oil and gas in several wells. It must be regarded as a potential reservoir bed here because it yields oil and gas in parts of Osage County (mainly in Tps. 22 and 23 N., R. 11 E.) and reacts favorably to acid treatment. In most logs it is recorded as a single bed of limestone about 75 feet thick in T. 23 N., Rs. 8 and 9 E., but in T. 22 N., Rs. 8 and 9 E., the Big lime is 120 to 140 feet thick, except in the southeastern part of each of these townships, where it thins abruptly to 15 to 30 feet. The combined total thickness of the Oswego lime, Labette shale, and Big lime varies little. In the areas where the Big lime is uncommonly thin the Cleveland sand is abnormally thick, and the Labette shale is thin. Only the lowermost part of the Big lime appears to be represented in these areas, or it may be that the position of the Big lime is entirely occupied by shale and sandstone and that the thin limestone bed recorded in the logs really belongs in the Labette shale. This limestone may be equivalent to a limestone bed, known as the Lexington cap rock, that lies in the Labette shale in Nowata County,[10] where it crops out.

[10] Moore, R. C., 11th Ann. Field Conference, Kansas Geol. Soc. Guidebook, p. 56, 1937.

CLEVELAND AND JONES SANDS

Throughout parts of Osage County the Nowata shale, which is about 40 feet thick, occurs above the Big lime and is overlain by the Lenapah limestone. The Lenapah limestone is in turn overlain by the Coffeyville formation, which is about 400 feet thick and is made up largely of shale. The thin Checkerboard limestone is a persistent member in the lowermost third of the Coffeyville formation. In Tps. 22 and 23 N., Rs. 8 and 9 E., however, the Lenapah limestone is not recorded in the well logs, whereas the sequence of shale beds above the Big lime and below the Checkerboard limestone is a little more than 200 feet thick and is probably in part equivalent to the Nowata shale, the Lenapah limestone, and the lower part of the Coffeyville formation. A bed of sandstone 50 feet or more thick is recorded in the logs of most wells in Tps. 22 and 23 N., Rs. 8 and 9 E., about 50 feet above the Big lime, and a second sandstone, variable in thickness and occurrence, is recorded in many wells about 75 feet higher, about 25 feet below the Checkerboard limestone. The lower sandstone bed is called the Cleveland sand, and the upper is called the Jones sand. Locally, as in secs. 35 and 36, T. 22 N., R. 8 E., the thickness of the Cleveland sand increases so that it occupies not only the lower part of the Coffeyville formation but also the position of the Lenapah limestone and much of the Nowata shale. Therefore, the Cleveland sand in parts of Osage County occupies the stratigraphic position of the Wayside sand, which lies in the upper part of the Nowata shale and is the principal oil-bearing bed in several fields in northeastern Osage County.[11] Although the logs of most wells in T. 22 N., R. 9 E., record water in the Cleveland sand, many record shows of oil or gas; locally oil and gas are produced from this bed. The principal producing area is in secs. 35 and 36, T. 22 N., R. 9 E. Shows of oil and gas are recorded in the Jones sand in many wells, and according to the log at least one well in the SE¼ sec. 35, T. 22 N., R. 9 E., yielded oil from this sand.

LAYTON SAND

The Layton sand is a lenticular bed in the uppermost part of the Coffeyville formation. It is separated from the overlying Hogshooter limestone by a bed of shale that ranges from 2 to 50 feet in thickness. The Layton sand is recorded in nearly all the well logs in T. 23 N., R. 8 E.; in about half the logs in Tps. 22 and 23 N., R. 9 E.; and in less than half the logs in T. 22 N., R. 8 E., where the sand is commonly from 20 to 40 feet thick. Many of the well logs record shows of gas in the Layton sand; several logs report shows of oil, and others report shows of oil and gas. This sand yields oil in several

[11] Bass, N. W., Kennedy, L. E., Dillard, W. R., and Leatherock, Constance, Subsurface geology of Osage County, Okla., United States Department of the Interior, Press Memorandum 105368, pl. 1, Jan. 1936.

wells in sec. 3, T. 22 N., R. 9 E., and sec. 34, T. 23 N., R. 9 E., where it is about 30 feet thick and lies at a depth of 1,000 feet. Oil or gas is produced from it in a few wells in other widely separated localities in Tps. 22 and 23 N., Rs. 8 and 9 E.

MUSSELLEM AND PEOPLES SANDS

Beds of shale, sandstone, and limestone with a total thickness of 200 to 250 feet overlie the Hogshooter limestone. Shale predominates over the sandstone and limestone, which are recorded as irregular beds in the well logs. This sequence of beds includes the Nellie Bly formation, the Dewey limestone, and the lower part of the Ochelata formation. The sandstone beds lie in the general position of the Peoples sand in the upper part of the Nellie Bly formation and the Mussellem sand in the lower part of the Ochelata formation. The Dewey limestone is the key bed, and in parts of northeastern Osage County it lies between these two sands. However, in Tps. 22 and 23 N., Rs. 8 and 9 E., the Dewey limestone is not recorded as a persistent bed. Locally, beds of sandstone or shale occupy the position of the Dewey limestone, and thin beds of limestone that are easily confused with the Dewey are recorded in the lower part of the Ochelata formation. It appears impossible to correlate these strata bed for bed, as recorded in the well logs. Therefore, the entire sequence is referred to here as the Mussellem and Peoples sands. In parts of T. 23 N., R. 8 E., the logs record thick beds of sandstone in this sequence, but in T. 22, N., Rs. 8 and 9 E., and T. 23 N., R. 9 E., the logs record only a few thin beds of sandstone. Oil and gas are produced from beds in this sequence in the Pettit and Osage-Hominy fields in T. 23 N., R. 8 E., and many well logs record shows of oil and gas.

OKESA, TORPEDO, AND CLEM CREEK SANDS

A sequence of beds, composed largely of sandstone but containing lesser amounts of shale, red rock, and limestone, lies 100 to 200 feet below the top of the Ochelata formation. The beds have a total thickness of about 250 feet and occupy the stratigraphic positions of the Okesa, Torpedo, and Clem Creek sandstone members of the Ochelata formation, all of which produce oil or gas in Osage County, and the position of the Suitcase sands of western Osage County. Single beds in the sequence, according to the well logs, are extremely lenticular. Therefore, the correlation of single beds from one locality to another is speculative. On the other hand, the sand sequence, considered as a unit, persists through a broad area. The Manion field in secs. 19 and 30, T. 23 N., R. 9 E., is the main area producing oil from these beds. The oil-bearing bed here lies at a depth of a little less than 500 feet and appears to be the Torpedo sand, which is the middle one of

the three main sands that make up the sequence. In some other localities the producing bed is tentatively identified as the Okesa sand. Many well logs record shows of oil and gas in beds in the sequence. It is likely that considerable additional oil and gas will be produced from the beds in new areas as well as in old fields that are now producing oil from deeper beds.

BIGHEART, REVARD, CHESHEWALLA, AND COCHAHEE SANDS

The Bigheart, Revard, Cheshewalla, and Cochahee sands, named in ascending order, occur in the lower part of the Nelagoney formation and lie at shallow depths in Tps. 22 and 23 N., Rs. 8 and 9 E. The sands are associated with beds of shale, limestone, and red rock. Some parts of these beds are probably equivalent to the Tonkawa sand of western Osage County. The logs of many wells in Tps. 22 and 23 N., Rs. 8 and 9 E., record shows of gas in these beds, and a few wells produced gas.

T. 22 N., R. 8 E.

T. 22 N., R. 8 E. is in south-central Osage County. Hominy occupies the northeastern part of the township, and the south boundary of the township is a mile north of Cleveland. About 160 wells have been drilled in localities that are widely distributed over the township. Oil has been found in nine relatively small tracts, and oil or gas occurs in 10 beds.

Oil was produced in T. 22 N., R. 8 E., in 1913; a few dry holes had been drilled as early as about 1910. The Hominy field in sec. 13 was developed mainly in the period between 1919 and 1922, and the small field in the SW¼ sec. 14 was drilled in 1923 and 1924. Most of the wells in sec. 27 were drilled between 1921 and 1923. Several of the wells in sec. 35 were drilled in 1923, and several were drilled in 1926. Most of the wells in sec. 36 were drilled in the period between 1925 and 1930. A few wells were drilled in 1937. Several of the wells in sec. 31, in the northeastern part of the Boston field, were drilled in 1913; others were drilled in 1918 and 1919. Several wells have been drilled in the township recently.

The subsurface geologic investigation of T. 22 N., R. 8 E., was made mainly by C. T. Kirk in 1935 and 1936. Parts of the investigation were made by W. R. Dillard, L. E. Kennedy, and N. W. Bass.

STRUCTURE AND DEVELOPMENT

The structure of the rocks in T. 22 N., R. 8 E., is characterized by sharply folded domes and basins lying on a westward-dipping monocline that occupies most of northeastern Oklahoma. The most prominent upfolds in this township shown on plate 2 are the Hominy dome in sec. 13, a dome in sec. 36, other domes in secs. 14, 23, 29, and 32,

and the northeast prong of the Boston dome in sec. 31. Most of the Boston dome is in T. 21 N., R. 7 E. All the main structural features in the buried rocks that have been revealed by the wells are evident in the exposed rocks, according to a structure contour map of the exposed beds prepared for the Geological Survey by Wood.[12]

The structural relief expressed by the buried rocks is greater than that of the exposed rocks, and the crests of the domes on the buried rocks are not directly beneath the crests on the surface beds.

HOMINY DOME

Evidently the fold most important for oil and gas accumulation yet developed in T. 22 N., R. 8 E., is the Hominy dome, which occupies parts of secs. 12 and 13 and extends eastward into secs. 7 and 18, T. 22 N., R. 9 E. The Hominy sand was discovered here. Most of the wells were drilled between 1919 and 1922. The discovery of oil here encouraged other deep drilling in this general vicinity. The dome has a structural relief of about 60 feet on the surface rocks [13] and more than 100 feet on the top of the Oswego lime (pl. 2). The long axis of the dome trends generally eastward transverse to the trend of many folds in the region. A fault has been mapped whose trend nearly parallels that of the crest of the dome and which cuts the surface rocks near well 7, in the center of the west line of the NE¼ sec. 13; however, no displacement of the buried rocks was revealed by the well logs.

A total of 31 wells has been drilled in secs. 12 and 13 on the Hominy dome. Of these, 27 produced oil from Ordovician rocks which were encountered at a depth of about 2,600 feet. Some oil was found in beds of sand in the lower part of the Simpson formation. Most of the oil, however, is found in the uppermost beds, 25 to 50 feet thick, of the Siliceous lime. Water was encountered in the upper part of the Simpson formation 25 to 75 feet above the oil-bearing beds. Early in the development period of the Hominy field it was believed that the main oil-producing strata were beds of sand in the lower part of the Simpson formation, and they were referred to as the Hominy sand. Later the geologists determined from microscopic study of well cuttings that the main oil-bearing beds are in the Siliceous lime. The term Hominy sand, however, is applied in northeastern Oklahoma by many geologists to the lowermost bed of sandstone in the Simpson formation.[14]

The initial yields of the wells ranged from 20 to 8,000 barrels a day. Well 4, in the center of the east line of the NW¼ sec. 13, which pro-

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

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

[14] White, L. H., Subsurface distribution and correlation of the pre-Chattanooga ("Wilcox" sand) series of northeastern Oklahoma: Oklahoma Geol. Survey Bull. 40, vol. 1, pp. 29-30, 1928.

duced oil initially at the rate of 8,000 barrels a day, is offset diagonally to the northeast by well 8, which found only a show of oil and was abandoned as a dry hole. Well 1, in the southwest corner of the SE¼ sec. 12, yields oil from the Skinner sand in the Cherokee shale, encountered at a depth of 2,020 feet. The Bartlesville sand, which is the most important oil-producing bed in eastern Osage County, is not present in the Hominy field according to the well logs. It is probable that additional oil could be found in the Siliceous lime near the center of the NE¼ sec. 13.

The Hominy field, which includes a portion of secs. 7 and 18, T. 22 N., R. 9 E., as well as portions of secs. 12 and 13, T. 22 N., R. 8 E., had produced 1,881,575 barrels of oil by the end of 1936 according to Rorschach and Dahlgren.[15] The wells in the field are spaced at intervals of 528 feet, or one well to each 6.4 acres. Therefore, assuming that 6.4 acres is drained by each well, the field contains 237 acres, from which 7,947 barrels to the acre had been produced by the end of 1936. The gravity of the oil ranges from 37° to 41°, A. P. I.

DOME IN SEC. 14

The small dome centering in the SW¼ sec. 14 has about 60 feet of structural relief as contoured on the upper surface of the Oswego lime (pl. 2). Of the eight wells drilled, four were dry holes and three are reported to be still producing oil from the uppermost beds, only a few feet thick, of the Siliceous lime, which were encountered at a depth of about 2,700 feet. Some oil was found in the Simpson formation, but the main producing bed is in the Siliceous lime.

Oil was discovered here in well 2 on March 15, 1923. Well 3 was drilled in 1923, and well 4 was drilled in 1924. The three wells had produced 578,400 barrels of oil by June 30, 1937, which is a total production to the acre of 30,125 barrels, if it is assumed that each well drains 6.4 acres. (The wells are spaced at intervals of 528 feet.) The gravity of the oil ranges from 38° to 41° A. P. I. The average daily total yield of the three wells during 1936 was 38.7 barrels. So far as known the beds have not been treated with acid in any of the wells.

Well 2, in the southwest corner of the SE¼NW¼ sec. 14, encountered pre-Cambrian crystalline rocks at a depth of 3,423 feet after penetrating the Siliceous lime, which is 757 feet thick here. The logs of three wells record gas yields of 2,000,000 to 2,500,000 cubic feet from sand encountered at a depth of a little more than 200 feet near the middle of the Nelagoney formation. The sand is probably the approximate equivalent of the Cochahee sand. Gas was found also

[15] Rorschach, H. E., and Dahlgren, E. G., Petroleum development in Oklahoma in 1936: Am. Inst. Min. Met. Eng. Trans., vol. 123, pp. 430–433, 1937.

in the Layton, Cleveland, and Red Fork sands. A few additional wells might be drilled into the Siliceous lime near the crest of the dome in the SW¼ sec. 14. Treatment of the reservoir bed with acid probably would increase the yield of the wells.

DOME IN S½ SEC. 23 AND N½ SEC. 26

Wood's structure contour map [16] of the exposed beds shows a dome in the S½ sec. 23 and the N½N½ sec. 26. The crest of the dome is shown by Wood to be in the SE¼SW¼ sec. 23. East of the dome a structural basin trends northward through the E½E½ sec. 23 and the W½ sec. 24 and extends also southwestward through parts of secs. 25 and 26. These features in the exposed rocks, together with the data supplied by the dry holes in secs. 23 and 26, provide the basis for showing the dome in secs. 23 and 26 on plate 2. The southeast corner of the SW¼ sec. 23 appears to be a satisfactory location to test the Siliceous lime on the dome. The top of the Ordovician rocks should be encountered at a depth of about 2,850 feet.

ANTICLINE IN SECS. 22 AND 27

The anticline shown on plate 2 in secs. 22 and 27 has a small amount of closure as mapped on the top of the Oswego lime and more than 40 feet of closure on the top of the Mississippi lime. Eight wells yielded a small amount of oil from Ordovician rocks, and one well in the SE¼ sec. 22 is reported to have yielded oil from the Bartlesville sand. In two wells in the SE¼ sec. 22 gas was found at a depth of 350 feet in sand near the middle of the Nelagoney formation. The sand is tentatively assumed to be equivalent to the Cochahee sand. The initial yield of one of the gas wells was reported to have been 5,000,000 cubic feet of gas a day.

ANTICLINE IN SECS. 35 AND 36

An anticline occupies parts of secs. 35 and 36 and extends into T. 21 N., R. 8 E., and into T. 22 N., R. 9 E. Superposed on its crest are two prominent domes, one in sec. 36, T. 22 N., R. 8 E., and the other in sec. 30, T 22 N., R. 9 E. The dome in sec. 36 has a structural closure of 35 feet on the exposed rocks, according to Wood's map,[17] and only slightly more than 20 feet on the Oswego lime, as shown on plate 2. Oil is produced from the Bartlesville sand in many wells on the southwest flank of the anticline; nine of the producers from the Bartlesville sand are in secs. 35 and 36, T. 22 N., R. 8 E. Oil has been found at shallow depth in the Okesa and Torpedo sands in many wells in sec. 36. Most of these wells found their oil in the upper sand of the Okesa and Torpedo sands and therefore probably should be classed as Okesa sand producers. The initial yields of the

[16] Wood, R. H., Unpublished map of parts of the Hominy quadrangle, in U.'S. Geol. Survey files.
[17] Wood, R. H., op. cit.

wells ranged from 3 to 225 barrels of oil a day; the yields of those producing from the Bartlesville sand ranged from 10 to 160 barrels a day. Gas was produced from the Cleveland sand in four wells and from the Layton sand in one well. A few other wells found shows of gas in the Layton sand. The initial yields of the gas wells are reported to range from 1,500,000 to 8,000,000 cubic feet a day.

A small amount of oil was found in uppermost Ordovician rocks in well 3–82, in the SE¼NW¼ sec 36. on the northwest flank of the dome. Well 2, in the NE¼SW¼ sec. 36, which is higher on the dome than well 3–82, failed to find oil in the Ordovician beds. The center of the SW¼ sec. 36 appears to be a better location on the dome for a test of the oil possibilities of the Ordovician rocks than the locations of the wells already drilled.

DOME IN SECS. 20 AND 29

Structure contours drawn on the top of the Oswego lime (pl. 2) show the dome in secs. 20 and 29 to have a closure of 80 feet. The area enclosed by the lowest structure contour is about two-thirds of a square mile. Wood's [18] map of the exposed rocks shows a small dome, whose crest is near the center of the NW¼ sec. 28. The crest of this dome on the buried rocks is shown on plate 2 in the NE¼ sec. 29. The shift of the crest of the dome with depth as shown on these two maps is greater than is commonly found in Osage County. Three out of seven wells drilled on the dome produced small amounts of oil from Ordovician beds and are now abandoned. The oil was found in the upper part of the Siliceous lime, according to the drillers' logs. So far as known, the beds were not treated with acid in any of the wells.

DOME IN SEC. 32

A relatively small fold in sec. 32 has a structural closure of about 40 feet as mapped on the Oswego lime (pl. 2). Few datum points were available to control the positions of the contours in this part of plate 2, except near the crest of the dome; the contours that appear on the flanks of the dome are, therefore, speculative. The Bartlesville sand produces oil in several wells, and the Skinner sand produces oil in one well in sec. 32. The initial yield of the wells ranged from 15 to 140 barrels. Two wells produced oil from the Oswego lime; one of these yielded 350 barrels a day after the beds had been treated with acid. Ordovician rocks have been tested by a dry hole on the northeast flank of the dome and by well 8 a short distance east of the crest of the dome.

BOSTON DOME IN SEC. 31

The Boston dome, whose crest is in the NE¼ sec. 1, T. 21 N., R. 7 E., extends into the southwestern part of sec. 31, T. 22 N., R.

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

8 E. It is a sharply folded dome whose axis trends northeastward. The Bartlesville sand early yielded oil in wells on the crest and flanks of the dome; 12 Bartlesville sand oil wells, all of which have been abandoned, are in sec. 31, T. 22 N., R. 8 E. Later, some of the wells producing from the Bartlesville sand, in sec. 1, T. 21 N., R. 7 E., on or near the crest of the dome, were deepened into Ordovician beds, where much additional oil was found. One deepened well is in the southwest corner of sec. 31, T. 22 N., R. 8 E. The Boston pool has been one of the most prolific oil-producing areas in Osage County. The combined yield for the entire field from the Bartlesville sand and Ordovician beds is reported to have been to date about 40,000 barrels to the acre.

SEC. 30

The dome whose crest is near the center of the S½ sec. 30 appears to be a subsidiary dome on a northeast-trending nose from the Boston dome. One well recently completed in the NW¼SE¼ sec. 30 found a small amount of oil in Ordovician rocks.

The lone producer in the northwest corner of sec. 30 is near the northeast end of an anticline that trends northeastward across the southwestern part of T. 22 N., R. 7 E. The well in sec. 30 yields a small amount of oil from dolomite that lies from 10 to 25 feet below the top of the Siliceous lime.

DOME IN SEC. 18

Three dry holes in sec. 18 have tested all beds down to and including the upper part of the Siliceous lime. The log of the dry hole in the northwest corner of the SE¼ sec. 18 recorded gas, with a flow of 10,000,000 cubic feet a day, in the Layton sand, encountered at a depth of 1,540 feet. The structure contours shown on plate 2 in secs. 18 and 19 are speculative, because too few wells have been drilled here to furnish control points on the datum bed.

NORTHWESTERN PART OF THE TOWNSHIP

So few data are available on the attitude of the Oswego lime in the northwestern part of T. 22 N., R. 8 E., that little confidence can be placed in the structure contours for that area shown on plate 2. The structure contour map shows only a generalized sketch of this part of the township. For example, the large structural basin shown in secs. 2, 3, and 4 is projected mainly from the record of one dry hole in the SE¼ sec. 3. The anticlinal nose that trends northwestward through secs. 9, 4, and 5 is based mainly on the record of the dry hole in the southwest corner of the NE¼ sec. 5. However, the western part of T. 22 N., R. 8 E., is in a region that is characterized by sharply folded domes, many of which have yielded large quantities of oil from several beds. The Siliceous lime is probably the most

prolific oil-producing bed on domes in this region. Inasmuch as the domes that yield oil from this bed are revealed by the attitude of the exposed rocks, these rocks should be thoroughly investigated in this area. Most domes and some anticlinal noses found in this area are worthy of testing for oil in the Siliceous lime; there is also a possibility of finding oil in beds younger than the Siliceous lime.

RECOMMENDATIONS

Additional wells should be drilled in the Siliceous lime in the NE¼ sec. 13 on the Hominy dome, in the SW¼ sec. 14, the SE¼SW¼ sec. 23, and the center of the SW¼ sec. 36. The reservoir beds should be treated with acid at these localities. Additional development of the dome in sec. 32 is warranted. The structural attitude of the exposed rocks in the northeastern and northwestern parts of T. 22 N., R. 8 E., should be investigated, and pronounced anticlinal noses and domes found will probably be worthy of prospecting.

T. 23 N., R. 8 E.

T. 23 N., R. 8 E., is in south-central Osage County, 10 miles southwest of Pawhuska, the county seat of Osage County, and also the seat of government of the Osage Indian Tribe. Oil or gas is produced in T. 23 N., R. 8 E., from 12 beds; as many as 10 beds yield oil or gas in a single oil field.

The upper part of the Siliceous lime and the upper part of the Mississippi lime are the two most important oil-producing beds. Wells that flowed between 7,000 and 8,000 barrels of oil a day have been completed in the Siliceous lime, and a few wells that flowed from 4,000 to nearly 5,000 barrels of oil a day have been completed in the Mississippi lime. Depths of many wells producing from the Mississippi lime are about 2,400 feet, and depths of many wells producing from the Siliceous lime are about 2,800 feet. The Bartlesville sand, which yields oil in many wells in secs. 12 and 13 and in a few wells in other localities in this township, is absent in parts of the township.

The subsurface geologic investigation of T. 23 N., R. 8 E., was made in 1935 and 1936 mainly by Otto Leatherock. A part of the investigation was made by W. R. Dillard and N. W. Bass.

In T. 23 N., R. 8 E., 370 wells have been drilled. Of these 226 are still producing oil or gas, according to records of the Osage Indian Agency. At least one well in the SE¼ sec. 8 in the Osage-Hominy field was drilled in 1913; most of the wells in secs. 8, 9, 10, 15, and 16 in this field were drilled between 1916 and 1918. Many of the wells in the SE¼ sec. 25 in the Manion field were drilled in 1917. A few wells in the North Manion field were drilled in 1920 and 1921, but

most of the wells in secs. 12 and 13 in this field were drilled between 1922 and 1926. Gas was found in the Pettit field in secs. 20 and 29 in 1920, and oil was discovered there in Ordovician rocks in 1923. The field was rapidly developed in 1924.

STRUCTURE AND DEVELOPMENT

T. 23 N., R. 8 E., lies in a belt of country that is characterized by many relatively steeply folded domes. This belt of folded rocks extends northeastward from the Cushing oil field in western Creek County to the vicinity of Pawhuska, in central Osage County.

The most prominent upfolds in T. 23 N., R. 8 E., shown on plate 2, are the Pettit dome, whose crest is in sec. 20, the North Manion anticline in sec. 13, a complex dome in secs. 8, 9, and 16, and the Manion anticline, whose crest is in sec. 25. An exceptionally deep syncline extends northeastward through the middle of the township. The Oswego lime dips from the crests of the domes in secs. 20 and 9 southeastward into this syncline as much as 220 to 260 feet in a mile. This bed dips from the dome in sec. 13 westward into the syncline 300 feet in 1¾ miles.

One of several belts of en echelon faults found in this part of Oklahoma trends northward across the western part of T. 23 N., R. 8 E.[19] The individual faults, which are from ½ to 1½ miles long, trend northwestward. The exposed rocks are displaced less than 50 feet along the faults,[20] but the data are insufficient to determine whether the deeply buried rocks are displaced. It is noteworthy that oil has been found on all the prominent domes in the township and that oil occurs in several beds on most of the domes. The logs of many wells record shows of oil or gas in from 6 to 10 beds, distributed in depth from 150 to 2,850 feet.

OSAGE-HOMINY FIELD

The Osage-Hominy field as defined by the Oklahoma Committee on Oil Field Nomenclature [21] contains all oil- and gas-producing tracts in secs. 3 to 10 and secs. 15 to 16. The field as thus defined includes several domes, among which is a dome in the N½ sec. 3, T. 23 N., R. 8 E., and sec. 34, T. 24 N., R. 8 E., a dome in secs. 3 and 10, a dome in sec. 5, one in sec. 6, a dome in the W½ sec. 8, and the main dome in sec. 9, which includes also parts of secs. 10, 15, 16, and 8.

Dome in N½ sec. 3.—The south flank of a dome which lies mainly in sec. 34, T. 24 N., R. 8 E., occupies a part of the N½ sec. 3, T. 23 N.,

[19] Fath, A. E., 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.
Miser, H. D., Geologic map of Oklahoma, U. S. Geological Survey, 1926.
[20] Wood, R. H., op. cit.
[21] Oil Field Nomenclature Committee, Kansas-Oklahoma Division, Mid-Continent Oil & Gas Association, Tulsa, Okla., 1935.

R. 8 E. Two wells in the N½NE¼ sec. 3, T. 23 N., R. 8. E., and five wells in the SE¼ sec. 34, T. 24 N., R. 8 E., found oil in the uppermost 40 feet of the Siliceous lime, which was encountered at a depth of about 2,500 feet. The initial yields of the wells ranged from 40 to 2,500 barrels a day. Several of the wells found shows of oil, and two wells are producing oil from beds that lie from 20 to 50 feet below the top of the Mississippi lime. Other shows of oil or gas were found in the Bartlesville sand, Oswego lime, Big lime, Peoples sand, Okesa sand, and Revard sand. Additional oil or gas may be developed in some of these beds. A development of shallow beds is taking place only 2 miles to the west in sec. 5, where wells with large initial yields are being found in the Oswego lime after acidizing the oil-bearing beds. Wells 3 and 5 in the SE¼ sec. 34, T. 24 N., R. 8 E., on the dome, were treated with 500 gallons of acid after each had produced oil from the Siliceous lime 4 to 6 years. No appreciable increase in yield of oil resulted from the acid treatment. Additional acid treatment in other wells in the field is advisable, however, because oil-bearing beds in the Siliceous lime have responded to acid treatment in many places in Osage County.

Dome in S½ sec. 3 and N½ sec. 10.—An irregularly shaped dome with small closure in the S½ sec. 3 and the N½ sec. 10 has yielded oil from four beds and gas from two beds. Five wells produced oil from the uppermost beds in the Siliceous lime, which were encountered at a depth of about 2,500 feet. The wells yielded initially from 25 to 1,000 barrels a day. Eight wells produced a small amount of oil from the upper part of the Mississippi lime. One well yielded oil at the rate of 50 barrels a day from the Bartlesville sand, and one yielded oil at a small daily rate from the Peoples sand. Gas was produced from the Bartlesville sand in one well and from the Peoples sand in one well.

Dome in sec. 5.—Beds of chert in the Mississippi lime, 20 to 40 feet below its top, yield oil in eight wells on a dome in sec. 5. Several of the wells yielded initially, in 1919 and 1920, from 100 to 200 barrels a day and are still producing at a small daily rate. Well 172, in the center north line of the NW¼SE¼ sec. 5, was drilled into the Mississippi lime recently. The well produces from 50 to 60 barrels of oil a day and about 5 barrels of water. Two wells tested Ordovician rocks; one of these (146, in the NE¼ sec. 5) yields oil from an Ordovician bed that is in either the Simpson formation or the Siliceous lime. Wells 147 and 148, in the S½NE¼ sec. 5, produced oil for years from the Peoples sand, which lies at a depth of 1,200 to 1,300 feet. Recently the wells were deepened to the Oswego lime, and each produced between 500 and 600 barrels a day after the reservoir bed had been treated with acid. Before the acid treatment well 147 flowed 110 barrels a day and well 148 flowed 173 barrels a day from the Oswego lime. Well 175,

drilled recently in the SE¼NW¼NE¼ sec. 5, found oil in sand at a depth of 700 feet. A log of the well has not been seen by the writers, but the depth to the oil-bearing bed suggests that it is the Okesa sand. Many wells will probably be drilled in sec. 5 to exploit the oil that is present in several beds.

Dome in sec. 6.—On a small dome in sec. 6 oil occurs in four wells in the uppermost beds of the Siliceous lime, which were encountered at a depth of about 2,900 feet. One well found oil in the Skinner sand. The logs record no appreciable show of oil or gas in other beds.

Main dome in secs. 8 to 10 and secs. 15 and 16.—Oil or gas has been produced from 10 beds on the large complex dome that occupies parts of secs. 8 to 10 and secs. 15 and 16 (pl. 2). The oil- and gas-bearing beds occur at depths ranging from 450 to 2,650 feet. The deepest oil- or gas-bearing beds are in the Siliceous lime and produce oil in one well (No. 171) in the SW¼ sec. 9. This well yielded initially 550 barrels a day from a depth of about 2,650 feet. The well was drilled into crystalline rocks 55 feet below the top of the Siliceous lime and then was plugged back to the oil-bearing beds. Six other wells on the dome have tested Ordovician rocks.

A sequence of beds about 75 feet thick in the uppermost part of the Mississippi lime yields oil in a few more than 80 wells in the field. Oil is recorded in two to three beds within this sequence in the logs of many of the wells. The oil-bearing beds are composed of chert, according to Borden,[22] who made a microscopic examination of well samples. The initial yields of wells producing from the Mississippi lime ranged from a few barrels to 4,800 barrels a day; many wells yielded more than 100 barrels a day. Most of the wells are still producing oil after a life of 20 years.

The Bartlesville sand, which, where present, ranges from 5 to 120 feet in thickness but is locally absent, is the oil-producing bed in 14 wells in this field. Shows of oil and gas were recorded in the Bartlesville in the logs of many wells that were drilled through the sand into the Mississippi lime. The initial yields of the wells producing from the Bartlesville sand ranged from 20 to 300 barrels a day.

A total of 14 wells in the W½ sec. 8 produced oil from the Squirrel sand, which lies from 10 to 40 feet below the top of the Cherokee shale. The initial yields of the wells ranged from a few to 500 barrels a day. Most of these wells were drilled in 1918 and 1919 and are still producing oil. Several wells that produce oil from the Mississippi lime found shows of oil in the Squirrel sand. The sand extends downward in the Cherokee shale through the position of the Verdigris lime, and the uppermost part of the Skinner sand, which lies below the Verdigris lime. The oil in the wells in the W½ sec. 8 appears to occur in beds that lie approximately in the position of the Verdigris lime. Several

[22] Borden, J. L., Pure Oil Co., Tulsa, Okla., oral communication.

other wells found shows of oil and gas in the Squirrel sand, and many wells found shale and lime containing no oil at the position of the sand.

Several wells in the field found shows of oil and gas in the Oswego lime. Inasmuch as wells in sec. 5, only a short distance from this field, are yielding several hundred barrels of oil a day from this bed after treatment with acid, these shows of oil and gas may indicate that wells could be developed in the Oswego lime.

Five wells near the middle of sec. 16 yielded initially from 5 to 60 barrels of oil a day from the Cleveland sand, which was encountered at a depth of about 1,750 feet. Shows of oil and gas were recorded in this bed in many wells in the field. Gas has been produced from the Mussellem and Peoples sands in wells 43 and 131 in the SW¼ sec. 9, and oil is produced from the Mussellem sand in well 108 in the SW¼ sec. 8. The gas wells yielded between 1,000,000 and 3,000,000 cubic feet a day, and the oil well yielded initially 50 barrels a day from a depth of about 1,200 feet. A gas-bearing bed, believed to represent the Torpedo sand in the Okesa and Torpedo sands, yielded gas in four wells, shown on plate 2, as follows: No. 64 in the NW¼NE¼ sec. 16, Nos. 80 and 81 in the NW¼SE¼ sec. 9, and No. 79 in the northeast corner of the SW¼ sec. 9 The wells yielded initially from 1,500,000 to 12,000,000 cubic feet a day. Well 24 near the center of the W½SE¼ sec. 9 yie'ded initially 50 barrels of oil a day from the Torpedo sand, which was encountered at a depth of 815 feet. After producing oil from this zone for a time, the well was deepened to 2,324 feet and is producing oil from the Bartlesville sand. Six wells (Nos. 34, 12B, 49, 45, 48, and 46) in the NW¼ sec. 9 and well 33 in the NE¼ sec. 8 produced oil from the Okesa sand, which lies at a depth of 700 feet. The Revard sand yielded gas from a depth of 400 to 420 feet in two wells—well 114 in the southwest corner of the SE¼ sec. 9 and well 121 in the NW¼SE¼ sec. 9. Many wells in the field that produce oil from the Mississippi lime and other deep beds found shows of oil or gas or both in most of the shallow beds described above. It appears probable, therefore, that the field will be exploited for additional gas and oil in the shallow beds. Furthermore, the possibility for additional oil from the Siliceous lime has not been thoroughly tested.

NORTH MANION ANTICLINE

The North Manion oil field occupies parts of secs. 1, 12, 13, 14, and 24, T. 23 N., R. 8 E., and extends a short distance into T. 23 N., R. 9 E. The field is on a pronounced anticline that trends northeastward. The anticline is broadest in secs. 13 and 14 near its south end, where there is a local dome with a closure of 90 feet on the Oswego lime (pl. 2). A second dome is superposed on the anticline in secs. 1 and 12, T. 23 N., R. 8 E., and secs. 6 and 7, T. 23 N., R. 9 E.

Most of the oil in the field is found in the Bartlesville sand at a depth of about 2,100 feet. The Bartlesville sand is about 75 feet thick in most wells. In some wells the producing sand is separated from the Mississippi lime below by a thin bed of shale, and in other wells it lies immediately on the Mississippi lime. The wells producing from the Bartlesville sand have yielded initially from 25 to 400 barrels a day. Most of them were drilled between 1922 and 1926 and are still producing oil.

Ordovician rocks yielded oil in nine wells, most of which are in the SE¼ sec. 1 and the NE¼ sec. 14. According to the well logs the oil is found in the uppermost beds of the Siliceous lime or in the lowermost part of the Simpson formation. Samples of the beds drilled through were not studied; therefore, positive differentiation between the Simpson formation and the Siliceous lime was not made. A few wells (shown by special symbols on plate 2), finding the upper beds of the Ordovician sequence to be barren of oil or gas, were plugged back to the Bartlesville sand, which yielded oil.

The following beds yielded oil or gas, or both, in one or two wells in the North Manion field: The Mississippi lime at a depth of 2,200 feet, the Cleveland sand at a depth of 1,500 feet, the Layton sand at a depth of 1,140 feet, the Mussellem sand at a depth of 950 feet, the Torpedo sand at a depth of 530 feet, and the Okesa sand at a depth of 450 feet. Many wells in the field found shows of oil or gas in the Cleveland, Layton, and Peoples sands; a few wells had shows of oil or gas in the Okesa sand; and other wells had shows of oil or gas in other beds.

It is probable that additional oil wells will be drilled in the E½ sec. 13 and elsewhere in this field to the Bartlesville sand and the Mississippi lime. It is not improbable that other wells will further test the oil possibilities of the Siliceous lime. In all new wells drilled the shallow sands should be watched carefully for possible occurrences of oil and gas in commercial amounts. All limy oil- or gas-bearing beds should be treated with acid.

MANION ANTICLINE

The Manion oil field lies mainly in the SE¼ sec. 25, T. 23 N., R. 8 E., and secs. 19 and 30, T. 23 N., R. 9 E. The structure of that portion of the field that is in T. 23 N., R. 8 E., is a sharply folded dome, a part of the Manion anticline, which trends northeastward from sec. 36, across sec. 25 into secs. 30 and 19, T. 23 N., R. 9 E. The crest of the dome on the Oswego lime (pl. 2) is slightly west of the crest on the exposed beds.[23] Three wells (Nos. 12, 14, and 16) on the dome

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

found crystalline rocks at depths between 2,380 and 2,545 feet. These wells show that the entire sequence of beds that constitute the Siliceous lime and the Simpson formation, which is about 1,000 feet thick in this part of Oklahoma, is absent locally, and that the lower part of the Mississippi lime lies on pre-Cambrian rocks.

The dome in sec. 25 has been disappointing as an oil field. Many wells have been drilled here, but only small amounts of oil have been found. A small yield of oil was found in the Simpson formation in well 6. Several wells produced oil for a time from the Mississippi lime. A few wells produced oil from the Oswego lime, and other wells produced oil from the Bartlesville sand. All except one well have been abandoned; the lone producer, No. 15, yields oil from the Bartlesville sand.

PENN CREEK DOME

Eight wells in the N½ sec. 34 and one in the southeast corner of the SW¼ sec. 27 found oil in Ordovician beds. The wells are on the Penn Creek dome—a structure that is elongated in an east-west direction and has only a small amount of closure. The crest of the dome on the Oswego lime (pl. 2) is north of the crest on the exposed beds.[24] The only logs of the wells available are drillers' logs, and it is not possible to determine from them whether the main oil-bearing beds occur in the Siliceous lime or in the Simpson formation. The beds have not been acidized.

PETTIT DOME

A sharply folded dome in secs. 20, 21, and 29 underlies the Pettit[25] oil field. The structural relief of the exposed rocks is about 100 feet; that of the Oswego lime is about 150 feet (pl. 2). Seven beds, which occur at depths ranging from 800 to 2,700 feet, yield oil or gas. The uppermost beds in the Siliceous lime, which lie at a depth of about 2,700 feet, furnish most of the oil in the field. Some oil was found in many wells in sandstone in the lower part of the Simpson formation, which is about 60 feet thick; the upper beds of the Simpson formation yielded water in many wells. The most productive oil-bearing beds, however, occur within the uppermost 50 feet of the Siliceous lime and are underlain by water-bearing beds. Most wells producing from the Siliceous lime found their first oil in the Simpson formation 20 to 25 feet above the Siliceous lime; they found more oil in the uppermost few feet of the Siliceous lime, and larger amounts as the uppermost 50 feet of the Siliceous lime was penetrated. In other wells the uppermost beds of the Siliceous lime were dry and the oil was found in thin beds 25 to 50 feet or more below the top of the formation. The upper

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

beds of the Siliceous lime yielded a small amount of water in some wells, and oil was found 25 to 40 feet deeper in the formation.

The initial yields of many wells that found oil in Ordovician rocks were large. The largest wells were well 2 in the NE¼SW¼SE¼ sec. 20 and well 8 in the SW¼NE¼SE¼ sec. 20, which yielded oil at the initial rates of 7,800 and 8,000 barrels a day. According to Beckwith [26] well 2 discovered oil in these beds in 1923. It is reported that no wells producing from the Siliceous lime have been treated with acid.

Two wells in the SE¼ sec. 20 yield gas, and one well in the SW¼ sec. 21 yields oil from the upper part of the Mississippi lime, which was encountered at a depth of about 2,450 feet. The gas wells yielded initially 2,500,000 and 5,000,000 cubic feet a day. Two wells produced oil from the Bartlesville sand, which is present only locally in the field. Two wells produced gas from the Squirrel sand. Two wells produced gas and one well produced oil from the Mussellem sand. Three wells produced gas from the Peoples sand. Thirteen wells produced oil and one well produced gas from the Okesa sand, which occurs at a depth of about 800 feet. Many of the wells that produced oil from deep beds found several shows of gas in the Revard and Bigheart sands and shows of oil and gas in the Okesa and Torpedo sands and in the Layton sand. It seems probable, therefore, that the oil- and gas-producing areas in several of the producing beds could be somewhat extended.

DOME IN SEC. 31

A small dome in sec. 31, T. 23 N., R. 8 E., and sec. 36, T. 23 N., R. 7 E., has a closure of more than 60 feet on the Oswego lime (pl. 2). Five wells in sec. 31 and 5 wells in sec. 36 found oil in Ordovician beds. The Bartlesville sand produced oil in one well in sec. 31 and in two wells in sec. 36; the Okesa sand produced gas in one well in sec. 36. The Bartlesville sand is absent in many parts of the field. The drillers' logs of most wells and an examination of well samples from one well suggest that the Ordovician beds that yield the oil in some wells are in the lower part of the Simpson formation, and the logs of other wells indicate that they are in the uppermost part of the Siliceous lime. However, the data available are too meager to determine whether the oil-bearing beds in most of the wells are in the Simpson formation or the Siliceous lime. Several sands that produce oil and gas elsewhere in the township yielded a hole full of water in many wells in this field. The logs of a few wells, however, report shows of gas or oil in these beds. The logs of several wells record gas in the Squirrel sand, which lies at a depth of about 2,300 feet. The Squirrel sand is recorded as about 35 feet thick in this section.

[26] Beckwith, H. T., Oil and gas in Oklahoma, Osage County: Oklahoma Geol. Survey Bull. 40, vol. 3, p. 258, 1930.

RECOMMENDATIONS

The oil- and gas-bearing beds have been tested by many wells in this township. Nevertheless, there appear to be several tracts within the oil fields capable of furnishing additional wells in beds that lie at shallow depth and were overlooked in the development of the oil production in the deeper-lying beds. The recent success of the Pure Oil Co. and Sinclair Prairie Oil Co. in completing many new wells in sec. 5 in the northern part of the Osage-Hominy field suggests that similar results may be obtained elsewhere. It seems probable that new wells could be obtained in beds that lie at shallow depth in secs. 8, 9, and 16 in the main part of the Osage-Hominy field and in secs. 20 and 29 in the Pettit field. It is not improbable that additional production from the Siliceous lime in the Osage-Hominy field could be obtained by deepening old wells that produced oil from the Mississippi lime..

The oil-bearing area in the Bartlesville sand may be extended somewhat in the E½ sec. 13, in the North Manion field. Old wells producing from the Bartlesville sand in this field should be deepened into the Mississippi lime before they are abandoned. Several beds that lie at shallow depth, but yield oil or gas in this field, may furnish new wells. All limy beds, where oil- or gas-bearing, especially the Oswego lime and the Siliceous lime, should be treated with acid. Probably the oil-bearing beds of the Mississippi lime are composed mainly of chert, which is unaffected by the acid. However, limy beds are commonly associated with chert beds in the Mississippi lime in parts of Osage County. Therefore, the oil reservoir beds in the Mississippi lime should be treated with acid in several wells to determine whether the treatment results in increased yields.

T. 22 N., R. 9 E.

T. 22 N., R. 9 E., is in southeastern Osage County, 5 miles northeast of Cleveland. Hominy is adjacent to the northwesternmost part of the township. Oil or gas has been found in eight beds from the Ordovician rocks to the Okesa and Torpedo sands in the Ochelata formation. The oil- and gas-producing beds are found at depths ranging from 2,700 feet to 400 feet. In all, 224 wells have been drilled; 144 of these produced oil, 6 produced gas, and 74 were dry holes. Many of the wells in this township were drilled between 1920 and 1922. The wells in the small oil field in sec. 1 were drilled between 1918 and 1922; most of the wells in sec. 3 were drilled between 1919 and 1922; and many of the wells in the field in sec. 6 were drilled in 1922. The wells in the Hominy field in sec. 18 were drilled in 1920 and 1921; the large East Hominy field centering in sec. 16 was developed mainly in 1920 and 1922; many wells in sec. 30 were drilled in 1919, and others in

1933. Most of the wells in secs. 35 and 36 were drilled from 1911 to 1914; several wells, however, were added in 1917 and others in 1920 to 1922.

The subsurface geologic investigation of this township was conducted in 1935 and 1936 mainly by C. T. Kirk. A part of the investigation was made by N. W. Bass.

STRUCTURE AND DEVELOPMENT

The structure of the rocks in T. 22 N., R. 9 E., is characterized by several sharply folded domes lying on a regional monocline that in this part of Osage County slopes westward at an average rate of about 40 feet to the mile. The main upfolds are (1) the Flesher anticline, whose crest is in sec. 1, (2) domes in secs. 4, 5, 6, 8, and 9, (3) the eastern part of the Hominy dome in secs. 7 and 18, (4) the East Hominy anticline in secs. 16 and 17, (5) a dome in sec. 30, and (6) two pronounced anticlinal noses, one in secs. 24 and 25 and the other in secs. 28 and 29. All these main structural features except the nose in secs. 28 and 29, shown by the subsurface structure contour map (pl. 2) are similar, with minor modifications, to those shown by the structure contour map of the exposed beds prepared by Wood.[27] Oil has been found on most of these upfolds, and gas has been found on a few. The folds have somewhat greater structural relief on the buried rocks than on the exposed beds, and the crests of the domes as mapped on the Oswego lime are not directly beneath the crests as mapped on the exposed beds. The crest of three domes on the Oswego lime (including the Hominy dome, whose crest is in sec. 13, T. 22 N., R. 8 E.) are west or southwest of the crests on the exposed beds, and the crests of two domes on the Oswego lime are east or northeast of the crests on the exposed beds.

FLESHER ANTICLINE

The Flesher anticline, whose crest is in sec. 1, has a structural relief on the exposed rocks of about 80 feet, according to Wood's map.[28] The crest of the anticline as mapped on the top of the Oswego lime is a short distance west of the crest on the surface beds, and the structural relief is greater on the Oswego lime than on the surface rocks. Oil has been produced in a few wells from Ordovician beds, the Mississippi lime (one well), and the Bartlesville sand; gas, with volumes ranging between 2,000,000 and 10,000,000 cubic feet, was found in the Bartlesville sand in wells 1 and 5 in the SW¼ and well 5 in the SE¼ sec. 1. Phenomenally large yields of oil are reported from wells 2 and 7 in the SW¼ sec. 1, indicating that either some abnormal structural condition exists there or that the reservoir beds have some unusual character. It is reported that well 2 produced initially 1,000 barrels of oil a day

[27] Wood, R. H., Unpublished map of parts of the Hominy quadrangle, in U. S. Geol. Survey files.
[28] Wood, R. H., op. cit.

from the Bartlesville sand. Well 7 is reported to have yielded 10,000 barrels of oil the first day, 8,000 barrels the second day, and to have had a normal decline in yield thereafter. The oil came from the uppermost 3 feet of Ordovician sand, which was struck at a depth of 2,320 feet. Only drillers' logs of the Ordovician wells are available. Therefore, it was not determined whether the oil occurs in the Siliceous lime or in the Simpson formation.

Nine wells on the dome have been drilled into Orodovician rocks. The initial yields of the Ordovician wells, except well 7, have ranged from 5 to 30 barrels a day. The distribution of the wells that produced oil from the Bartlesville sand suggests that Bartlesville sand producers might be drilled in the NE¼ sec. 12.

OIL FIELD IN SEC. 3

The Layton sand encountered at a depth of 1,010 feet yielded oil in 11 wells in sec. 3. The initial yields of the wells ranged from 5 to 90 barrels a day. The Layton sand is recorded as being from 10 to 35 feet thick. Two wells in the SW¼ sec. 3 produced oil from the Skinner sand, which was encountered at a depth of about 1,880 feet. Well 2, in the NW¼ sec. 3, produces oil from the Bartlesville sand according to the log. The oil in sec. 3 occurs low on an anticlinal nose. The structural position of the oil-bearing bed appears to be unfavorable for the occurrence of oil. The few data available here and elsewhere in Osage County, however, suggest that the occurrence of oil in the Layton, Skinner, Burbank, and Bartlesville sands, and possibly in some other sands, is not controlled primarily by the attitude of the beds.

DOMES IN SECS. 4, 5, 6, 8, AND 9

Several small domes on two of which oil has been found, are shown on plate 2, in the northwestern part of the township, including secs. 4, 5, 6, 8, and 9. The structure contours in secs. 4, 5, and 9 are projected from very few datum points. Therefore, little confidence can be placed in that part of the map (pl. 2). The structure contours in secs. 6 and 8 are controlled by several datum points furnished by deep wells. Wood's [29] structure contour map of the exposed beds shows an anticlinal nose that trends southwestward through the NW¼ sec. 3; it broadens out in sec. 4 and projects into the SE¼ sec. 5. A pronounced dome on the exposed rocks occupies sec. 6, and another dome has its crest in the SE¼ sec. 8. A broad anticlinal nose on the exposed rocks occupies much of the W½ sec. 9.

The wells in sec. 6 yielded initially from 30 to 200 barrels of oil a day, and the two abandoned producers in sec. 8 yielded 12½ and 50 barrels a day. The oil pools in secs. 6 and 8 occur in the upper beds of the Orodvician sequence, in either the Simpson formation or in the

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

Siliceous lime. Several wells had shows of oil or gas in the Bartlesville sand and in the Cleveland and Jones sands. All of these wells are abandoned. The total oil production from the wells in sec. 6, which produced oil from 1922 to March 1928, was only 62,914 barrels, according to records on file at the Osage Indian Agency. A very small amount of oil was produced from the wells in sec. 8.

EAST HOMINY ANTICLINE

The East Hominy field is in secs. 15, 16, 17, 21, and 22, on a pronounced anticline that has a structural closure of 30 feet or more on the exposed beds, according to Wood's map,[30] and twice that amount on the top of the Oswego lime (pl. 2). Oil was produced there from one well in 1919. Many wells that still yield oil were drilled in 1920 and 1921. The Bartlesville sand, which lies at depths ranging from 2,100 to 2,200 feet, is the main oil-yielding bed and has yielded gas in some wells. Two wells yielded oil from the Skinner sand and two wells yielded oil from the Burgess sand-Mississippi lime zone. One well (No. 2–51) that produces from the Mississippi lime in the SE¼ sec. 16 is shown on the map as a Bartlesville sand gas well. However, it was later deepened to the Siliceous lime and then plugged back to the Burgess sand-Mississippi lime zone. The Bartlesville sand yields oil on the crest of the anticline and on the flanks as far as 90 feet below the crest. The initial yields of the oil wells ranged from 5 to 300 barrels a day, and that of the gas wells ranged from 4,000,000 to 24,000,000 cubic feet a day. The gas wells are on the higher part of the anticline, but the oil wells are on the high part of the anticline and low in the syncline that trends northeastward through the NE¼NE¼ sec. 21, the NW¼NW¼ sec. 22, and the SW¼SW¼ sec. 15. Lack of structural control of the occurrence of oil in the main reservoir bed is characteristic of the Bartlesville sand in Osage County. It is therefore not surprising to find that the oil-bearing sand extends southeastward off the dome into sec. 22. The total thickness of the Bartlesville sand in most wells that penetrated it is from 100 to 125 feet, but most of the oil and gas wells in the field penetrated only the upper 20 to 50 feet of the sand. It is reported that the lower part of the sand contains water. According to the logs many of the producing wells have been abandoned without being drilled through the sand. Recently the yields from the Bartlesville sand in eastern Osage County have been materially increased by deepening old wells. Therefore, unless the wells are yielding large amounts of water, it is advisable to deepen some of the Bartlesville sand wells in the East Hominy field before they are abandoned to determine whether oil or water occupies the lower part of the sand.

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

The East Hominy field had produced 1,911,812 barrels of oil by the end of 1936, according to Rorschach and Dahlgren.[31] The average daily rate of production in 1936 was 82 barrels. The productive area is about 380 acres. The field had yielded a total of 5,031 barrels of oil to the acre by the end of 1936. The gravity of the oil ranges from 34° to 36°, A. P. I.

Two Bartlesville sand wells in the SW¼ sec. 22 (outside the area generally considered as the East Hominy field), which were drilled in 1912, are still producing oil. The two wells produced 13,340 barrels of oil from July 1916 to May 1937, according to records on file at the Osage Indian Agency. The production data for the period prior to July 1916 are not available. These wells indicate that the Bartlesville sand will yield oil throughout much of the W½ sec. 22 and part of the E½ sec. 21; additional test wells should be drilled. The information from the well logs suggests that additional wells should be drilled also in the SE¼ sec. 17. The initial yields of wells 1, 3, and 4, in the SE¼ sec. 17, ranged from 45 to 100 barrels a day. The wells were drilled in 1920 and 1922 and are still producing oil. Furthermore, only the uppermost 40 to 55 feet of the Bartlesville sand has been penetrated in these wells.

Ordovician beds offer a possibility of producing oil in the East Hominy field. These beds have been tested in seven wells on the dome, but none was in the most favorable location. Wells 6 and 14, in the SW¼ sec. 16, penetrated the upper part of the Ordovician beds, but if a test well were located in the southwest corner of the NW¼SW¼ sec. 16, it would be more nearly on the crest of the dome on the Siliceous lime.

HOMINY DOME

The eastern end of the Hominy dome, which is mainly in T. 22 N., R. 8 E., projects into secs. 7 and 18, T. 22 N., R. 9 E. The Hominy dome has a structural closure on the exposed rocks of 70 feet [32] and a structural closure on the Oswego lime (pl. 2) of nearly twice that amount. The crest of the dome on the exposed beds is near the center of the SE¼NE¼ sec. 13, T. 22 N., R. 8 E. The crest of the dome on the Oswego lime is about a quarter of a mile west of its position on the exposed rocks. The area productive of oil in T. 22 N., R. 9 E., occupies about 60 acres and has yielded an unusually large amount of oil. In T. 22 N., R. 9 E., all wells except one produce oil from Ordovician beds; one well derives its oil from the Mississippi lime. The initial yield of the wells ranged from 40 to 700 barrels a day. As described in the report on T. 22 N., R. 8 E., the average yield of oil to the acre for the field had been 7,947 barrels by the end of 1936.

[31] Rorschach, H. E., and Dahlgren, E. G., Petroleum development in Oklahoma in 1936: Am. Inst. Min. Met. Eng. Trans., vol. 123, pp. 430–433, 1937.

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

DOME IN SEC. 30

The dome in sec. 30 has a structural closure of about 30 feet on the exposed beds [33] and slightly more than 30 feet on the Oswego lime (pl. 2). The dome is a part of a northeast-trending anticline that includes a dome near each end; one dome is in sec. 30 and another dome, which is larger and more steeply folded than the one in sec. 30, is in sec. 36, T. 22 N., R. 8 E. Oil is found in sec. 30, T. 22 N., R. 9 E., mainly in a sequence of sands that includes the Okesa sand, which is encountered a little below 400 feet, and the Torpedo sand, which is about 100 feet lower. The sands are interbedded with red rock and shale. The Layton sand, encountered at a depth of about 1,200 feet, yields oil in a few wells in sec. 30. Ordovician rocks were found barren of oil or gas in well 1, drilled in 1934 in the NW¼NE¼ SW¼ sec. 30, near the crest of the dome. It is probable that another well will be drilled near the center of the north line of the S½SW¼ sec. 30 to test the Ordovician beds.

OIL FIELD IN SECS. 35 AND 36

Several wells near the south boundary of secs. 35 and 36 have produced oil from the Cleveland and Jones sands, which are encountered at a depth of about 1,400 feet. The sequence of beds containing the sands consists mainly of two beds of sandstone separated by a shale bed about 50 feet thick. The oil in most of the wells occurs in the lower sandstone, which is probably equivalent to the Cleveland sand. The wells were drilled between 1911 and 1917. Most of them have been abandoned.

ANTICLINAL NOSES

Several anticlinal noses, including those in secs. 24 and 25, secs. 28 and 29, and secs. 32 to 34, deserve thorough investigation. No deep dry holes have been drilled on any of these anticlinal noses. The nose in secs. 28 and 29 is projected almost entirely on the data furnished by the single dry hole in the SE¼ sec. 29. Wood's structure map [34] of the exposed rocks shows this area to be structurally low. The nose shown on plate 2 must be regarded as speculative therefore, until the elevation of the well in sec. 29 is redetermined and the well log is checked against the original record. The nose in secs. 24 and 25 is a promising feature for further investigation. The exposed beds also are arched into a pronounced nose. A test well would penetrate prospectively oil-producing beds in the Bartlesville sand, in the Burgess sand-Mississippi lime zone, and in the uppermost part of the Siliceous lime. Several beds that lie above the Bartlesville sand, particularly the Cleveland sand, would also have possibilities as producing beds.

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

[34] Wood, R. H., Unpublished map of parts of the Hominy quadrangle, Okla., in U. S. Geol. Survey files.

RECOMMENDATIONS

Additional oil wells might be obtained in the Bartlesville sand (1) in the W½ sec. 22, (2) in several sites on the East Hominy anticline, (3) in the NE¼ sec. 12 on the Flesher anticline, and (4) near the lone producer (No. 2) in the NW¼ sec. 3. Inasmuch as the entire township lies in a region in which the Bartlesville sand is productive, the Bartlesville should be regarded as a possible producing bed in all future wells drilled. The dome in the W½ sec. 9 and the dome in the E½ sec. 4 should be thoroughly investigated before Ordovician beds are tested. The Ordovician beds remain untested on the crest of the East Hominy dome in sec. 16. The anticlinal noses that lie mainly in secs. 24 and 25, 28 and 29, and 32 to 34 should be more thoroughly investigated than was possible for this report. The nose in secs. 24 and 25 appears favorable for a test of the Ordovician rocks. A similar test should be made of the nose in secs. 28 and 29 provided further investigation shows that the contours are correctly drawn in these sections.

T. 23 N., R. 9 E.

T. 23 N., R. 9 E., is in south-central Osage County, about 10 miles south of Pawhuska. Hominy is adjacent to the southwest corner of the township. Oil or gas has been found in 10 or more beds. A group of beds, including the Okesa and Torpedo sands in the Ochelata formation, produce oil or gas in more wells than any other bed or closely associated sequence of beds. The Bartlesville sand yields oil in several wells in four small tracts. Other beds each yield oil in only a few wells. A total of 195 wells has been drilled in the township; about half of these were less than 1,000 feet deep and therefore fail to test many important beds that yield oil and gas in the Osage County region.

The main development of the oil fields of this township began in 1919. Most of the wells in the Manion field in secs. 19 and 30 were drilled in 1920; most of the wells in sec. 4 were drilled between 1921 and 1925; and the wells in the SE¼ sec. 5 were drilled between 1926 and 1930. Some of the wells producing from Ordovician rocks in the SW¼ sec. 6 were drilled in 1926, and those producing from the Bartlesville sand in the N½ sec. 6 were drilled in 1929. Most of the small group of wells in secs. 28 and 29 were drilled in the period between 1929 and 1934.

The subsurface geologic investigation of this township was made mainly by H. D. Jenkins in 1935 and 1936. L. E. Kennedy made a part of the investigation.

STRUCTURE AND DEVELOPMENT

The western part of T. 23 N., R. 9 E., is in a narrow northeastward-trending belt of country that contains many sharply folded domes,

and the eastern part of the township is in an area that is for the most part devoid of pronounced folds. Several of the domes in the western part of the township have a closure on the Oswego lime of more than 100 feet (pl. 2). The area covered by each dome is commonly less than 2 square miles. Most of the oil- and gas-producing wells in this township are on domes; the most notable exceptions are those producing from the Layton sand in sec. 34. The wells producing from the Bartlesville sand in sec. 6 also are low on the flank of an anticline, and it is probable that the occurrence of the oil there is not controlled by the presence of the anticline nearby.

DOME IN SECS. 4, 5, AND 8

A sharply folded dome occupies mainly parts of secs. 4, 5, and 8. The dome has a closure of about 30 feet on the exposed beds [35] and 140 feet on the Oswego lime (pl. 2). The crest of the dome on the exposed beds is in the W½SW¼ sec. 4; the crest on the Oswego lime is in the E½SE¼ sec. 5, which is about a quarter of a mile west of its position on the exposed beds. Oil is produced on the dome from the Bartlesville sand and from the Burgess sand-Mississippi lime zone. Gas has been produced from the Bartlesville sand in two wells, from the Torpedo sand in two wells, and from the Bigheart sand in one well. Two wells have tested Ordovician rocks, but neither test well is on the crest of the dome; well 8 in the SW¼ sec. 4 is on the east flank, and well 3 in the SE¼ sec. 5 is on the west flank of the dome. Well 5, in the SE¼ sec. 5, should be deepened into Ordovician beds before it is abandoned. It is probable that the area producing oil from the Bartlesville sand could be extended northward and southward and the area producing from the Burgess sand-Mississippi lime zone also could be extended. Several wells on the dome had shows of oil or gas in the Cleveland, Layton, Okesa, and Torpedo sands. These shows indicate that these beds might be made to produce gas or oil in commercial amounts.

NORTH MANION ANTICLINE

The North Manion field occupies the North Manion anticline, whose crest trends northeastward through the northeasternmost part of T. 23 N., R. 8 E., and crosses secs. 6 and 7, T. 23 N., R. 9 E. Two domes in T. 23 N., R. 8 E., are superposed on the crest of the anticline; the northernmost dome extends into secs. 6 and 7, T. 23 N., R. 9 E. Four wells in the SW¼ sec. 6 and in the NW¼NW¼ sec. 7 produce oil from Ordovician rocks—beds that occcur either in the Simpson formation or in the Siliceous lime. Eight wells in the N½ sec. 6, on the flank of the North Manion anticline, found oil in the Bartlesville sand. Only one of the Bartlesville sand wells has been abandoned. It is probable that the oil-producing area in the

[35] Wood, R. H., Unpublished map of parts of the Hominy quadrangle, Okla., in U. S. Geol. Survey files.

Bartlesville sand can be extended by drilling more wells. Additional oil wells might be completed in Ordovician beds along the crest of the anticline in the NW¼SW¼ and W½NW¼ sec. 6.

MANION ANTICLINE

The Manion anticline occupies parts of secs. 19 and 30 and extends southwestward across the west boundary of the township into T. 23 N., R. 8 E. Two domes are superposed on the anticline. The crest of one of the domes is in the SW¼ sec. 19, T. 23 N., R. 9 E., and the crest of the other is in sec. 25, T. 23 N., R. 8 E. The anticline and both domes are prominent structural features on the exposed rocks [36] as well as on the buried rocks (pl. 2). The crest of the northeastern dome on the Oswego lime, as shown on plate 2, is a quarter of a mile west of the crest on the surface rocks, but the crest of the southwestern dome on the Oswego lime is only a few hundred feet from the position of the crest on the surface rocks. However, the structure contours in secs. 19 and 30, T. 23 N., R. 9 E., on plate 2, are based for the most part on wells that were too shallow to penetrate the Oswego lime—the datum bed. Therefore, the position of the crest of the dome, as shown on plate 2, is somewhat speculative.

Most of the wells on the dome produce oil from a thin sand in the Ochelata formation that is tentatively called the Torpedo sand. The sand lies at a depth of a little less than 500 feet and is about 30 feet thick. It occurs in a sequence of sandstone and shale beds and a few thin beds of limestone, which persists as a zone throughout much of southern Osage County, but individual beds within the sequence are lenticular. The designation of the producing bed as the Torpedo sand is, therefore, speculative. The initial yield of the wells producing from the Torpedo sand ranged from 10 to 100 barrels a day; many wells produced about 50 barrels a day initially. Two wells in the NE¼ sec. 30 found oil in the Peoples sand, which was encountered at a depth of 900 feet. One well produced gas and a few wells found shows of oil in the Layton sand. A few wells that are widely separated in the field found oil or gas in the Bartlesville sand. Well 1, near the center of the E½SW¼ sec. 19, and well 27, near the center of the N½SW¼ sec. 19, found oil in the Siliceous lime, which was encountered at a depth of 2,470 feet. These data indicate that the Manion oil field is only partly developed. Many wells in this field will be deepened to lower producing beds. The Peoples sand, Layton sand, and Bartlesville sand are beds in which oil is likely to be found in deepened wells; several other beds, such as the Cleveland sand and Oswego lime, are possible producing beds. The sequence of beds at the contact of the Mississippi lime and the Cherokee shale might

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

contain oil or gas. Additional wells will probably be drilled into Ordovician beds.

DOME IN SECS. 28 AND 29

Oil and gas have been found in several beds on a dome whose crest on the Oswego lime is in the SE¼ sec. 29. The crest of the dome on the exposed rocks is near the southeast corner of sec. 29, about 1,000 feet southeast of the crest on the Oswego lime. The structural closure on the exposed beds is 35 feet [37] and on the Oswego lime is a little more than 100 feet (pl. 2).

The zone of sands in the Ochelata formation, which includes beds equivalent to the Okesa and Torpedo sands, lies at depths of 300 to 600 feet and yields oil and gas on the dome. Several beds of sand within the zone contain oil and gas; the producing sand is not the same bed in all wells. It is probable that additional wells could be completed in these sands. The daily yield of the wells probably would be small, however. The Peoples sand, found at a depth of 900 feet, yielded gas at the rate of 2,500,000 cubic feet a day in one well. The Bartlesville sand yielded oil or gas in several wells and shows of oil and gas in other wells. One well (No. 1A) in the SE¼ sec. 29, on the crest of the dome, found oil in Ordovician beds. It was not determined definitely whether the oil-bearing beds in this well are in the Siliceous lime or the Simpson formation, but it is probable that they are in the Siliceous lime. The well yielded about 40 barrels a day, but after treatment of the beds with acid it yielded at the rate of 480 barrels a day. Additional wells should be drilled into Ordovician rocks. Also, the area producing from the Bartlesville sand can probably be extended.

DOME IN SEC. 26

Several deep dry holes have been drilled on a small dome whose crest is in the NW¼ sec. 26 (pl. 2). Shows of oil and gas were found in the Bartlesville sand, the Simpson formation, and the Siliceous lime.

OIL FIELD IN SEC. 34

Five wells in the W½ sec. 34 produce oil at a small daily rate from the Layton sand, which lies at a depth of about 1,000 feet. Other wells can probably be found in this sand. One well in sec. 34 found a good show of oil in the Bartlesville sand. The wells are near the axis of a comparatively deep syncline. However, the occurrence of oil in the Layton and Bartlesville sands and several other sands in Osage County appears not to be controlled by the attitude of the beds.

DOMES IN SECS. 16, 17, 20, AND 21

The dome whose crest is near the southeast corner of sec. 17 is worthy of thorough investigation to determine whether it should be tested further for oil in the Siliceous lime. The logs of several wells

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

on this dome and the dome in the NE¼ sec. 16 record shows of oil and gas in several beds. The exposed rocks form an anticline whose crest trends westward through the S½S½ sec. 16 and the S½SE¼ sec. 17.[38] The highest part of the anticline is near the center of the SE¼SE¼ sec. 17. The structural closure on the exposed beds is a little more than 20 feet. However, attention is called to the fact that the dome is structurally lower than other domes in the region (pl. 2.) A test well near the center of the SE¼SE¼ sec. 17 should encounter the Siliceous lime at a depth of about 2,600 feet.

OTHER PARTS OF T. 23 N., R. 9 E.

T. 23 N., R. 9 E., lies in a region that contains many oil fields producing from the Bartlesville sand. Moreover, several dry holes in the township found shows of oil and gas in the Bartlesville sand, and 35 wells in four widely separated fields in the west half of the township have produced oil or gas from this sand. It is probable, therefore, that other Bartlesville sand oil fields will be found in the township.

RECOMMENDATIONS

The tracts producing oil from the Bartlesville sand in secs. 4, 6, 19, and 30 and 28 and 29, should be extended by new wells, for all deep wells drilled in the township have potential value for discovery of oil or gas in the Bartlesville sand. Well 5 in the SE¼ sec. 5 should be deepened into the Siliceous lime before it is abandoned. The area on the dome in secs. 4 and 5 in which oil is produced from the Burgess sand-Mississippi lime zone should be extended. Sands at shallow depths, including the Cleveland, Layton, Clem Creek, and Torpedo sands, are potential producing beds. The tract producing oil from Ordovician beds in sec. 6 should be extended northeastward along the crest of the anticline. In the Manion oil field the area producing from the Torpedo sand should be extended southward; the Peoples sand, Layton sand, and particularly the Bartlesville sand should be thoroughly tested by several wells; additional wells near the crest of the dome should be drilled into the Siliceous lime. The Okesa and Torpedo sands, the Peoples sand, and particularly the Bartlesville sand and the Siliceous lime, are prospectively valuable for oil and gas in new wells on the dome in secs. 28 and 29. More wells should be drilled on the tracts in sec. 34 that contain wells producing oil from the Layton sand. Several of these should be deepened to the Bartlesville sand before abandonment. There is a probability that a thorough investigation of the domes in secs. 16, 17, 20, and 21 will determine that the Siliceous lime should be tested in the center of the SE¼SE¼ sec. 17.

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

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