

THE NESSON ANTICLINE, WILLIAMS COUNTY, NORTH DAKOTA.

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INTRODUCTION.

The rocks of North Dakota in general lie nearly flat; anticlines or domes are not easily detected, and the structure is generally considered so simple that in most reports it has been described in a single paragraph. For this reason the following description of a fairly well marked anticline or dome and of an artesian well yielding a small flow of gas a few miles from its crest may be of interest. This anticline, here named the Nesson anticline from a small village in Williams County, in the northwest corner of North Dakota, is about 30 miles east of Williston, 13 miles southeast of Ray, and 80 miles west of Minot and was discovered in 1917 by a United States Geological Survey party which mapped in detail the outcrops of the lignite beds in the Ray quadrangle, in cooperation with the North Dakota Geological Survey.

FIELD WORK.

The field work on which this report and the structure map (Pl. XXVI) are based included a very accurate survey with plane table and telescopic alidade of the lignite beds exposed on the north and south sides of Missouri River in the Ray quadrangle, which covers the west half of the area described. The results of this work are satisfactory in all parts except T. 155 N. and the north half of T. 154 N., R. 96 W., where heavy deposits of glacial drift and alluvium conceal the bedrock. In the area east of the Ray quadrangle the field work was not nearly so complete, and consisted of a single line of observations without instruments, made on a trip down the north side of the Missouri from Nesson to Sanish and return. Locations and altitudes given for this area are derived from maps published by the Missouri River Commission.¹ The exposures of bedrock in the eastern part of the area are good, however, and an instrumental survey of the lignite beds north and south of the river would probably make it possible to determine the shape of the anticline a little more closely than can be done at the present time.

¹ The assumed altitudes given on the maps of the Missouri River Commission are about 67 feet too high and must be corrected before they can be used in connection with those given on the map of the Ray quadrangle made by the United States Geological Survey. This correction has been made for Plate XXVI.

TOPOGRAPHY.

The Ray quadrangle has been mapped by the United States Geological Survey with a 50-foot contour interval, but for the country to the east the only contour map available is that of the Missouri River Commission, showing a small strip of land on both sides of the river.

The surface of the region consists of a rolling upland in which Missouri River is intrenched from 300 to 500 feet. The upland is more or less covered with glacial drift, and the lowland along the river, which is in most places less than 2 miles wide, is mainly occupied by the flood plain. At Nesson, where the lowland widens to about 5 miles, a bench 3 miles wide and 50 to 100 feet above the flood plain is covered with gravel and silt.¹ The underlying bedrocks are well exposed only in hillsides and badlands between the upland plain and the river level.

KINDS OF ROCKS.

Underlying the area described the shale and fine-grained sandstone of the Fort Union (Eocene) and Lance (Eocene?) formations reach a depth estimated at about 1,700 feet.² The sandy layers in many places show regular cross-bedding due to deposition by currents of water, or more wavy and irregular cross-bedding due to wind action, and at the time of their deposition the waters were shallow. Lignite beds, fossil leaves, petrified wood, and the shells of fresh-water mollusks are abundant in the Fort Union formation. The Lance formation carries in addition to these the fossil remains of many large reptiles called dinosaurs, but it contains fewer lignite beds than the Fort Union. Rocks containing fossils of this character were evidently deposited in fresh water. Such rocks cover to a greater or less depth a large part of eastern Montana and western North Dakota. Beneath the Lance formation is the Pierre, composed almost entirely of dark-gray shale. Its fossils are all remains of marine creatures of Cretaceous time, such as *Baculites*, *Inoceramus*, and marine reptiles, and show that the sea extended to this region when the mud now forming the shale was deposited. No sandstone layers are known to be present in the upper part of the Pierre shale. To the west and southwest in Montana beds of sandstone which occur far down in the equivalent of the Pierre shale are found in the Judith River and Eagle formations at a depth of about 1,000 feet below the Lance.³ To the east in North Dakota

¹ Wilder, F. A., North Dakota Geol. Survey Second Bienn. Rept., pp. 103-104, 1903.

² Stebinger, Eugene, The Sidney lignite field, Mont.: U. S. Geol. Survey Bull. 471, p. 285, 1912.
Beekly, A. L., The Culbertson lignite field, Mont.: Idem, p. 326.

³ Collier, A. J., The Bowdoin dome, Mont.: U. S. Geol. Survey Bull. 661, p. 204, 1917.

these sandstones are not found, but the Dakota sandstone, which is far below the Pierre shale, is reached in artesian wells at depths of 2,000 to 3,000 feet.¹

All the rocks exposed in this area, below the glacial drift and alluvium, belong to the Fort Union formation.

The accompanying section (Pl. XXVI) and the following details regarding the lignite beds exposed near the Nesson anticline are given in order to make the description of the structure intelligible.

The Williston lignite bed, the structure of which is shown in Plate XXVI (No. 6), is the bed mined by the Reclamation Service at Williston and is believed to be continuous where not eroded in the area here described. It is from 5 to 12 feet thick and may be recognized on a great many exposures by a hard layer either in the base of the lignite bed or a foot or two below it, which appears to be made up of the petrified stems and leaves of grass. Associated with this layer, and also in the shale for several feet below the bed, are many petrified stumps and widely spreading roots of trees, which are strewn over the surface where the bed is eroded. Above the Williston bed there is 20 or 30 feet of light-colored sandstone grading upward into shale. Bed No. 7, which can be distinguished by a bluish shale, often weathering into sticky blue clay, immediately above and below it, is about 70 feet above bed No. 6. Ash-gray shale lies below the Williston bed (No. 6) for 40 feet, more or less, to bed No. 5, which is variable in thickness. In T. 154 N., R. 97 W., it ranges from 4 feet 5 inches to 6 feet in thickness, but near the west side of T. 153 N., R. 98 W., it is not more than 1 foot thick. Below bed No. 5 there is a few feet of dark-gray shale overlying sandstone or sandy shale. About 60 feet below bed No. 5 in T. 152 N., R. 97 W., is bed No. 4, which is very irregular but contains 14 feet of lignite in one exposure. In T. 153 N., R. 100 W., bed No. 4 is not more than 1 foot thick, and though it was not recognized in T. 154 N., R. 97 W., it is probably very thin there. For 60 feet below this bed the rocks are mainly light-yellow sandstone, below which is bed No. 3, exposed at several localities in T. 153 N., R. 96 W., where it is more than 4 feet thick. At 80 feet below bed No. 3 is bed No. 2, on which the structure of the rocks of the townships south of the Nesson flat has been determined. It has several partings but is thick enough to have burned in many places, leaving a mass of clinker. Bed No. 1 has been identified only at the Pittsley mine, where it is about 14 feet thick and is overlain by 8 feet of light-blue clay shale, which weathers light yellow and grades upward into massive yellow sandstone. This bed is estimated to be at least 100 feet below bed No. 2.

¹ Willard, D. E., U. S. Geol. Survey Geol. Atlas, Jamestown-Tower folio (No. 108), p. 1, 1909.

STRUCTURE.

The Fort Union formation for 60 miles west of Williston is reported to have a low easterly dip,¹ and through much of the area between Glendive, Mont., and Williston a northeasterly dip has been found.²

In the vicinity of Williston, according to Herald,³ and in the western part of the Ray quadrangle, in T. 153 N., Rs. 98 and 99 W., the strata lie nearly flat, as indicated by the altitudes read on the Williston bed. For 90 miles east of the Nesson anticline the structure has not been examined critically except in the Fort Berthold Indian Reservation,⁴ where there is evidently a syncline or trough extending north and south. The strata on the west limb of this trough dip to the east, and on the east limb a slight dip to the west is indicated.

The accompanying map shows the Nesson anticline by means of structure contours—that is, by lines represented as connecting points of equal altitude at stated intervals above sea level, on the Williston lignite bed where this bed was actually found and on its calculated position where it is eroded. Solid lines are used where the position of the bed has been fairly well determined, and broken lines where no outcrops have been found and the structure is hypothetical.

The Williston bed in sec. 19, T. 154 N., R. 97 W., has an altitude of 1,910 feet, and from that locality it was traced by many exposures to sec. 10 of the same township, where its altitude is 1,994 feet. Beyond this place it is eroded, but bed No. 5, 40 feet below the Williston bed, was found at an altitude of 2,033 feet in sec. 2, about 1½ miles farther northeast, and the altitude of the Williston bed at that place is therefore estimated to be 2,073 feet. South of the river the altitude of the Williston bed is 1,979 feet in sec. 7, T. 153 N., R. 97 W. It is 2,056 feet near the west line and 2,085 feet near the east line of sec. 3 of the same township, and what is believed to be an imperfect exposure of the same bed caps the upland in sec. 7, T. 153 N., R. 96 W., at an altitude of about 2,240 feet. Bed No. 2, 240 feet below the Williston bed, crops out on the west side of Tobacco Garden Creek, in sec. 2, T. 153 N., R. 97 W., at an altitude of 1,885 feet. It is exposed again in sec. 7, T. 153 N., R. 96 W., where its altitude is 1,982 feet in the NW. ¼ and 2,010 feet in the NE. ¼, showing a rise of 80 feet to the mile toward the southeast. In sec. 16, T. 153 N., R. 96 W., its altitude is 2,028 feet, and in sec. 10 it

¹ Beekly, A. L., The Culbertson lignite field, Valley County, Mont.: U. S. Geol. Survey Bull. 471, p. 330, 1912.

² Stebinger, Eugene, The Sidney lignite field, Dawson County, Mont.: U. S. Geol. Survey Bull. 471, pp. 285-287, 1912.

³ Herald, F. A., The Williston lignite field, Williams County, N. Dak.: U. S. Geol. Survey Bull. 531, p. 96, 1913.

⁴ Smith, C. D., The Fort Berthold Indian Reservation lignite field, N. Dak.: U. S. Geol. Survey Bull. 381, p. 33, 1910. Pishel, M. A., Lignite in the Fort Berthold Indian Reservation, N. Dak., north of Missouri River: U. S. Geol. Survey Bull. 471, p. 175, 1912. Bauer, C. M., and Herald, F. A., Lignite in the western part of the Fort Berthold Indian Reservation: U. S. Geol. Survey Bull.—(in preparation).

is 2,040 feet. The altitude last mentioned, if carried north to point F of the section on Plate XXVI, shows the position which bed No. 2 would have if it were not eroded, and the natural conclusion is that across Tps. 153 and 154 N., Rs. 96 and 97 W., a pronounced rise to the east brings the Williston bed to the level of the upland, and if this rise were continued only beds lower in the section would be exposed in the townships farther east. The position of the lignite beds in the east half of the area described may be seen in Strawberry Butte, in the northwestern part of T. 154 N., R. 95 W., about 7 miles east of Nesson and 2 miles east of Hofflund post office. This butte presents a steep bluff 500 feet above the river level for several miles on its southwest side. Near the foot of the bluff there is a line of low hills capped by masses of clinker, which in sec. 17, T. 154 N., R. 95 W., has an altitude, as given on Missouri River Commission chart 89, of about 2,020 feet, and the top of the butte, also capped with clinker, has an altitude of 2,263 feet. The series of low hills slopes down to the east for about 2 miles, the one farthest east noted on the chart having an altitude of 1,876 feet, and probably indicates a dip of the strata in that direction. About a mile farther down the river, at a point not closely located on the map, a lignite bed thought to be the same bed as that which caps the series of low hills with clinker has been opened near the edge of the flood plain and has yielded a small amount of fuel to the farmers. This bed has several partings and resembles bed No. 2 as seen in T. 153 N., R. 96 W. About 3 miles farther down the river, near Grinnell post office, a large bed of lignite is mined on a commercial scale. The mine was closed and locked when visited, and the exact thickness of the bed can not be given, but it is surely more than 7 feet. The many petrified stumps and much petrified wood which are strewn over the surface for about half a mile along the wagon road near the edge of the flood plain and the character of the overlying and underlying shale suggest that the lignite exposed is the Williston bed. This bed can be traced for at least a mile up the river by large masses of clinker, and in that distance it certainly rises about 60 feet. Beyond this stretch the outcrop of the bed is farther back from the road, and its exposures, marked by masses of red clinker, were seen only here and there. It is the writer's opinion that this bed is identical with that capping Strawberry Butte, at an altitude of about 2,263 feet, 7 miles to the northwest, and if this is true it shows conclusively that the rise toward the east noted in the western part of the area is not continuous but that the beds exposed in the eastern part dip eastward about 60 feet to the mile and are the same as those which rise toward the east in the western part of the area. That such a dip may not be merely local is shown by unpublished

field notes¹ made in examining the western part of the Fort Berthold Indian Reservation, which indicate an east dip of about 40 feet to the mile in T. 151 N., R. 94 W., 12 miles south of Grinnell.

The highest part of the anticline indicated on Plate XXVI is not far from Hofflund post office, but owing to the facts that T. 155 N., R. 96 W., is so heavily covered with glacial drift that the lignite beds could not be traced in the time available, and that the field work on the east half of the area described consisted of a single line of observations, it is impossible at the present time for the writer to state positively the direction of its axis. This anticline may possibly be a fold parallel with the Glendive anticline in Montana and if so it should strike northwest. South of the Missouri, however, near the west line of T. 153 N., R. 96 W., a northeasterly strike was observed for about a mile, but whether this is merely local was not determined.

OIL AND GAS IN NORTH DAKOTA AND EASTERN MONTANA.

No oil and but little natural gas in commercial quantities has been found in either North Dakota or eastern Montana. Oil in commercial quantities has never been found in either the Fort Union or the Lance formations, and considering the great depth to the Pierre shale and the absence of sand layers in the shale, which might serve as reservoirs for oil and gas and which could be reached by present methods of drilling, it is the writer's opinion that the chances of finding oil in the Nesson anticline are very small. At Williston and Minot wells have been drilled in search of oil, but at neither place have commercial accumulations been found, though small samples resembling gasoline are said to have been obtained from the Minot well. Should this report prove true it would demonstrate the possibility of oil in the Nesson anticline, for the source of the oil would be practically the same in both places.

The towns of Westhope and Lansford, in Bottineau County, N. Dak., about 100 miles northeast of Nesson, are supplied with natural gas from shallow wells in the glacial drift above the Pierre shale. At Edgeley, Lamoure County, about 250 miles southeast of Nesson, artesian wells drilled to the Dakota sandstone yield a small quantity of gas which is separated from the water by mechanical means and used by the residents.² Wells drilled in the Pierre shale on the Glendive anticline in Montana, about 80 miles southwest of Nesson, supply the towns of Glendive and Baker with heat and light.

Natural gas, probably from the Fort Union formation, was reported in the northern part of Williams County about 40 miles north

¹ Bauer, C. M., and Herald, F. A., Lignite in the western part of the Fort Berthold Indian Reservation; U. S. Geol. Survey Bull. — (in preparation).

² Leonard, A. G., Natural gas in North Dakota; U. S. Geol. Survey Bull. No. 431, pp. 7-10, 1911.

of Nesson in 1909,¹ and a report of gas struck at a depth of 900 feet in an artesian well on the Black ranch, near Sanish, Mountrail County, 24 miles southeast of Nesson, and probably far down on the east flank of the Nesson anticline, has lately been published.² In September, 1917, D. W. Barrett began drilling an artesian well for H. A. Nelson on the Bonanza farm, in sec. 36, T. 155 N., R. 97 W., 2½ miles north of Nesson. The well was completed early in October and is reported to have struck, at a depth of 750 feet, a flow of gas, which burns as it comes to the surface, and at 883 feet a good flow of water. If this flow is permanent and in sufficient quantity, the gas can be collected for domestic use, like that found at Edgeley. The strata at the Nelson well, according to the writer's interpretation, dip to the west, and the crest of the anticline is several miles to the east.

As it is generally recognized that the highest parts or crests of anticlines or arches in the rocks are the most likely places to find accumulations of natural gas, it would seem advisable that one or more wells be drilled about 4 miles east or southeast of the Nelson well in search of a larger gas flow. Wells to test the Fort Union and Lance formations can be drilled rather economically with machinery like that used at the Nelson well, and if they were unsuccessful in finding gas they might still be used for water supply. They should if possible be drilled to the Pierre shale, at a depth of about 1,700 feet. The logs of a line of such wells about 1 mile apart running east from the Nelson well would probably make it possible to determine the position of the crest of the anticline more exactly than can be done from the surface exposures. A deeper well, located as near the crest of the anticline as possible, might be drilled to the Dakota sandstone (the source of the gas at Edgeley, N. Dak.), which would be reached at a depth of about 3,700 feet. Such a well would test the upper part of the Pierre shale (the probable source of the gas in Bottineau County, N. Dak.) as well as the underlying equivalents of the Judith River formation and the Eagle sandstone, which are the possible sources of gas below the Lance formation in eastern Montana.

¹ Leonard, A. G., *op. cit.*

² Oil and Gas Jour., vol. 16, No. 28, p. 62, 1917.

