T. 24 N., RS. 11 AND 12 E.

By Oliver B. Hopkins and Sidney Powers.

INTRODUCTION.

The area covered by T. 24 N., Rs. 11 and 12 E., lies in the eastern part of the Osage Reservation east of Bigheart and north of Avant. (See fig. 1.) These townships were mapped entirely by plane table, in part by stadia traverse and in part by triangulation. Sidney Powers, with the assistance of G. R. Hensen, an instrument man, mapped the structure of T. 24 N., R. 12 E., and O. B. Hopkins, with the assistance, at different times, of G. R. Hensen, J. T. Richards, and H. J. Weeth, as instrument men, mapped T. 24 N., R. 11 E. The text of this report was written by Mr. Hopkins.

STRATIGRAPHY.

EXPOSED ROCKS.

The rocks exposed in these two townships comprise about 525 feet of alternating beds of shales and sandstones with beds of limestone at intervals, as shown in Plate XXXVIII. In the lower part of the section shales and limestones predominate; in the upper part, shales and sandstones. A complete description of the rocks of the area will not be given: only those beds or key rocks which were most helpful in determining the geologic structure are described. The relative position of the key beds is shown in Plate XXXVIII.

Avant limestone.—The Avant limestone, the only thick, conspicuous limestone in the area, is exposed in the lower valley of Candy Creek near the south line of T. 24 N., R. 12 E., and in the extreme northeast corner of that township. (See Pl. XXXVII.) The Avant thins from 44 feet in the vicinity of the town of Avant, near the south line of T. 24 N., R. 12 E., to 12 or 15 feet at the northeast corner of that township. The upper part of the limestone is platy and is loaded with Bryozoa and fragments of crinoid stems; the lower part is more massive and less fossiliferous. The top of this limestone was traced over the area of its outcrop shown on Plate XXXVIII.

Fusulina-bearing gray limestone.—The *Fusulina*-bearing gray limestone was traced over the greater part of T. 24 N., R. 12 E., where it is a conspicuous and valuable key bed. It crops out in the hill slope

22 feet above the southwest corner post of the township and was traced over the greater part of its area, as shown on Plate XXXVII. It is a gray to yellow thin-bedded to platy limestone from 2 to 4 feet thick. Its upper surface is covered with large *Fusulina*, which have much the shape and size of wheat grains, and its lower surface shows many *Productus* and fragments of crinoid stems. Over a large area it appears to be characterized by the presence of a species of large *Pinna*. The interval from this limestone to the Avant decreases from 115 feet in the southern part of T. 24 N., R. 12 E., to 30 feet near its northeast corner. Between the *Fusulina*-bearing limestone and the Avant there is another thin limestone (the shelly limestone of Pl. XXXVIII), but this limestone was not traced in these townships. The shelly limestone is also found in the townships to the south.[1]

Red limestone.[2]—From 8 to 20 feet above the top of the *Fusulina*-bearing limestone is the base of another limestone which because of its large content of iron usually weathers red on exposed surfaces. This limestone was traced over a considerable area in the northwestern part of T. 24 N., R. 12 E., and across the southern part of T. 24 N., R. 11 E., where it is a valuable horizon marker. (See Pl. XXXVII.) It is exposed above the *Fusulina*-bearing limestone at the southwest corner of T. 24 N., R. 12 E., and as a prominent ledge rimming the valley of Bird Creek on its north side in secs. 2, 3, and 4, T. 23 N., R. 11 E.; it is also exposed 100 feet west of the southwest corner of sec. 32, T. 24 N., R. 11 E. This limestone usually occurs in two benches, of which the lower is the more persistent and conspicuous. It is at most places a massive red or reddish-brown sandy limestone ranging from 8 to 20 feet in thickness; here and there, however, it is a purer limestone, is loaded with fossils, particularly crinoid stems, and is gray on exposed surface. In the eastern part of the area it is overlain and underlain by shale, but in the western part the shale is represented by a heavy bench of sandstone (the Clem Creek sandstone).

"Worm-tube" limestone.—Overlying the red limestone in the western part of the area is a series of massive medium-grained sandstones, with thin, lenticular beds of shale, 58 to 90 feet thick, which represent the Clem Creek sandstone. From 11 to 25 feet above the base of this series is a thin gray shaly limestone characterized by tubular markings, which probably represent remains of algae or worm tubes. This limestone is from 1 to 3 feet thick and is present in the same area in T. 24 N., R. 11 E., as the red limestone, and in

[1] See Emery, W. B., report on T. 23 N., R. 11 E., and Tps. 22 and 23 N., R. 12 E.: U. S. Geol. Survey Bull. 686-B, p. 3, 1918.

[2] This is not the same limestone as that referred to by Winchester and others as the red limestone member of the Pawhuska limestone. See Winchester, D. E., report on T. 27 N., R. 9 E.: U. S. Geol. Survey Bull. 686-C, p. 12, 1918.

a considerable area in the western part of T. 24 N., R. 12 E., also in the northern and northeastern parts of that township, where the red limestone is absent. It was used as a key bed mainly in the northern part of T. 24 N., R. 12 E. (See Pl. XXXVII.) It is exposed, as are also the red and *Fusulina*-bearing limestones, at the southwest corner of that township; about 5 feet above a prominent sandstone bench fringed by trees near the northwest corner of sec. 3 of the same township; and in the bottom of a deep draw near the middle of the south line of the NE. ¼ sec. 13, T. 24 N., R. 11 E. The interval between this limestone and the *Fusulina*-bearing limestone increases from 36 feet at the southwest corner of T. 24 N., R. 12 E., to 59 feet in sec. 17 of that township.

Clem Creek sandstone.—Above the red limestone and including the "worm-tube" limestone is a series of massive medium-grained sandstones with thin lenticular beds of shale, 58 to 90 feet thick, which has been termed the Clem Creek sandstone.[1] The top of this sandstone is generally marked by the upper limit of the growth of trees; it is overlain by 55 to 70 feet of shale which forms a belt of open prairie country. From 5 to 10 feet above the top of the Clem Creek sandstone, which was used locally as a horizon marker, there is in places a thin bed of limestone, which weathers red on exposed surfaces. In this area the top of this sandstone does not represent a definite horizon except locally, as in different localities different ledges of sandstone form its top. The limestone above it is believed to be at about the same horizon at such widely separated points as about 300 feet northwest of the southeast corner of sec. 25, T. 24 N., R. 11 E.; on top of the prominent sandstone bench about 150 feet west of the southeast corner of sec. 1 of the same township; and along the road near the middle of sec. 5, T. 23 N., R. 11 E. To the east, in T. 24 N., R. 12 E., the Clem Creek sandstone thins, and its interval is represented almost entirely by shale.

Birch Creek limestone.—Above the 55 to 70 feet of shale which overlies the Clem Creek sandstone is another series of sandstones which is substantially the equivalent of the Okesa and Torpedo sandstones of the townships to the north.[2] At the base or at some places 12 to 15 feet above the base of this series of sandstones there is a sandy limestone, named the Birch Creek limestone.[3] This limestone has been traced entirely across T. 24 N., R. 11 E., from east to west and over more than one-half of its area. (See Pl. XXXVII.) In the northeast corner of this township the limestone is absent, but a sandstone into which it grades was traced over that area. It is

[1] Emery, W. B., op. cit., p. 3.

[2] Hopkins, O. B., report on T. 25 N., Rs. 11 and 12 E.: U. S. Geol. Survey Bull. 686–H, pp. 76–77, 1918. Clark, F. R., report on T. 26 N., Rs. 10 and 11 E.: U. S. Geol. Survey Bull. 686–I, p. 95, 1918.

[3] Bowen, C. F., report on T. 24 N., R. 10 E.: U. S. Geol. Survey Bull. 686–D, pp. 17–18, 1918.

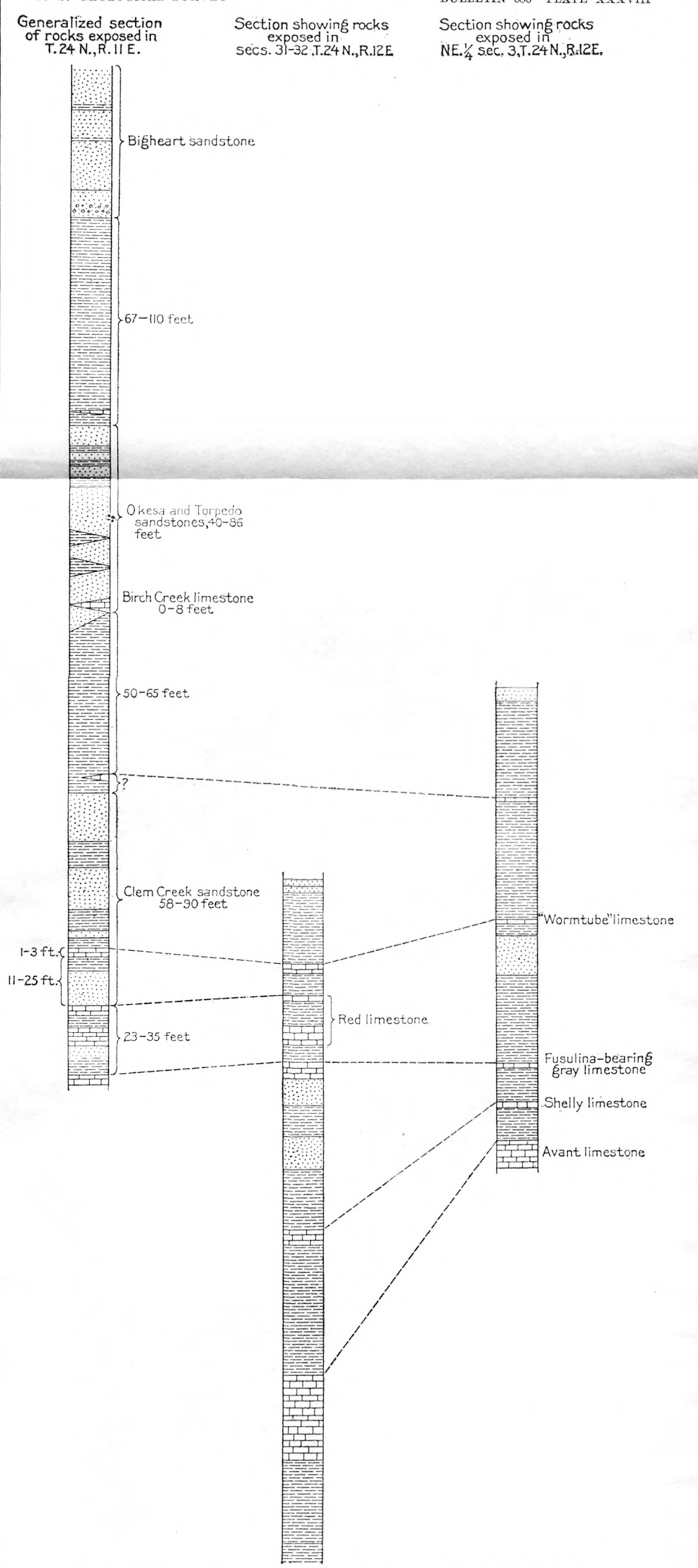
best exposed in the railroad cut 1½ miles south of Bigheart, near the east quarter corner between secs. 19 and 20; it is also exposed on the west side of Dogthresher Creek on the Avant-Bigheart road; and it rims the hollows in the NE. ¼ sec. 22, T. 24 N., R. 11 E.

The Birch Creek limestone is a hard light to dark-gray crystalline, somewhat dolomitic limestone, which contains few fossils. Its high iron content causes it to weather on exposed surfaces to a rusty-brown color. This limestone, which ranges in thickness from 4 to 11 feet, is usually sandy, at least in part, and grades laterally into sandstone. Over much of the area traced it is really a limy phase of the sandstone. The interval between this limestone and the red limestone increases from 116 feet at the southwest corner of T. 24 N., R. 11 E., to 160 feet near the southeast corner of the same township.

Okesa and Torpedo sandstones.—The Birch Creek limestone occurs at or near the base of a series of sandstones from 40 to 86 feet thick, which is substantially the equivalent of the Okesa and Torpedo sandstones farther north. The shale unit that separates these sandstones in the northern area disappears toward the south, causing the sandstones to merge so that they can not be separated easily. The top of the Okesa can be fairly definitely traced over the northern part of T. 24 N., R. 11 E., where it is ususally marked by a prominent bench with an open grassy belt formed by shale above and a rough, wooded sandstone belt below. At some places the top of the Okesa is marked by a thin but hard fine-grained even-bedded sandstone loaded with pelecypods; at other places its top is massive. It attains a maximum thickness of 86 feet in sec. 10, T. 24 N., R. 11 E.; elsewhere it ranges in thickness from 40 to 60 feet. Locally, as near the center of the W. ½ sec. 3, T. 24 N., R. 11 E., a thin limestone occurs 6 feet above the top of the sandstone.

Bigheart sandstone.—The Okesa sandstone is separated by 65 to 110 feet of shale with thin flaggy sandstones from the next massive sandstone series above, the Bigheart sandstone. This name was first applied by Snider[1] to the entire sandstone series that forms the bluffs west of Bigheart; it is here limited to the lower 40 to 70 feet of massive beds of this sandstone series. This sandstone forms a prominent escarpment along the north half of the west side of T. 24 N., R. 11 E., and caps the high hills in the northern part of that township. (See Pl. XXXVII.) The basal bed is coarse grained to conglomeratic along the west line of that township but grades into medium-grained sandstone toward the northeast. The base of this sandstone or the top of its lowest prominent bench was traced over the area outlined on Plate XXXVII.

[1] Snider, L. C., Preliminary report on the clays and clay industry of Oklahoma: Oklahoma Geol. Survey Bull. 7, p. 221, 1911.



COLUMNAR SECTIONS OF ROCKS EXPOSED IN T. 24 N., RS. 11 AND 12 E.

ROCKS NOT EXPOSED.

The rocks underlying these townships to a depth of 1,600 to 1,800 feet are fairly well known from the logs of more than 1,000 wells that have penetrated them, and in a general way they have been found to agree in character with their outcrops to the east. Plate XXXIX shows the logs of eight scattered wells, with a tentative correlation of the more important beds recorded in them.

The most generally recognized beds penetrated by the wells in this area are the Big lime, the Peru sand, the "Oswego lime," the Squirrel sand, the pink lime, the Bartlesville sand, and the "Mississippi lime." The relative position and thickness of these beds are shown on Plate XXXIX. The Bartlesville is the principal productive oil and gas bearing formation in the area, although the Peru sand yields oil in a few scattered wells. Showings of gas have been found in the Big lime, "Oswego lime," and "Mississippi lime" and in some places in shallow sands above the Big lime, but so far as known not any oil or gas has been produced from either of these formations in these townships.

The beds below the Big lime are fairly uniform in thickness and lithology over the area, but owing to the thinning of the beds to the west there is a slight convergence, amounting to about 80 feet across these two townships.

Big lime.—The Big lime is reached at a depth of 900 to 1,100 feet and has an average thickness of approximately 80 feet. This lime, which has yielded gas in commercial quantities in a number of widely scattered wells in T. 25 N., Rs. 11 and 12 E., has made only showings of gas in the wells in T. 24 N., Rs. 11 and 12 E.

Peru sand.—The Peru sand underlies the Big lime and is usually separated from it by 5 to 20 feet of black shale. This sand probably underlies the whole area of these townships, although it is not recorded in all the logs. It yields oil in the NW. ¼ sec. 3, in the SE. ¼ sec. 8, and in the NE. ¼ sec. 17, T. 24 N., R. 12 E., and in the NW. ¼ sec. 15, T. 24 N., R. 11 E. The initial daily production in these wells ranged from 8 to 50 barrels. All wells penetrating this sand should be tested to determine whether they will yield oil in commercial quantities.

"Oswego lime."—The "Oswego lime" occurs at a depth of 1,150 to 1,300 feet and has an average thickness of about 76 feet. This lime yields gas in a number of localities in the Osage country but has made only showings of gas in wells in these townships.

Squirrel sand.—The name Squirrel sand is given by the drillers to a more or less continuous bed of sand which underlies the "Oswego lime" and is separated from it by 10 to 50 feet of dark-colored shale.

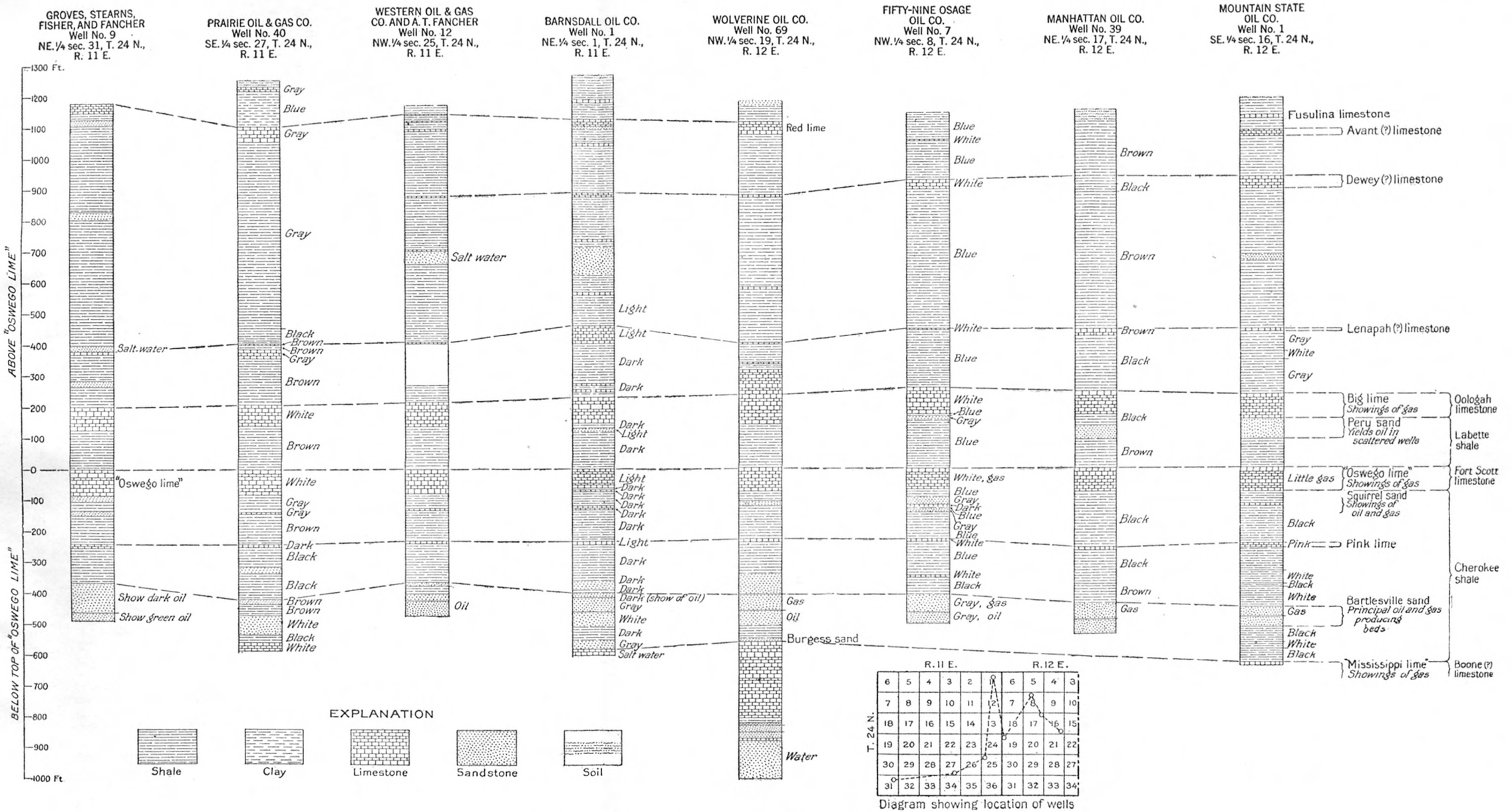
Sands at this horizon underlie these townships and have made prominent showings of gas at many places, notably in the NE. ¼ sec. 7 and the NW. ¼ sec. 8, T. 24 N., R. 12 E.

Bartlesville sand.—Under the name Bartlesville sand is included a group of lenticular beds of sand ranging from 25 to 150 feet in thickness, which lie from 350 to 450 feet below the top of the "Oswego lime," or 1,550 to 1,725 feet below the surface in this area. The Bartlesville has yielded at least 99 per cent of all the oil so far produced in this area and probably an equal percentage of gas.

The upper part of the Bartlesville is commonly gas bearing, and in many places it is separated from the main oil-bearing beds below by a thin bed of black shale. This upper sand is commonly referred to by the driller as "barren." The best yield of oil is usually found from 50 to 100 feet below the top of the sand. The Bartlesville has been reached by more than 1,100 wells in this area. So far as known it is recorded in the logs of practically all these wells, although its thickness and porosity vary from place to place, causing local variations in the yield of the wells.

Burgess sand.—The sand which in places lies immediately on top of the "Mississippi lime" is called by the drillers the Burgess sand. This sand is shown in two logs in Plate XXXIX. It is not known whether any oil wells have been finished in this sand, as many of the logs are not available and many are too incomplete to permit the identification of the sand; at least one small gas well has been completed in it. It is safe to say that this sand has been reached in relatively few of the wells, and that it is untested in a large part of the area.

"Mississippi lime."—The limestone reached in the wells in this area at a depth of 1,750 to 1,900 feet is commonly called the "Mississippi lime." The age of this limestone is not definitely known, but it is believed to be the equivalent of the Boone limestone of the Kansas-Oklahoma section. This limestone has been reached in at least 15 wells in this area and it has been penetrated in at least one. (See Pl. XXXIX.) The log of the Wolverine Oil Co.'s well No. 69, in the NW. ¼ sec. 19, T. 24 N., R. 12 E., shows this limestone to be 249 feet thick and to be underlain by almost 200 feet of sand. This limestone is an important gas-bearing formation in different parts of Osage County, and it probably contains gas in some of the areas of favorable structure in these townships. Before a hole is abandoned as dry it should be drilled through this lime into the underlying sand, unless near-by wells have adequately tested these formations.



SECTIONS SHOWING TYPICAL WELL LOGS IN T. 24 N., RS. 11 AND 12 E.

STRUCTURE.

GENERAL FEATURES.

The structure of this area is shown on Plate XXXVII by means of contours based on a theoretical datum 370 feet above the top of the *Fusulina*-bearing gray limestone. In the area in which this limestone crops out the datum elevations on which the contours are based were determined by adding 370 feet to the elevation of the top of the limestone; in most places where the limestone was absent higher beds were traced and elevations on them were reduced to that of the limestone by subtracting the interval between them. As these intervals are not constant, because the beds are not exactly parallel, different intervals were used in different places, causing the structure as shown on Plate XXXVII to disagree in minor details with that determined from elevations based on a locally traced bed, except in areas where the intervals have been found to remain constant. The contours drawn for this area do not agree exactly with those drawn for the townships to the south, because they are based on different datum beds which are only approximately parallel. The interval between the datum on which the contours are drawn and the "Oswego lime" ranges from 1,440 to 1,480 feet. The depth to the "Oswego" at any point may be determined approximately by subtracting the contour elevation at that point from 1,460 feet and adding the elevation of the surface.

The structure of this area conforms broadly to that of the region, showing the generally westward dip interrupted here and there by local folds and faults. The major structural features of the area are three strongly developed anticlines or domes—(1) the Gypsy dome, in sec. 32, T. 24 N., R. 12 E.; (2) the Eleven-twelve anticline, extending from sec. 18, T. 24 N., R. 12 E., into sec. 12, T. 24 N., R. 11 E.; and (3) the very steep-sided Birch Creek dome, in the southwest corner of T. 24 N., R. 11 E. The Gypsy dome and Eleven-twelve anticline are connected by a low saddle. A belt of relatively steep dips extends from northeast to southwest across T. 24 N., R. 11 E., and a number of subordinate anticlines and synclines are seen in the areas of gently dipping beds in the eastern part of T. 24 N., R. 12 E., and the southeastern and northwestern parts of T. 24 N., R. 11 E.

AREAS OF FAVORABLE STRUCTURE.

BIRCH CREEK DOME.

The Birch Creek dome lies mainly in secs. 29, 30, 31, and 32, T. 24 N., R. 11 E., but extends into the adjoining township on the west.[1] It is an oval dome with steep dips on all sides and curved

[1] Bowen, C. F., report on T. 24 N., R. 10 E.: U. S. Geol. Survey Bull. 686-D, pp. 21-22, 1918.

axis. This axis extends from a point near the center of the NW. ¼ sec. 31 northeastward to a point one-eighth of a mile north of the northeast corner of that section, where it bends to the east; farther on it turns slightly south of east and continues to the south line of sec. 29. The area of closure, outlined by the 1,080-foot contour, includes considerably more than two sections, and the reversal in dip amounts to about 120 feet. The beds on all sides of this dome have abnormally strong dips for this region but the dip is steepest on the northwest side, where it amounts to as much as 270 feet to the mile, or approximately 3°. This dome is separated from the Minnehoma dome, on the east, by a narrow syncline.

This large dome with steep dips on all flanks furnishing an extensive gathering ground, affords exceptionally favorable structural conditions for oil accumulation. Oil has been obtained at many places on its north and northeast slopes and gas along its crest, particularly near its east end. One of the largest wells in the Osage Reservation, reported to have had an initial daily production of 3,100 barrels, was drilled on the north slope of this dome. The initial production of the wells in sec. 29 varies widely, suggesting that there is considerable local variation in the porosity of the sand. The chances of finding oil on the northwest and west slopes of this dome, in secs. 30 and 31, are good, notwithstanding the presence of several dry holes there. All the promising area on this dome has been leased, and future drilling will soon define the limits of this pool. The dry hole in the NW. ¼ sec. 30 penetrated 82 feet of Bartlesville sand and was abandoned 32 feet below the top of the "Mississippi lime." This hole is in the bottom of a syncline and is therefore unfavorably located structurally. The dry hole in the SE. ¼ sec. 30 was drilled 360 feet into the "Mississippi lime" and did not encounter any sand at the horizon of the Bartlesville; this seems strange, because almost 100 feet of the Bartlesville was reported in the log of the well drilled in the NE. ¼ sec. 31.

LABARDIE DOME.

The Labardie dome [1] is a relatively small fold whose crest is near the middle of the line between secs. 3 and 4, T. 23 N., R. 11 E. It is cut in sec. 4 by a fault which has a maximum downthrow on its northeast side of about 50 feet in sec. 33, T. 24 N., R. 11 E., and which extends northwestward across Birch Creek and probably joins with one on the eastern flank of the Birch Creek anticline. The Labardie dome has a closure of 30 feet and a closed area of about 600 acres as outlined by the 1,100-foot contour. A dry hole has been drilled on the crest of this dome, but it is not known whether

[1] Emery, W. B., report on T. 23 N., R. 11 E., and Tps. 22 and 23 N., R. 12 E.: U. S. Geol. Survey Bull. 686-B, p. 8, 1918.

this hole is an adequate test, as its record is not available. This dome is small, however, and does not offer particularly favorable conditions for the accumulation of oil, because of its relatively small gathering ground.

The Labardie dome is connected by a shallow saddle with a smaller dome, whose crest is near the northeast corner of sec. 3, T. 23 N., R. 11 E. This dome has a reversal of dip of about 20 feet and an area of closure of approximately 175 acres, outlined by the 1,100-foot contour. No wells have been drilled on this dome, which is considered worthy of a test. A good location for a test would be in the SE. ¼ SE. ¼ sec. 34, T. 24 N., R. 11 E.

MINNEHOMA DOME.

The Minnehoma dome is situated in secs. 27, 28, 33, and 34, T. 24 N., R. 11 E., covering an area of about two sections. It is an irregularly shaped dome, its symmetry being destroyed by two faults which cut it, and by relatively steep dips to the north and west and gentle dips to the south and east. It is limited on the west by a pronounced syncline, which separates it from the Birch Creek dome, and on the east by a broad, shallow syncline. This dome is cut by a northwestward-trending fault which appears to be continuous with that observed on the opposite side of Dogthresher Creek, where it has a maximum throw of approximately 50 feet. The upthrow is on the southwest side of the fault. It is difficult to contour accurately the beds at the southeast end of the fault, as they appear to have been dislocated by slumping as well as by faulting. Another fault trending N. 75° W. cuts across the southwest corner of sec. 27. It has a maximum throw of 15 feet, with the upthrow on the north side.

Oil has been obtained in numerous wells on the north and northwest slopes of this dome in sec. 27. If the large fault referred to above offsets the oil-bearing sand so that oil can not migrate from one side of it to the other, oil may not be found in large quantities on the west slope of the Minnehoma dome, as the oil which would normally have collected there appears to have been trapped in the saddle between this dome and the Birch Creek dome. Only one failure on the west slope of the dome has been recorded, and this slope can not yet be considered fully tested. If oil is not found near the crest of this dome in the SE. ¼ sec. 28 and the NE. ¼ sec. 33, gas will probably be found.

BIGHEART ANTICLINE.

Because of the wide belt of alluvium east of Bigheart the structure in that vicinity is difficult to determine. The structure contours on Plate XXXVII, which are believed to be essentially

correct, indicate that there is a low anticline, extending almost due north from the NE. ¼ sec. 19 to Bigheart, where it bends sharply to the east. The crest of this anticline, as outlined, follows closely the Midland Valley Railroad south of Bigheart and the south line of secs. 7 and 8 east of the town. In reality this is not a true anticline but a much elongated anticlinal nose, without closure, leading westward from the Dogthresher dome.

The anticline is cut near Bigheart by a northwesterly fault that has a downthrow locally of about 60 feet on its northeast side. A northward extension of this fold appears to connect it with the Redeagle anticline, in the township to the west.[1]

Oil has been obtained on the northwest slope of this anticline just west and northwest of Bigheart. The oil is derived from the Bartlesville sand, and the wells range in initial daily production from 8 to 800 barrels. Two wells having an initial capacity of 10 and 13 barrels were drilled on the eastern part of this anticline in the NE. ¼ sec. 17. It seems probable, from a consideration of the structure and the present development, that small wells can be drilled along the crest of this fold east and probably south of Bigheart. Drilling away from the productive areas should be continued until the commercial limits of the pool are clearly defined.

DOGTHRESHER DOME.

The Dogthresher dome, so named from the creek which crosses it, lies 2 miles east of Bigheart, largely in secs. 15 and 16 but extending into the sections which border these on the north and south. This low, flat, oval dome, outlined by a single closed contour, the 980-foot contour, has an area of closure of about 150 acres, mainly in the NE. ¼ sec. 16. This area of closure is near the middle of a broad structural flat or terrace which covers the greater part of secs. 15 and 16, the southeast corner of sec. 9, and the southern part of sec. 10.

Oil has been obtained at many places on this dome, as shown on Plate XXXVII, from which it will be seen that the productive area is practically continuous toward the south with that on the Minnehoma and Bird Creek domes. The wells range in initial daily production from a few barrels up to 600 barrels, but most of them range from 25 to 100 barrels. The belt in which the largest wells have been developed extends from about the center of the NE. ¼ sec. 21 north-northeastward past the northeast corner of sec. 16 to the middle of sec. 10. All the favorable territory on this dome has been leased, and the drilling that is now under way will soon limit the area over which this pool is commercially productive. To judge

[1] Bowen, C. F., report on T. 24 N., R. 10 E.: U. S. Geol. Survey Bull. 686-D, pp. 22, 23, 1918.

from the structure and the initial production of the wells, there is a considerable belt on all sides of the present producing area in which wells can be drilled that will have an initial production of 5 to 15 barrels a day.

MANHATTAN DOME.

The Manhattan dome lies mainly in the SW. ¼ sec. 24 and the NW. ¼ sec. 25, T. 24 N., R. 11 E., but extends into the adjoining sections on the west. It is a low roughly circular dome with a closure of about 20 feet. It has an area of closure of not more than a quarter section, outlined by the 1,120-foot contour. This dome is at the upper edge of a wide belt in which the beds have an abnormally steep dip. The beds to the north and especially to the south of this dome are relatively flat over a large area. This area of relatively flat beds, because of its position near the upper edge of the belt of steeply dipping beds, affords conditions favorable for oil accumulation beyond the limits of the dome. The Manhattan dome, together with the Eleven-twelve anticline, to the north, the Gypsy dome, to the east, and the saddle which connects them, gives rise to the accumulation of probably the largest developed oil pool in the Osage region.

To judge from the structure and the wells that have been drilled the chance is good of further extending the pool from a quarter to half a mile along its western edge by wells with an initial daily production of 5 to 20 barrels. It is probable that wells of small yield may be obtained over the greater part of sec. 36. An attempt should be made to extend the pool to the southwest along the anticlinal axis which crosses sec. 35 diagonally from its northeast to its southwest corner. All the oil in the area comes from the Bartlesville sand. The wells range in initial daily production from 10 to 400 barrels, but most of them produce initially from 10 to 75 barrels.

ELEVEN-TWELVE ANTICLINE.

The Eleven-twelve anticline, so named because half of it is in R. 11 E. and half in R. 12 E., covers most of secs. 12 and 13, T. 24 N., R. 11 E., and secs. 7 and 18, T. 24 N., R. 12 E. It is a strongly developed fold about three times as long as it is broad. Its axis extends southeastward from a point near the center of the S. ½ sec. 12, T. 24 N., R. 11 E., to the middle of the south line of sec. 18, T. 24 N., R. 12 E., beyond which it is connected by a broad saddle with a nose of the Gypsy dome. The dips are steep on the west, north, and northeast sides of this anticline but fairly gentle on its south and southeast sides. The area of closure, as outlined by the 1,160-foot contour, consists of about one section, or 640 acres. The reversal of dip is approximately 50 feet.

The strong dips which prevail over a wide belt on the west side of this anticline, amounting to 210 feet within a distance of 2 miles, and also the strong dips on its north and northeast sides, amounting to 130 feet within less than 2 miles, make the structural position of this anticline particularly favorable for large accumulations of oil and gas. Six gas wells have been drilled on the crest of this fold and on its southwest slope, and a large number of oil wells have been drilled on its southwestern, southern, and eastern slopes. The logs of the three gas wells in sec. 12, T. 24 N., R. 11 E., are not available, and it is not known how deep they were drilled or from what horizon their gas is produced. The gas wells in sec. 13 of the same township appear to yield gas from the Bartlesville sand. So far as is known, all the oil wells are producing from the Bartlesville. Well No. 69 of the Wolverine Oil Co., in the NW. ¼ sec. 19, T. 24 N., R. 12 E. (see plotted section of this well on Pl. XXXIX), was drilled to the depth of 2,190 feet; it penetrated the "Mississippi lime" and drilled through 195 feet of water-bearing sand below it.

Most of the wells thus far drilled on this anticline range in initial daily production from 10 to 50 barrels; one well, however, yielded 1,000 barrels, another 600 barrels, and still another 500 barrels. The small initial production of most of the wells is due to the thinness and fineness of the pores of the Bartlesville sand, which ranges in thickness from 25 to 80 feet, but in most wells is less than 40 feet thick.

Notwithstanding the relative thinness of the Bartlesville sand and the presence of three dry holes, the chances of extending the productive area on this anticline are good, especially on its western and northern slopes. One dry hole near the center of sec. 14, which was drilled to about the top of the "Mississippi lime," is too far down the dip to be productive; the one in the northeast corner of the same section has no available record and its depth is not known; the third one, in the SW. ¼ NW. ¼ sec. 13, was drilled to a depth of 2,059 feet, probably through the "Mississippi lime," and although it encountered some Bartlesville sand, it was not commercially productive. Drilling should be continued in an effort to extend the pool over the southern and western parts of sec. 13 and over those parts of sec. 12, T. 24 N., R. 11 E., and sec. 7, T. 24 N., R. 12 E., lying between the 1,100 and 1,150 foot contours. Above the 1,150-foot contour gas is likely to be found unless it has been exhausted by the gas wells already drilled.

GYPSY DOME.

The crest of the Gypsy dome is slightly north of the center of sec. 32, T. 24 N., R. 12 E. This is an oval dome with steep dips on its west side and gentle dips on its north, east, and south sides. It has an area of closure, as outlined by the 1,220-foot contour, of approxi-

mately 240 acres and a reversal of dip of about 30 feet. The doming, however, affects an area three to four times as large, covering almost all of sec. 31, the southern part of sec. 29, and parts of the sections bordering these on the east. A nose projecting from this dome to the northwest connects it with the Eleven-twelve anticline.

Oil has been obtained in many places on the southern, western, and northern flanks of this dome. The area of oil development on it merges with that on the Eleven-twelve anticline and on the Manhattan dome, forming a single extensive pool. No well has yet been drilled on the crest of this dome; the one nearest the crest is on its southwestern slope and is a dry hole. Two others near the crest but on its eastern slope were also dry. The largest wells in this pool were drilled on the western flank of the Gypsy dome in a narrow belt between the center of the W. ½ sec. 32 and the center of sec. 31. Over a small area in that belt the wells produced initially from 100 to 2,400 barrels a day. On the northwestern flank, in an area as favorably located structurally, the wells produced from 20 to 100 barrels. This difference in initial production is probably due to differences in the porosity or thickness of the productive sand.

The chances are not especially good for an extensive development of this pool, as the surrounding area has been well tested. However, it seems likely that the productive area may be extended somewhat by the drilling of wells, which will probably be small producers, over much of the undeveloped parts of secs. 29 and 32.

OTHER AREAS OF FAVORABLE STRUCTURE.

An anticlinal nose extends from the SW. ¼ sec. 9 to the NW. ¼ sec. 8, T. 24 N., R. 12 E., and is roughly outlined by the 1,140-foot contour. The beds are flat over a considerable area in the southwestern part of sec. 9 and the southeastern part of sec. 8, except in a small area of gentle doming in sec. 8, outlined by a closed 1,150-foot contour. Oil has been obtained on this nose in both the Peru and Bartlesville sands near the southeast corner of sec. 8 and in the Bartlesville farther northwest, on the end of the nose. The wells in this area produced initially 5 to 125 barrels a day, and so far no favorably located well has been unproductive. To judge from the structure and the production of the wells, the productive area may be extended over practically all of sec. 8 except the N. ½ N. ½ and probably over a considerable part of the W. ½ sec. 9.

Along the eastern boundary of the Osage Reservation in T. 24 N., R. 12 E., there is evidence of anticlinal folding at two places, but as the mapping was not carried beyond the limits of the reservation, these folds are not outlined in their entirety. From the 1,230-foot contour in sec. 10, which is near the edge of the area mapped,

the beds dip to the north, west, and south, suggesting the presence of a fold here. This area in sec. 10 is undoubtedly anticlinal, as shown by the swing of the contours around it to the north and south. Extensive drilling in this section, however, resulted in only a few producing wells, which are now abandoned.

In sec. 22 there is a broad flat, outlined by the 1,200-foot contour, and within it a small area of gentle doming, outlined by the 1,210-foot contour. Considerable oil has been obtained on this flat and even beyond its limits to the north and south. In fact, the presence of the pool of oil which extends from the south line of the township northward along the reservation boundary can not be adequately explained on the basis of the surface structure as mapped. It would seem that the productive area here is controlled largely by the character of the sand, or by folding in the sand which is not reflected in the surface beds.

AREAS OF UNFAVORABLE STRUCTURE.

Oil is usually found in the Osage Reservation associated with anticlines, terraces, or structural noses, and most abundantly on the west or northwest sides of these features; it is seldom found in commercial quantities in major synclines or in areas of featureless, normal west dip. A study of Plate XL will show that in this area the oil pools are associated with anticlinal folds, although some of them extend beyond the limits of individual folds across synclinal areas and unite with pools on other folds, as in the syncline between the Birch Creek and Minnehoma domes. In at least one pool of oil, the one lying along the eastern edge of the reservation in T. 24 N., R. 12 E., the surface structure does not adequately account for the accumulation, which seems to be controlled rather by the thickness and porosity of the productive sand. Wherever the productive sand is uniform in thickness and porosity in this area the structure is believed to be the controlling feature in the accumulation of oil, and oil should generally be looked for only in areas of favorable structure; however, as the productive sand varies much in thickness and porosity, oil may be found in areas of unfavorable structure if the sand conditions are favorable. Oil is least likely to occur in commercial quantities in major synclines, even under favorable sand conditions.

Major synclines occur in sec. 6, T. 23 N., R. 11 E., as outlined by the 1,030-foot contour and in secs. 5 and 6, T. 24 N., R. 11 E., as outlined by 910-foot contour. One extends from the southwest corner of sec. 19, T. 24 N., R. 11 E., northeastward and northward into the NE. ¼ sec. 17; and another extends from a point near the center of sec. 2, T. 24 N., R. 11 E., east-northeastward and eastward, through the northern part of sec. 6, T. 24 N., R. 12 E., from which one branch turns southward through sec. 7 and southeastward across

sec. 17 into sec. 20, where its southern extension becomes less pronounced. It is likely that oil will be found in commercial quantities in the area of steep dips below the 1,060-foot contour between sec. 23 and sec. 11, T. 24 N., R. 11 E., or below the 1,010-foot contour in sec. 3 of the same township.

RELATION BETWEEN SURFACE STRUCTURE, UNDERGROUND STRUCTURE, AND PRODUCTION.

To show some differences between the structure of the exposed rocks and that of the deeper strata and to illustrate the productivity of different parts of the folds, a part of the area described in this chapter is specially mapped in Plate XL. In this map, which covers the southeast corner of T. 24 N., R. 11 E., and the southwest corner of T. 24 N., R. 12 E., are shown structure contours based on (1) the surface beds, (2) the top of the "Oswego lime," and (3) the top of the oil sand (Bartlesville). The contouring of the underground structure is based on well logs, many of which are old and not absolutely reliable; however, the area in which the underground structure is contoured is thoroughly drilled, and so many data are available that the major features are believed to be correctly shown.

A consideration of this plate shows a fairly close resemblance between the surface structure and the structure of the "Oswego lime," in the southwest corner of T. 24 N., R. 11 E. The anticline in the northwest corner of sec. 25 is indicated by the same two sets of contours, as are also the nose extending southwestward past the northeast corner of sec. 35 and the parallel syncline in the northwestern part of sec. 36, though these features are more pronounced in the "Oswego" than in the surface beds. In the southwest corner of T. 24 N., R. 12 E., this similarity of the structure at these two levels is less apparent; a narrow, sharp syncline in the "Oswego" extends from the southwest corner of sec. 30 to and beyond the northeast corner, crossing a belt in which the surface rocks dip gently to the west.

A comparison of the structure of the Bartlesville sand with that of the surface beds and the "Oswego lime" reveals more striking differences. In the southeast corner of T. 24 N., R. 11 E., the contours based on the oil sand (more precisely the top of the productive bed of sand or the top of the oil surface) show a slight similarity to those based on the other data, but in the southwest corner of T. 24 N., R. 12 E., there is no similarity whatever. In secs. 30 and 31, where the surface beds and the "Oswego" dip steeply to the west, the oil sand is essentially flat. This may indicate either that the Bartlesville does not conform to the structure in the overlying beds in that area or, what is more likely, that the top surface of the oil is not parallel to the top of the sand, possibly because the oil occurs

in more or less closely connected lenses of sand lying at different horizons. Sufficient work has not been done to explain why the oil surface is essentially horizontal where the overlying beds dip steeply.

In the southeast corner of T. 24 N., R. 11 E. (see Pl. XL), the areas of large initial production are chiefly in the areas of most favorable structure. This is also true of the Dogthresher dome. In the southwest corner of T. 24 N., R. 12 E., the areas of large initial production are more irregular than in the township to the west, and they do not conform so well to the areas of favorable structure. The variation in the initial production in secs. 29, 30, 31, and 32, as shown on Plate XL, is believed to be due to local variations in the thickness or more probably in the porosity of the sand. As the Bartlesville sand is a shore or near-shore deposit, it was laid down irregularly and its beds vary widely from place to place in texture, and consequently in the size of the pore spaces. This variation may have been increased by subsequent cementation.

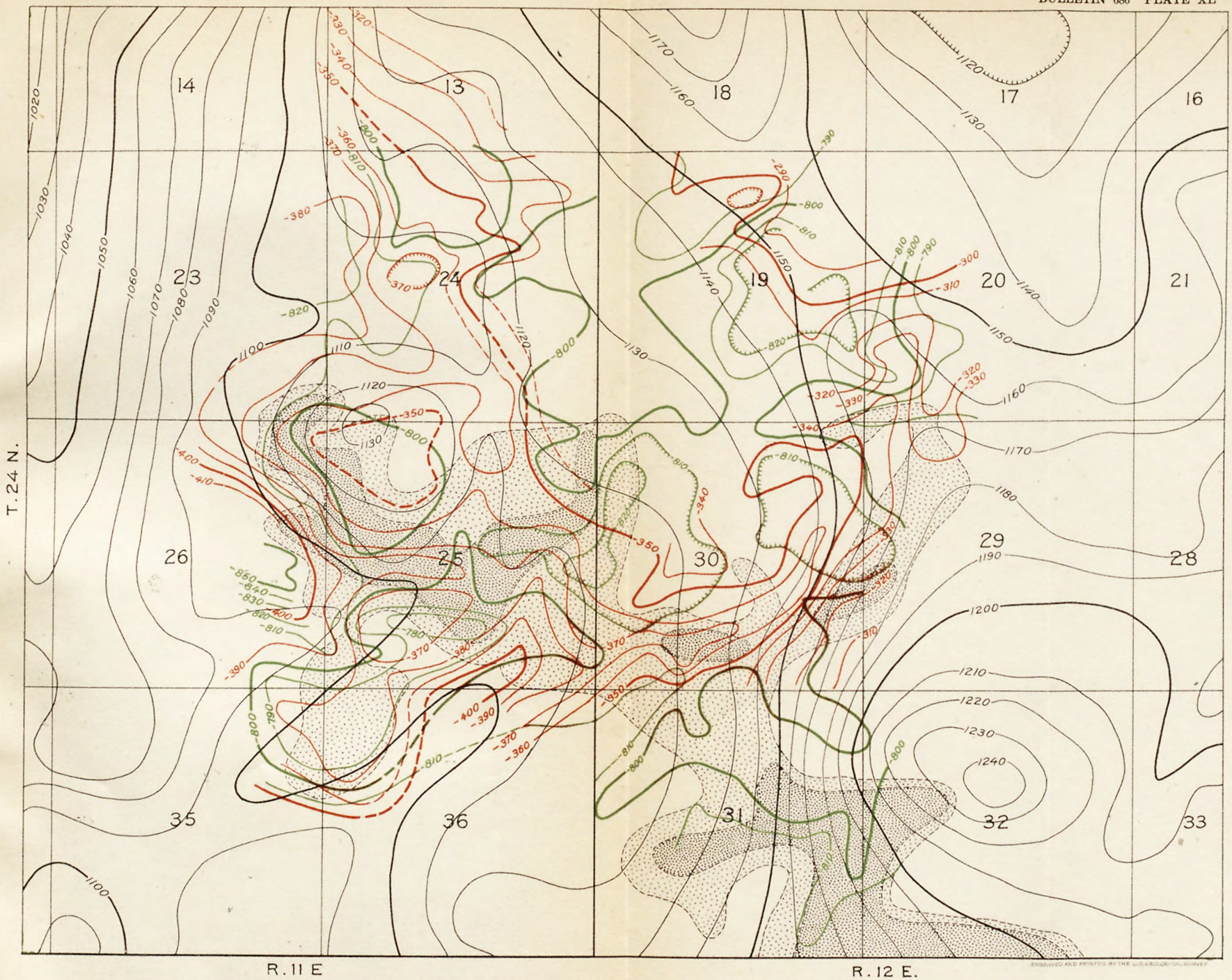
PRODUCTION.

A study of the record of the initial daily production of 519 wells in these townships showed that six wells had a production of 1,000 barrels or over and one had the maximum production of 3,600 barrels. One well in T. 24 N., R. 11 E., produced 3,100 barrels a day; the available records of 289 other wells in this township showed an average initial daily production of 85 barrels.

Initial daily production of 289 wells in T. 24 N., R. 11 E.

Production in barrels.	Number of wells.	Percentage of total wells.
0–25	97	33.6
26–50	75	26.0
51–75	29	10.0
76–100	27	9.4
101–200	32	11.0
201–300	15	5.2
301–400	4	1.4
401–500	7	2.4
501 or more	3	1.0
	289	100.0

Of 229 wells in T. 24 N., R. 12 E., five showed an initial daily production of 1,000 barrels or more; the average production of the remaining 224 wells was 93.1 barrels.



EXPLANATION

Initial daily production 101 barrels or more

Initial daily production 50-100 barrels

Initial daily production less than 50 barrels

Structure contours drawn on a theoretical bed 370 feet above top of *Fusulina*-bearing gray limestone

Structure contours on top of "Oswego lime"

Structure contours on top of oil-bearing bed in Bartlesville sand

Contour interval 10 feet
Datum is mean sea level

SKETCH MAP SHOWING THE GEOLOGIC STRUCTURE OF PARTS OF T. 24 N., RS. 11 AND 12 E., OKLAHOMA AND ITS RELATION TO INITIAL PRODUCTION

Scale $\frac{1}{31,250}$

1 ½ 0 1 Mile

1919

Initial daily production of 224 wells in T. 24 N., R. 12 E.

Production in barrels.	Number of wells.	Percentage of total wells.
0–25	62	27.7
26–50	55	24.5
51–75	22	9.8
76–100	32	14.3
101–200	34	15.2
201–300	8	3.6
301–400	4	1.8
401–500	1	.4
501 or more	6	2.7
	224	100.0

In general the areas in which the wells have the greatest initial production are within those that show favorable structure in the surface rocks, but the distribution of the most productive areas within the areas of favorable structure is dependent on the porosity and thickness of the sand. The position of the belts in which the wells have large initial production is dependent on the thickness, porosity, and extent of beds of sand, and they do not, as a rule, correspond in trend to the folds. It therefore follows that the areas of maximum production do not conform in all respects to the structural features, and a lease on the flank of a fold may be more valuable than one whose location is structurally more favorable.