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GAS IN THE BIG SAND DRAW ANTICLINE FREMONT COUNTY, WYOMING

BY

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CONTENTS.

ILLUSTRATIONS.

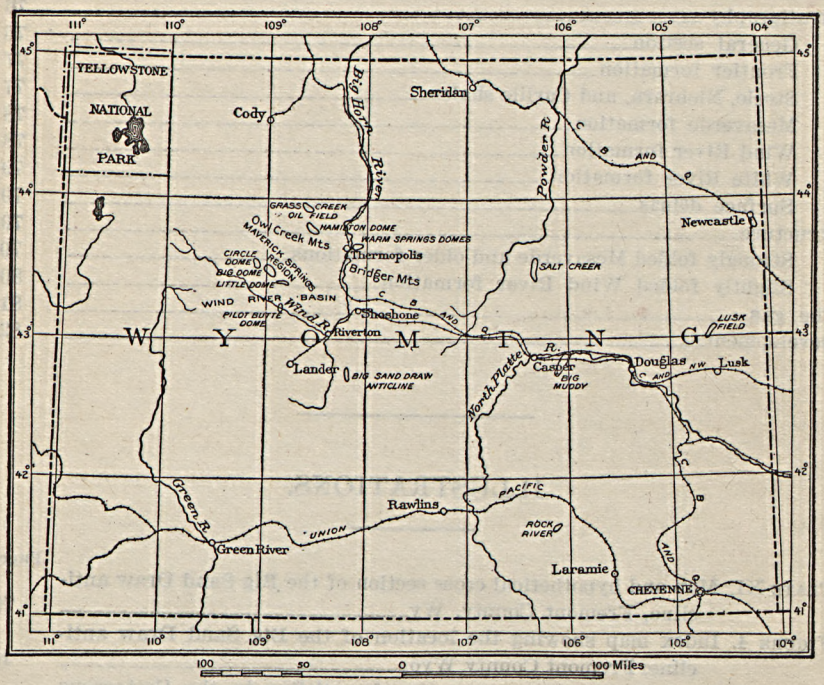


FIGURE 4.—Index map showing the location of the Big Sand Draw anticline, Fremont County, Wyo.

GAS IN THE BIG SAND DRAW ANTICLINE, FREMONT COUNTY, WYOMING.

By A. J. Collier.

INTRODUCTION.

The Big Sand Draw anticline, 18 miles southeast of Riverton, Fremont County, Wyo., has been known for a number of years, but it is so largely concealed by flat overlying rocks that, before a drill was put down, it was impossible to say whether it was a pitching anticline from which all the oil that it ever may have contained had risen to the surface and escaped, or one of the most promising anticlines of the region. It was tested in the winter of 1917–18 by a well that brought in a flow of about 7,000,000 cubic feet of gas a day, and preparations were at once made to sink at least 10 other wells to see if the gas was accompanied by oil. These wells, when completed, will probably determine the form and extent of the anticline much more definitely than it can be determined from a study of the outcropping rocks.

The anticline is named from Big Sand Draw, a ravine that crosses its north end. This ravine is usually only a dry sand wash about 100 feet wide, but after heavy rains it is filled with a raging torrent which can be forded only with difficulty. The anticline is in Tps. 32 and 33 N., R. 95 W. of the sixth principal meridian, in the southeastern part of Fremont County. The nearest railroad point is Riverton, the center of a thriving agricultural district, on the Lander branch of the Chicago & Northwestern Railway. (See fig. 4.) It was briefly described and rather roughly mapped by Hares[1] in 1916. As it seemed possible that this anticline might contain a large quantity of oil the Geological Survey decided to examine it more carefully to see if light could be thrown on some of the obscure points regarding its structure.

[1] Hares, C. J., Anticlines in central Wyoming: U. S. Geol. Survey Bull. 641, pp. 251–252, 1916.

FIELD WORK.

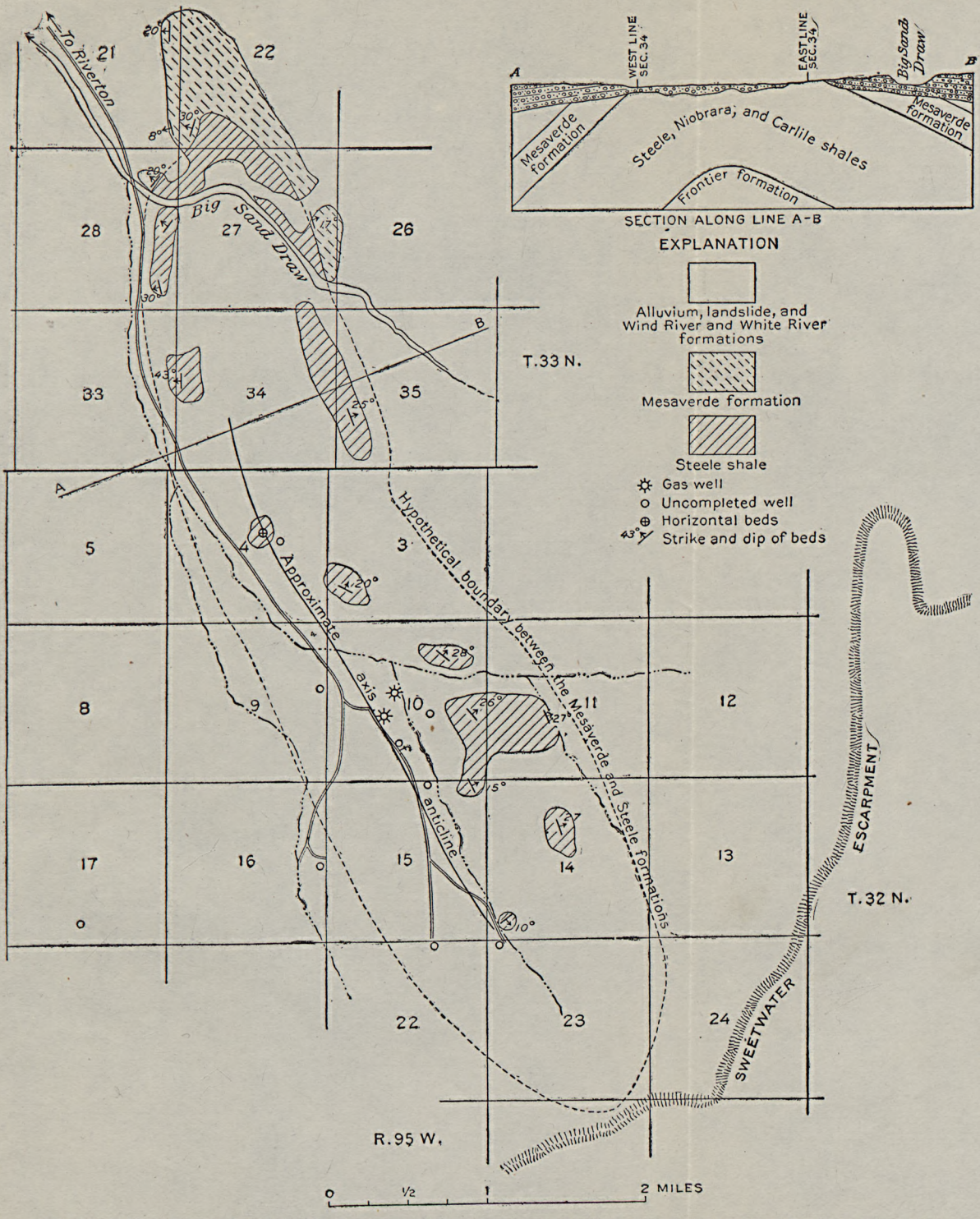
In October, 1918, Harvey Bassler and the writer visited the Big Sand Draw district and spent about seven days in locating the positions of outcrops and well derricks, with a view to determining in greater detail the geologic structure. The results of this work are shown in Plate XI. The representatives of the Producers & Refiners Corporation, which is exploring the anticline, afforded every facility to the members of the party. The company had already erected flags on the prominent surface features in the district, had located such land corners as could be found, and had made surveys to determine as nearly as possible the positions of the many missing corners.

SURFACE FEATURES.

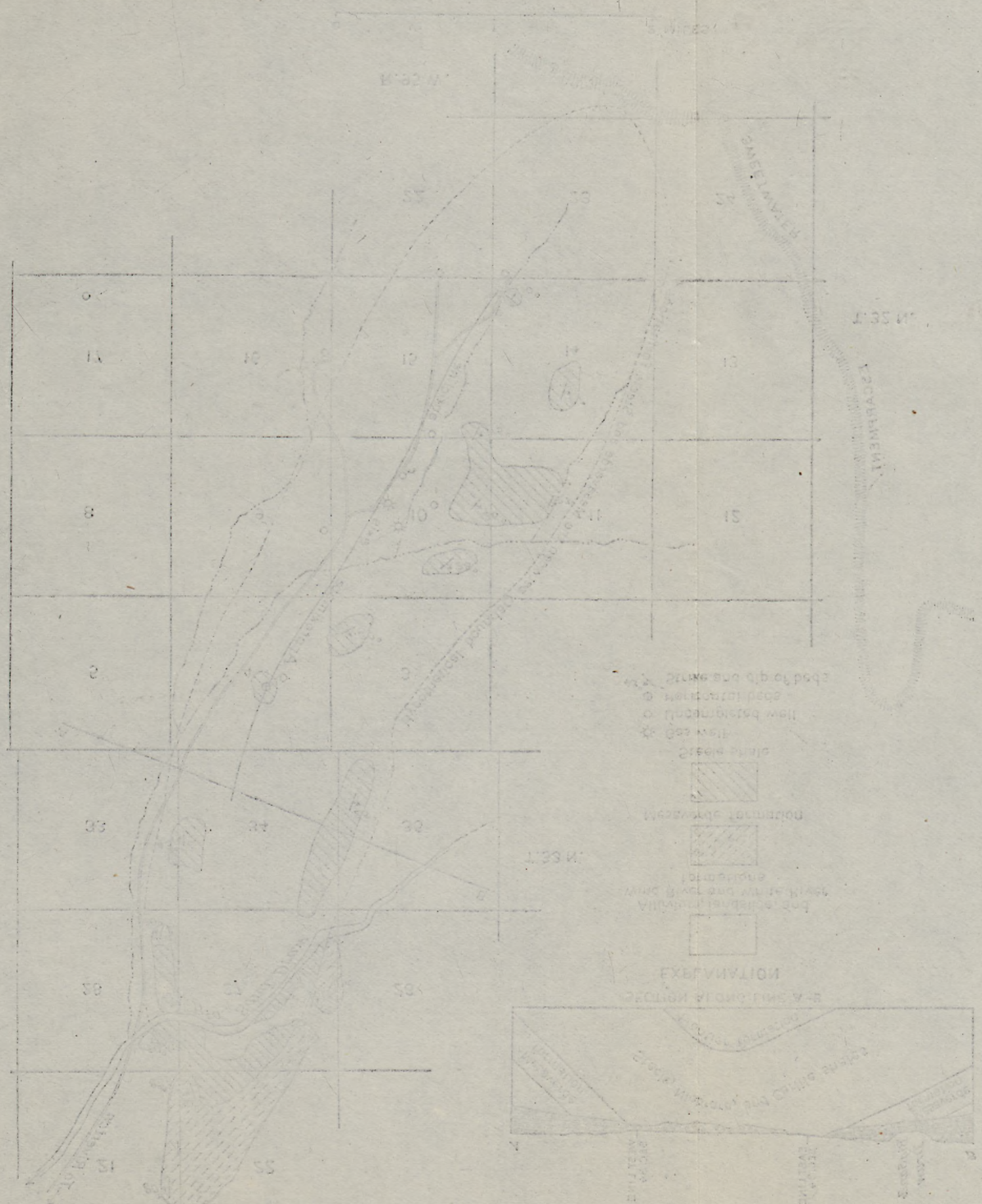
From Riverton, on Big Horn and Wind rivers, at an altitude of 5,100 feet above the sea, a gently undulating plain rises southeastward to an altitude of about 5,900 feet at the Big Sand Draw anticline. The southeast end of the anticline is crossed by the Sweetwater escarpment, which separates the plain to the northwest, just described as extending from Riverton, from one to the southeast that is about 1,000 feet higher. The escarpment extends from Sheep Mountain, about 18 miles southwest of the Big Sand Draw anticline, northeastward to Rogers Mountain, which lies east of the anticline. Northeast of Rogers Mountain a tongue of high land that is only slightly lower than the higher plain extends a little west of north for about 6 miles to Alkali Butte, which may be seen rising above the plain a few miles to the north from the road to Riverton. The rocks of the escarpment and the plains above and below it are nearly flat lying, with the exception of those in Rogers Mountain, Alkali Butte, and the Big Sand Draw anticline, which are folded and represent older formations that are only partly exposed. The Big Sand Draw anticline is at the level of the lower plain. Its north end is exposed, but its south end is generally concealed by flat-lying rocks and can be located only by the drill.

STRATIGRAPHY.

General section.—The formations involved in the Big Sand Draw anticline, as determined by Hares, are given in the following table:



MAP AND HYPOTHETICAL CROSS SECTION OF THE BIG SAND DRAW ANTICLINE, FREMONT COUNTY, WYO.



Section of formations in Big Sand Draw anticline, Wyo.

System.		Formation.	Thickness (feet).	Character of rocks.
Recent.				Débris of siliceous boulders from the White River formation.
		Unconformity		
Tertiary.	Oligocene.	White River formation.	0–1,500	Loosely cemented highly colored sand, arkose, and conglomerate.
	Eocene.	Wind River formation.	0–2,900	Soft variegated shale, coarse brown sandstone, arkose, and conglomerate.
		Unconformity		
Upper Cretaceous.	Montana group.	Mesaverde formation.	300+	Light-colored, thick-bedded sandstone.
		Steele shale.	3,500±	These three formations, which correspond to the Cody shale of the Big Horn Basin, are composed of thin-bedded shale and sandstone.
		Niobrara shale.		
	Colorado group.	Carlile shale.		
		Frontier formation.	800–1,000	At least three layers of sandstone separated by shale. The strong flow of gas is supposed to come from the upper sandstone.

Frontier formation.—The sands of the Frontier formation contain oil and gas in nearly all parts of Wyoming, where they are deeply buried and folded into anticlines or domes. The sand from which the large gas flow at Big Sand Draw is derived is probably the highest one of these sands and in this vicinity is commonly called the Wall Creek sandstone. This formation was not examined here by the writer, but according to Hares it is well exposed on Rogers Mountain, in T. 33 N., R. 94 W.

Steele, Niobrara, and Carlile shales.—The Steele, Niobrara, and Carlile shales correspond to the Cody shale of the Big Horn Basin and have a thickness estimated at about 3,500 feet. Where exposed in the Big Sand Draw anticline the Steele shale consists of thick beds of sandy shale and thinner beds of sandstone from a fraction of an inch to 3 feet thick. It is inferred from the dips measured in the field and shown on Plate XI that the first gas well started in the Steele shale about 1,000 feet below the base of the Mesaverde formation. As the gas sand was struck in this well at a depth of 2,531 feet, and this is about 1,000 feet less than the estimated thickness of the Steele, Niobrara, and Carlile formations, the sand probably lies near the top of the Frontier formation. The drillers report that the rocks passed through in this well are all of about the same character as those to be seen on the surface. A log of the well furnished to the writer by the president of the Producers & Refiners Corporation is as follows:

Log of well No. 1 in Big Sand Draw, somewhat generalized.

	Thickness.	Depth.
	Feet.	*Feet.*
Sand, yellow, probably Wind River formation		50
Shale, more or less sandy; brackish water struck at 200 and 315 feet	2,180	2,230
"Lime," black	20	2,250
Shale	20	2,270
Sand; gas	10	2,280
Shale	125	2,405
Shale, sandy, and light sandstone	65	2,470
Sand; gas	12	2,482
Sand, "shell"	3	2,485
Shale	22	2,507
Sand; gas	5	2,512
Shells	8	2,520
Sand; gas	11	2,531

The big flow of gas came in at 2,531 feet and it has since been used for fuel for drilling other wells.

Mesaverde formation.—At Alkali Butte, in T. 34 N., R. 95 W., the Mesaverde formation consists of a sandstone member about 450 feet thick overlain by a shale member about 700 feet thick.[1] The sandstone member is exposed on the crest of the Big Sand Draw anticline for about a mile north of the draw, but at all other places it has been eroded and is covered with flat-lying rocks.

Wind River formation.—Before the Wind River formation was deposited the older rocks of this region had been folded and eroded, forming an irregular surface on which the outcrops of the different formations showed varying dips. The Wind River formation was then deposited in nearly flat beds over this old surface. It consists essentially of soft variegated shale, coarse brown sandstone, arkose, and conglomerate. On the north side of Big Sand Draw, just above the Mesaverde-Wind River contact, the Wind River formation contains a bed of fossil leaves, from a large collection of which F. H. Knowlton made the following identifications:

Lot 7395, Big Sand Draw, Wyo.:
Lygodium kaulfussi Heer.
Dryopteris sp., fragment—new?
Cyperacites or Typha sp., fragments.
Myrica microphylla Newberry.
Quercus haidingeri Ettingshausen of Lesquereux.
Platanus or Liquidambar fruit.
Two or three dicotyledons not identified.

Knowlton says: "This is a very large collection, but it is disappointing in that it includes so few species, fully 80 per cent being referable to a single form. I should place it in the approximate position of the Green River, but it may be slightly older, though certainly not much."

[1] Woodruff, E. G., and Winchester, D. E., Coal fields of the Wind River region, Fremont and Natrona counties, Wyo.: U. S. Geol. Survey Bull. 471, pp. 523–526, 1910.

As the Wind River was laid down on an old irregular surface the thickness of the formation naturally varies greatly from one locality to another. The greatest thickness in the vicinity of Big Sand Draw is estimated at about 500 feet.

White River formation.—The White River formation, which caps the Sweetwater escarpment southeast of Big Sand Draw, is about 800 feet thick and is composed of loosely cemented light-colored sand, arkose, and conglomerate.

Hares reports that a little asphaltic material occurs in rhyolitic bombs in the upper part of the formation on the Sweetwater escarpment in secs. 10 and 11, T. 32 N., R. 94 W., about 6 miles east of the camp at well No. 1.

A collection of fossil shells made about 4 miles east of the gas well was examined by W. H. Dall, who identified the three following species, which are elsewhere known in the Bridger formation:

Vivipara wyomingensis Meek.
Physa bridgerensis Meek.
Planorbis spectabilis Meek.

Besides these there are specimens of an *Aplexa*, possibly new, and a very minute *Lymnaea* with a strong columellar fold not identified with any known species but possibly immature. These fossils indicate Bridger rather than White River age. They probably come from the local deposits of late Eocene age which Sinclair and Granger[1] recognized in this neighborhood between the Wind River and White River formations. They found Uinta vertebrates in the upper part of this interval and assigned the lower part tentatively to the Bridger.

Surface débris.—About a mile east of the camp mentioned there is a great confused mass of rocks which have slid down from the Sweetwater escarpment and have covered the outcrops of the Mesaverde. Scattered over much of the surface north of the camp there are large boulders which when broken with the hammer are found to be somewhat porous and composed of quartz. It is the writer's opinion that these boulders represent some large concretionary masses of quartz from the Sweetwater escarpment, though no such large masses of similar rocks were seen in place.

STRUCTURE.

Strongly folded Mesaverde and older formations.—The major portion of the Big Sand Draw anticline is covered and concealed by the Wind River formation. On the north side of Big Sand Draw in the NE. ¼ sec. 28 an outcrop of massive sandstone of the Mesaverde

[1] Am. Mus. Nat. Hist. Bull., vol. 30, pp. 86–89, 1911.

formation strikes N. 38° E. and dips 20° NW. About a mile up the draw to the east, in sec. 27, the Mesaverde again crops out showing a strike of N. 20° W. and a dip of 17° NE. Between these points the Mesaverde is covered, but about a quarter of a mile north of the draw it crops out in a large triangular area, the northernmost point of which is in sec. 22. South of Big Sand Draw the outcrop of the Steele shale on the west limit of the anticline can be traced nearly to the southeast corner of sec. 28, and in sec. 34 its southernmost exposure is found in an isolated outcrop where the dip is 42° W. and the strike is N. 5° W. On the east side of the anticline the Mesaverde formation is not exposed south of Big Sand Draw, but there are outcrops of thin sandstone in the Steele shale in sec. 35, T. 33 N., R. 95 W., where the strike is N. 23° W. and the dip about 25° E.; in sec. 11, T. 32 N., R. 95 W., where the strike is N. 33° W. and the dip 25° E.; and near the center of sec. 14, in the same township, where the strike is N. 20° W. and the dip about 23° E. East of this line of strike there are several exposures that show a lower dip to the east. A partial exposure of what appears to be a thin sandstone in the Steele shale near the center of sec. 4 shows the strata lying nearly flat. A very good exposure in the SW. ¼ sec. 3 shows a strike of N. 60° W. and a dip of 20° NE., and near the east line of sec. 10, in an excavation for a well, the strike is N. 37° W. and the dip 26° NE. The southernmost exposure of the Steele shale is near the southwest corner of sec. 14, where the strike is about N. 50° E. and the dip about 10° SE. Taking into consideration these exposures, the writer has drawn on the map (Pl. XI) a line to represent the approximate position of the crest of the anticline. If this line is correctly located the highest part of the dome should be between the southwest corner of sec. 3 and the southwest corner of sec. 14.

Slightly folded Wind River formation.—The Wind River formation along Big Sand Draw has a definite easterly dip of 7° on the east side of the anticline and also a perceptible westerly dip on the west side of the anticline. No such dips could be recognized in the same formation at the south end of the fold, but the formation there does not include any definite beds that can be traced, and therefore it was impossible to ascertain by the use of surveying instruments whether or not it lies absolutely flat. Above the anticline as developed in the Mesaverde formation at Big Sand Draw the Wind River formation is also folded into a low anticline with very gentle dips. An occurrence of an apparently similar phenomenon is well exposed in the bluff on the south side of Wind River at the Pilot Butte dome, east of Riverton, where the Cretaceous shale forms an arch with dips from 15° to 30° on either limb and the unconformably

overlying Tertiary rocks also form an arch but with much lower dips. (See fig. 5.)

If all well-developed anticlines in the Cretaceous rocks are marked by slight anticlines in the Tertiary rocks, where they are present, then it may be possible to locate oil-bearing anticlines where the Cretaceous rocks are completely covered and concealed by rocks of the Wind River formation. It must be understood, however, that this is merely a suggestion based on observations on two anticlines, and

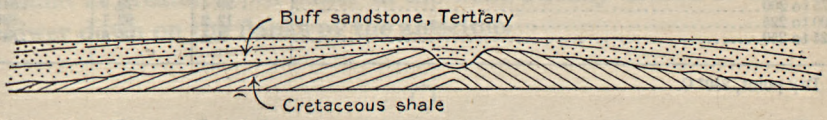


FIGURE 5.—Diagram showing a pronounced anticline in the Cretaceous rocks overlain by a slight anticline in the Tertiary rocks at the Pilot Butte dome, Wyo. Apparently there has been a recurrence in late Tertiary time of the movements that produced the fold in the Cretaceous rocks, and this has resulted in increasing the fold in the Cretaceous, though only a slight fold is developed in the overlying Tertiary rocks.

it may not hold for the region generally; but should some oil operator be willing to take a long chance, he might test the suggestion by drilling on some of the slight anticlines in the Wind River formation, hoping thereby to strike a more pronounced anticline that contains oil in the underlying Cretaceous rocks. Such a test well would necessarily be very deep, for it must pass through the overlying Wind River formation before reaching the Cretaceous rocks.

THE GAS.

In two of the wells at Big Sand Draw large flows of natural gas have been obtained. Mr. F. F. Hintze, chief geologist of the Producers & Refiners Corporation, has informed the writer that while no analyses of the gas have been made its specific gravity has been tested and ranges from 0.60 to 0.65, which indicates that it is a dry gas. Absorption tests show that it contains a very small amount of gasolene vapor.

Well No. 1 is capable of producing from 6,000,000 to 10,000,000 cubic feet of gas a day, and well No. 2 is rated at 10,000,000 to 12,000,000 cubic feet a day. The rock pressure at the well is approximately 1,350 pounds to the square inch. At the time of the writer's visit there was at well No. 1 a rather crude apparatus for collecting gasoline from the expanding gas and a tank partly filled with the product. It was claimed that in a day about six barrels of the "drip" could be obtained by allowing all the gas to escape. A sample taken from this tank was analyzed by the chemists of the Bureau of Mines at the Pittsburgh laboratory with the following results:

Analysis of the "drip" from the gas at Big Sand Draw anticline, Wyo.

[Laboratory No. 00371, specific gravity at 15° C., 0.807 (43.5° B., modulus 140). Air distillation in Bureau of Mines Hempel flask, with fractioning column. Amount distilled, 200 cubic centimeters; first drop, 95° C.]

Temperature (°C).	Fraction (per cent by volume).	Total per cent distilled, by volume.	Specific gravity.
Up to 125	5.6	5.6	0.769
125 to 150	23.0	28.6	.780
150 to 175	30.9	59.5	.802
175 to 200	20.4	79.9	.818
200 to 225	12.2	92.1	.836
225 to 250	3.5	95.6	.848

Dry point, 240° C.

The analysis shows that the sample contains about 67 per cent kerosene and probably justifies the expectation that oil will be found farther down on the flank of the anticline.

DEVELOPMENT.

In 1917 the Producers & Refiners Corporation began drilling a well with a standard rig in the NE. ¼ SW. ¼ sec. 10, and in January, 1918, the large flow of gas was brought in at a depth of 2,531 feet. The great pressure of the gas forced the drilling tools up to the top of the hole, where they became entangled with and broke the casing. Later they settled to the bottom of the hole and were lost. Drilling was necessarily abandoned. The gas flow has been partly controlled, but never entirely shut off because of the broken casing. The gas is used as fuel in drilling other wells in the field.

Water that is only slightly alkaline is obtained for use at the driller's camp from two large springs about halfway up the escarpment and about 2½ miles south. When the camp was visited eight derricks had been erected and preparations were made for the erection of several more. Well No. 2, about 1,000 feet northeast of well No. 1, came in early in October, 1918, with gas rated at 10,000,000 to 12,000,000 cubic feet a day, struck at about the same depth as the flow in well No. 1. In drilling this well a rotary rig with a 75-foot derrick was used, and precautions were taken to prevent the mishaps that occurred in the first well by cementing in the upper part of the casing and by having ready a large supply of mud to be used in stopping the flow of gas. Considerable depth had been reached with standard rigs in the well in the NE. ¼ sec. 9 and the well near the south line of sec. 15, but at the time of writing (June 15, 1919) neither of the wells reached the gas sand. The manager of the camp proposed to move the rotary rig to the well near the south line of sec. 15 as soon as it was available, because the great quantity of water encountered in this well interfered with drilling. A standard der-

rick erected by the Allies Oil Co. in sec. 17 is probably not on the anticline. Near this derrick there is a shallow well drilled with a light portable outfit from which water can be obtained. The Producers & Refiners Corporation has obtained a franchise to supply Riverton with natural gas, but owing to the war conditions it has not yet laid a pipe line. Although supplying the demand for natural gas will partly compensate for the expense of drilling the wells, the field will be tested further to determine whether or not oil may be found at greater depth either in the wells already drilled or in wells lower down on the flanks of the anticline.

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