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OIL IN THE WARM SPRINGS AND HAMILTON DOMES, NEAR THERMOPOLIS, WYOMING

BY

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OIL IN THE WARM SPRINGS AND HAMILTON DOMES, NEAR THERMOPOLIS, WYOMING.

By A. J. Collier.

INTRODUCTION.

Wildcat wells drilled near Thermopolis, Wyo., within the last two years have demonstrated that the Warm Springs domes, at the east end of the Thermopolis anticline, and the Hamilton dome or Cottonwood anticline, as it is called in a previous report [1]—folds heretofore regarded as barren—really contain oil in commercial quantities. The product of the Warm Springs domes is a very heavy, dark oil, derived, like that of the Lander field, from the Embar beds, and the entire output is estimated at 800 to 1,000 barrels a day. The product of the Hamilton dome is a somewhat lighter oil from the Chugwater formation, and this is the first discovery of petroleum in commercial quantities in the Chugwater. Oil was struck too recently in this dome to justify an estimate of its probable production.

The geographic position of the Warm Springs and Hamilton domes is shown on the index map (fig. 4). They are easily accessible by automobile from Thermopolis, on the Chicago, Burlington & Quincy Railroad.

The Thermopolis anticline is a well-known and well-marked arch of the rocks in Hot Springs County, extending about 22 miles in an east-west direction through the town of Thermopolis. It is shown on the maps prepared by Darton [2] and Fisher [3] and is briefly described by Lupton,[4] who, owing to the occurrence of hot springs near its axis and the exposure near its crest of the lowest oil-bearing formation, decided that it was of doubtful value as a reservoir for oil and gas and did not attempt to determine its geologic structure.

[1] Hewett, D. F., and Lupton, C. T., Anticlines in the southern part of the Big Horn Basin, Wyo.: U. S. Geol. Survey Bull. 656, pp. 135, 147, 1917.

[2] Darton, N. H., Geology of the Owl Creek Mountains; 59th Cong., 1st sess., S. Doc. 219, pl. 1, 1906.

[3] Fisher, C. A., Geology and water resources of the Big Horn Basin, Wyo.: U. S. Geol. Survey Prof. Paper 53, pl. 3, 1906.

[4] Hewett, D. F., and Lupton, C. T., op. cit., pp. 135–136.

The Warm Springs domes, on the east end of the anticline, are 4 miles east in a direct line from the Thermopolis Hot Springs, about 3 miles east of an outcrop of the phosphate-bearing part of the Embar group on the axis of the anticline, and about 6 miles east of the sulphur deposits[1] near Thermopolis, which are probably a product of the hot springs. The travertine deposits made by ancient as well as recent hot springs are all at least 3½ miles west of the westernmost

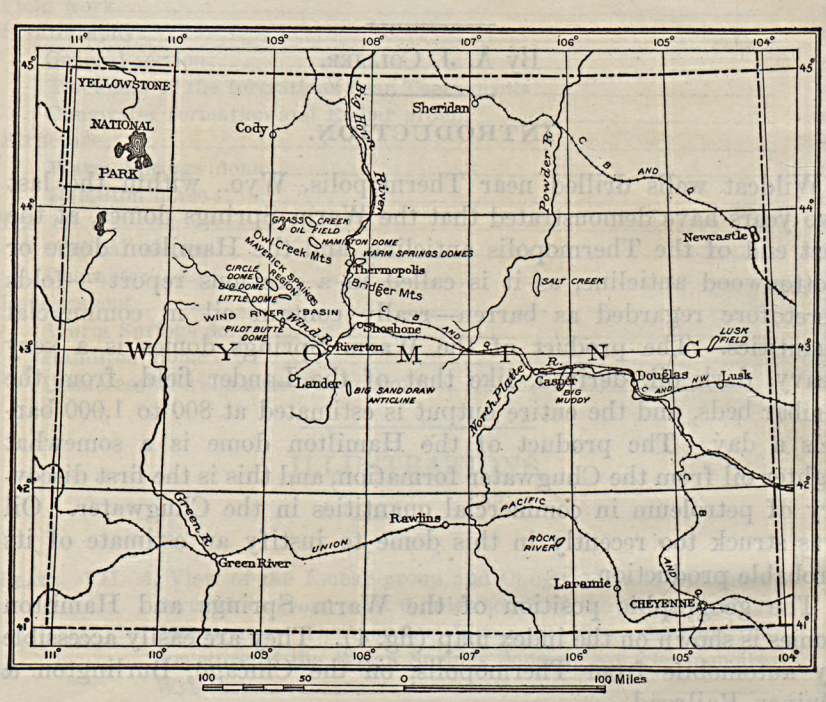


FIGURE 4.—Index map showing the location of the Warm Springs and Hamilton domes, the Maverick Springs region, and the Big Sand Draw anticline, Wyo.

productive well of the Warm Springs domes. A seep of heavy oil in the Red Springs anticline, 2 miles northeast of the Warm Springs domes, was noted by Lupton,[2] and what were thought to be oil seeps were found in Bea Ogwa Canyon south of Thermopolis.

The Hamilton dome, about 20 miles northwest of Thermopolis and a short distance west of the Thermopolis anticline, is described and mapped by Hewett and Lupton[3] under the name Cottonwood anticline. It was regarded by them as unfavorable territory for further exploration, as the sandstones of the Frontier formation crop out

[1] Woodruff, E. G. Sulphur deposits near Thermopolis, Wyo.: U. S. Geol. Survey Bull. 380, pp. 373–380, 1908.
[2] Hewett, D. F., and Lupton, C. T., op. cit., p. 135.
[3] Idem, pp. 147–149.

around it, and as two wells drilled near the crest of the dome by Dr. Hamilton, of Thermopolis, had failed to show the presence of water, oil, or gas.

SURFACE FEATURES.

The domes here described (see Pl. VII, *B*) lie in a belt about 25 miles wide extending from east to west along the south margin of the Big Horn Basin. This belt contains many hogback ridges, which reach a maximum altitude of 6,000 feet, but the streams and consequently the roads and agricultural lands are much lower. The altitude of Thermopolis, on Big Horn River, is 4,397 feet. The Owl Creek and Bridger mountains, which lie south of this belt, rise like a great swell of the earth's crust, their summits being 7,000 feet or more above the sea, and are interrupted only by Bea Ogwa Canyon,[1] through which Big Horn River enters the basin. The central part of the Big Horn Basin lies north of this belt and is characterized by long, even slopes and mesas, in some places cut by the streams into badlands. It evidently is a region of comparatively soft rocks lying nearly horizontal.

The climate of this part of Wyoming is semiarid, the annual rainfall being from 11 to 12 inches. On account of this slight rainfall there is a dearth of vegetation, especially on the steeper slopes, where the cut edges of the harder rocks stand out prominently, revealing the structure of the hogback ridges so that it may be easily recognized, even from the car windows of passing trains.

At Thermopolis the anticline, of which the Warm Springs domes, a few miles to the east, are a part, is very evident. It brings to view several hard-rock formations which crop out in steep escarpments and in many cliffs on the north limb, where they are slightly inclined, and almost symmetrical sharp ridges on the south limb, where they dip at an angle of about 45°. Only comparatively soft rocks are exposed in the Hamilton dome, and the ridges that encircle it are all low, but they are much more conspicuous on the north than on the south side.

[1] So far as the author is aware, this canyon has no generally accepted name. In local parlance it is sometimes referred to as the Big Horn Canyon and sometimes as the Wind River canyon, and in geologic reports both names have been used. The name Big Horn Canyon would be suitable were it not for the fact that this name is more appropriately applied to the canyon which the river has cut through the Big Horn Mountains, and this usage has been approved by the United States Geographic Board. The name Wind River canyon is not satisfactory, as the term Wind River is applied only to the headwater branch of Big Horn River, which lies above Riverton, some 25 miles south of the canyon. As the name Big Horn is already in use for another canyon and as Wind River is not appropriate, it seems best to propose a new name, and Bea Ogwa (Shoshone for "big river") has been selected by the United States Geographic Board.

FIELD WORK.

In the summer of 1917 a wildcat well drilled for Dr. Carter, of Thermopolis, in the east end of the Thermopolis anticline struck a heavy, dark oil about 1,000 feet below the surface. Since that time the region has been rather thoroughly tested, and two areas yielding oil have been found. A pipe line to Thermopolis has been laid, and these particular parts of the anticline have come to be known as the East and West Warm Springs domes. Owing to this and other recent discoveries of oil reported from neighboring parts of Wyoming, Harvey Bassler and the writer spent a short field season in 1918 in making an investigation of them. The work done on the Warm Springs domes consisted of a short visit in the late part of August and about a week's survey with plane table and telescopic alidade in October. The results of this work are embodied in the structure map (Pl. IX). In compiling this map the writer has made use of maps by Hewett and Lupton[1] of the Red Spring and Lucerne anticlines, to the north, and the unpublished reports of D. D. Condit on the phosphate rocks that crop out in the neighborhood.

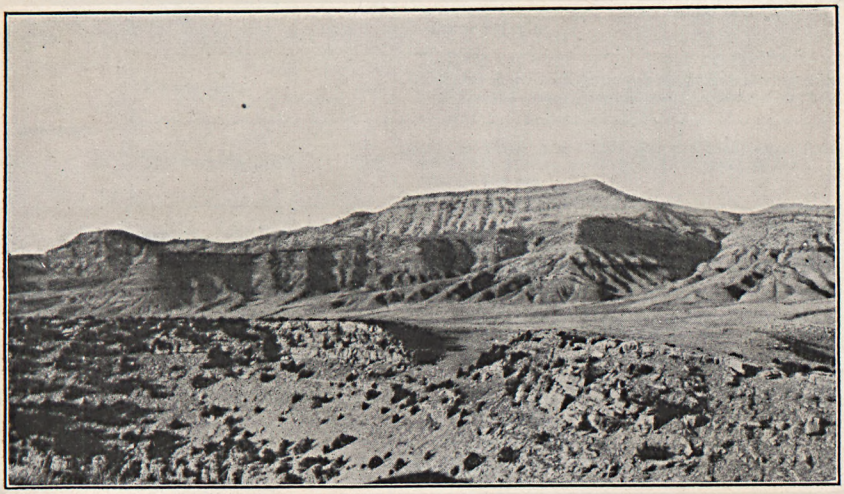
The work on the Hamilton dome consisted of a visit in October to the first successful well, where a good production of oil of a little higher grade than that from the Warm Springs domes was brought in while the party was in the field. The structure of the Hamilton dome is well shown in Plate XXII of Hewett and Lupton's report, reproduced with slight modification in Plate X.

STRATIGRAPHY.

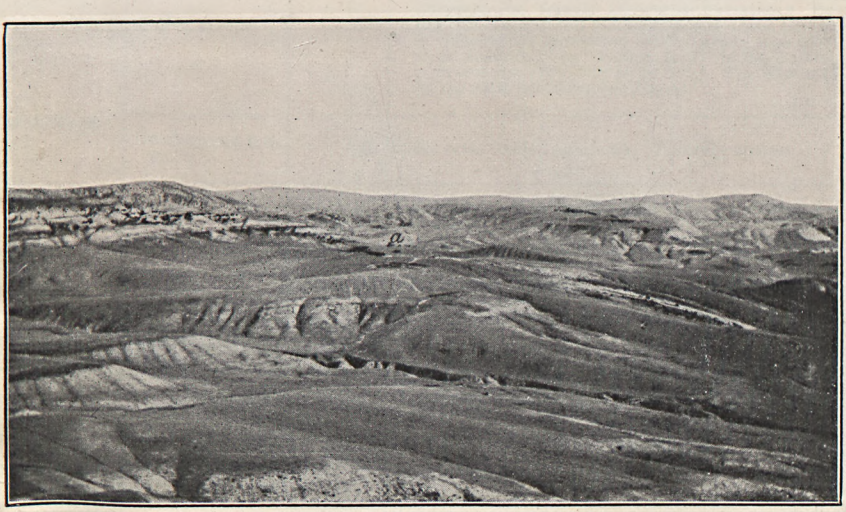
GENERAL SECTION.

The geologic column of the rock formations which must be considered in describing the oil in the Warm Springs and Hamilton domes is given below. (See also Pl. VIII.)

[1] Hewett, D. F., and Lupton, C. T., op. cit., pls. 21 and 19.



A. VIEW OF THE EMBAR GROUP AND CHUGWATER AND SUNDANCE FORMATIONS, FROM POINT 6 MILES SOUTH OF THE WARM SPRINGS DOMES, NEAR THERMOPOLIS, WYO.



B. VIEW SHOWING THE STRUCTURE OF THE WARM SPRINGS DOMES, NEAR THERMOPOLIS, WYO.

a, Location of the Carter wells.

Geologic formations exposed near Thermopolis, Wyo.

System.	Formation or group.	Thickness (feet).	Character of the rocks.
Cretaceous.	Frontier formation.	390	Seven or more beds of gray and buff sandstones with interbedded gray and brown shales and bentonite. Marine deposits.
	Mowry shale.	266	Hard gray shale containing fish scales and having a few interbedded lenses of sandstone. A marine deposit.
	Thermopolis shale.	589	Gray to black shale with one persistent sandstone, called the Muddy sand by drillers, near its base. A marine deposit.
	Cloverly formation.	248	Two beds of massive buff sandstone separated by variegated shale. Upper bed is known as the Greybull sand. In part at least a fresh-water deposit.
Cretaceous (?).	Morrison formation.	145	Purplish and pale greenish-gray shales with sandstone interbedded. A fresh-water deposit.
Jurassic	Sundance formation.	240	Greenish-gray sandstone, shale, and limestone containing many oyster, *Gryphaea*, and belemnite shells. Marine deposits.
Triassic.	Chugwater formation.	1,200	"Red Beds." Red sandstone and shale containing beds of gypsum, the largest having a thickness of more than 60 feet near the top of the formation, and at least one bed of limestone near the middle. Largely a fresh-water formation.
Carboniferous.	Embar group.	270	About 60 feet of the upper part consists of calcareous shale, sandstone, and gypsum, which are not distinguished from the "Red Beds" by the drillers but which represent the Triassic Dinwoody formation.[a] Below this about 60 feet of limestone and about 150 feet of thin-bedded sandstone, reddish shale, and limestone, including the "Embar sand" of the drillers, represent the Park City formation.[a] The Embar is for the most part a marine deposit.
	Tensleep sandstone.	250	Gray cross-bedded sandstone. Probably marine.
	Amsden formation.	300	Red sandy shale and sandstone with layers of limestone and chert. Marine.
	Madison limestone.	600–1,000	Gray massive limestone. Marine.
Ordovician.	Bighorn dolomite.	150–300	Siliceous gray limestone. Marine.
Cambrian.	Deadwood formation.	700–900	Sandstone, shale, conglomerate, and limestone. Marine.
Pre-Cambrian.	Metamorphic complex.		A complex of schists, gneiss, etc.

[a] Condit, D. D., Relations of the Embar and Chugwater formations in central Wyoming: U. S. Geol. Survey Prof. Paper 98, pp. 263–270, 1916.

THICKNESS OF THE FORMATIONS NEAR THERMOPOLIS.

The Frontier, Mowry, Thermopolis, Cloverly, Morrison, and Sundance formations were carefully measured a short distance north of

Thermopolis, within 4 miles of the Warm Springs domes. The estimate of thickness of the Chugwater formation is based on the log of the Wyoming Dixie Oil Co.'s well No. 1, in sec. 26, T. 43 N., R. 94 W., kindly furnished by Mr. M. L. Hoover, the driller. The thickness of the Embar group given in this table is based on measurements made by Blackwelder[1] in Bea Ogwa Canyon about 6 miles south of Thermopolis. The thicknesses of the formations below the Embar are adapted from Hewett and Lupton's report.

CHUGWATER FORMATION AND EMBAR GROUP.

As the oil here described is contained in the "sands" of the Chugwater and Embar formations, a view of the Embar, Chugwater, and Sundance formations where they are well exposed, about 6 miles south of the Warm Springs domes, on the flanks of the Bridger Mountains, is shown in Plate VII, *A*.

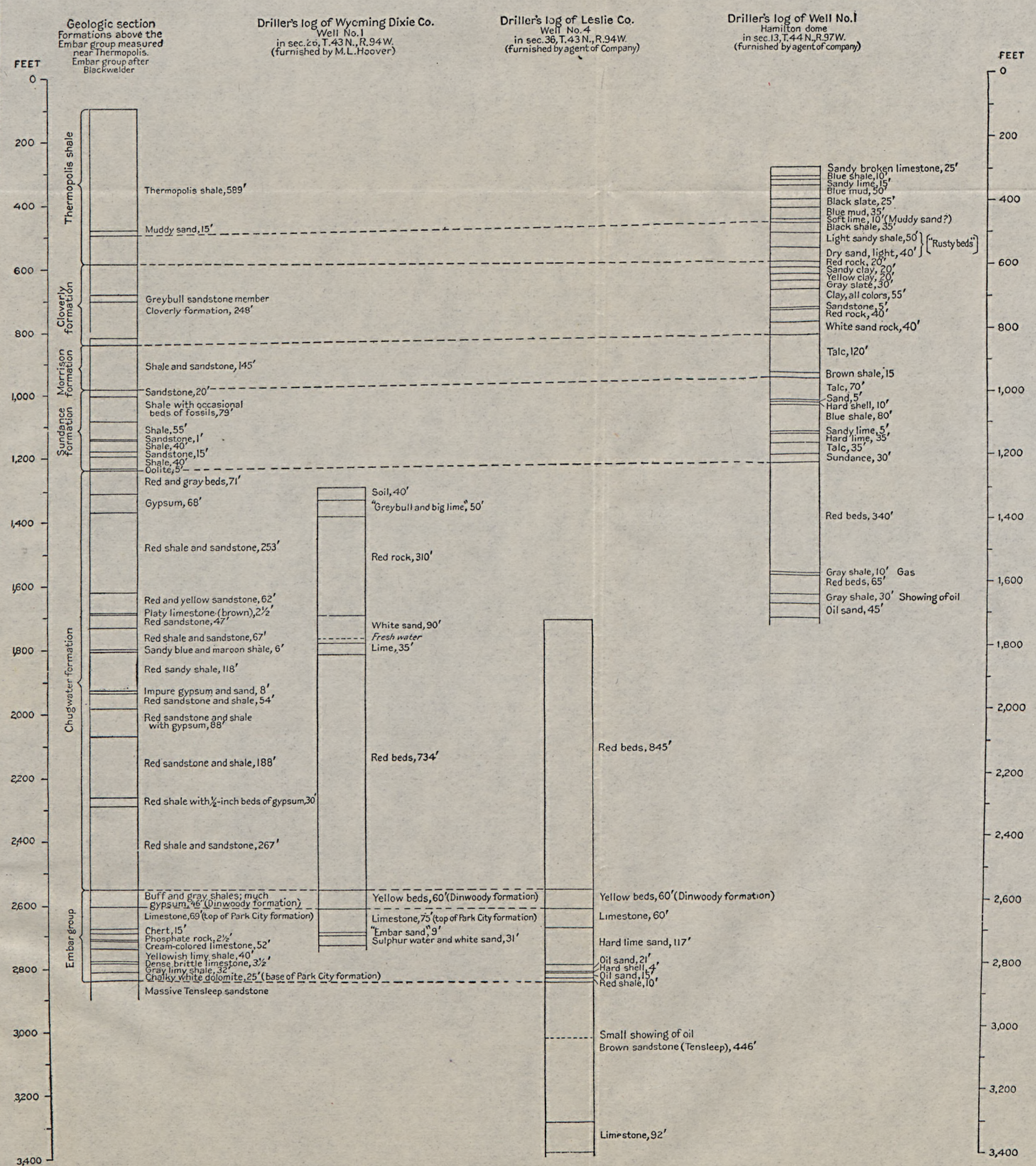
A detailed section of the Chugwater formation carefully measured by Bassler north of Thermopolis and of the Embar group measured by Blackwelder[2] in Bea Ogwa Canyon 6 miles south of Thermopolis is as follows:

Section of the Chugwater formation and Embar group near Thermopolis, Wyo.

	Ft.	in.
Chugwater formation:		
Oolite, gray; top of Chugwater or base of Sundance	4	
Shale, red and gray	14	
Limestone, shaly, light gray	2	
Shale, gray, violet, and pink	16	
Limestone, platy, brown	3	
Shale, sandy, light gray	6	
Shale, red, and gypsum	28	
Gypsum, loose and porous, usually white	60	
Sandstone, red and yellow	62	
Limestone, platy, brown	3	
Sandstone, red	46	
Shale and interbedded shaly sandstone, predominantly red; gypsum beds noted at four horizons	770	
	1,279	
Embar group:		
Dinwoody formation:		
Gypsum, impure, yellowish	17	
Shale, buff, sandy, with beds of impure gray limestone	29	
Park formation:		
Limestone, variable, gray to chalky white, partly dolomitic	55	

[1] Blackwelder, Eliot, A reconnaissance of the phosphate deposits in western Wyoming: U. S. Geol. Survey Bull. 470, pp. 452–481, 1911.

[2] Idem, pp. 480–481.



GEOLOGIC SECTION OF THE FORMATIONS EXPOSED NEAR THERMOPOLIS, WYO., AND LOGS OF THREE IMPORTANT WELLS.

	Ft.	in.
Embar group.—Continued.		
Park formation—Continued.		
Chert, nodular, with many partings of dark-brown shale	15	
Shale, brown, phosphatic		3½
Phosphate rock, massive gray muddy oolitic limestone sprinkled with waxy grown granules; a few *Productus subhorridus* shells (34.4 per cent tricalcium phosphate)	1	5
Limestone, brownish gray, hard, argillaceous, with brown phosphatic granules (14.9 per cent phosphate)		9½
Limestone, crystalline, cream-colored	52	
Shale, soft, yellowish, limy	40	
Limestone, dense, brittle, gray	3	6
Shale, gray, limy	32	
Dolomite or massive chalky-white limestone	25±	
	302±	

The upper two members of the foregoing section of the Embar deposits correspond to the Dinwoody formation of recent reports. The rest of the section corresponds to the Park City formation of western Wyoming and northeastern Utah. This section is shown graphically on Plate II, where it may be compared with the logs of several important wells. The slight differences in total thickness of the Chugwater formation shown in these logs may be due either to a failure of the geologist to allow sufficiently for the dip of the rocks or to the actual variation in thickness of the formation between the places where the sections were measured. The thickness as given by the driller in the second section on Plate II is considered a nearly correct determination for the Warm Springs domes, as the well is near the outcrop of the gray oolite noted by the geologist as the lowest bed of the Sundance formation. The upper formation (Dinwoody) of the Embar group, about 60 feet thick, is not distinguished from the "Red Beds" (Chugwater formation) by the driller.

The differences in the sections of the Embar group are due mainly to the facts that the group is composed of several distinct kinds of rocks which can not be readily identified by the fine cuttings of the drill and that the geologists in making the examinations on which the sections are based have had in mind only the phosphate rocks and have usually failed to distinguish the sandy character in parts of the Embar. Several sections of the Park City or lower formation of the Embar group carefully measured by Blackwelder and Condit in the Owl Creek Mountains do not show any sandstone, though the drillers of wells both in the Warm Springs domes and in the Maverick Springs region, which lies about 40 miles southwest of Thermopolis, invariably report the occurrence of sands, samples

of which consist of well-rounded grains of quartz. A more critical examination of the Park City formation with this point in view would probably clear up this discordance. The oil produced from the Warm Springs domes is believed to have been confined to the Park City formation below the horizon of the phosphate rocks. In one of the wells, however, a showing of oil is reported from the Tensleep sandstone, but this is believed by the drillers to have come from the Embar through a leak in the casing.

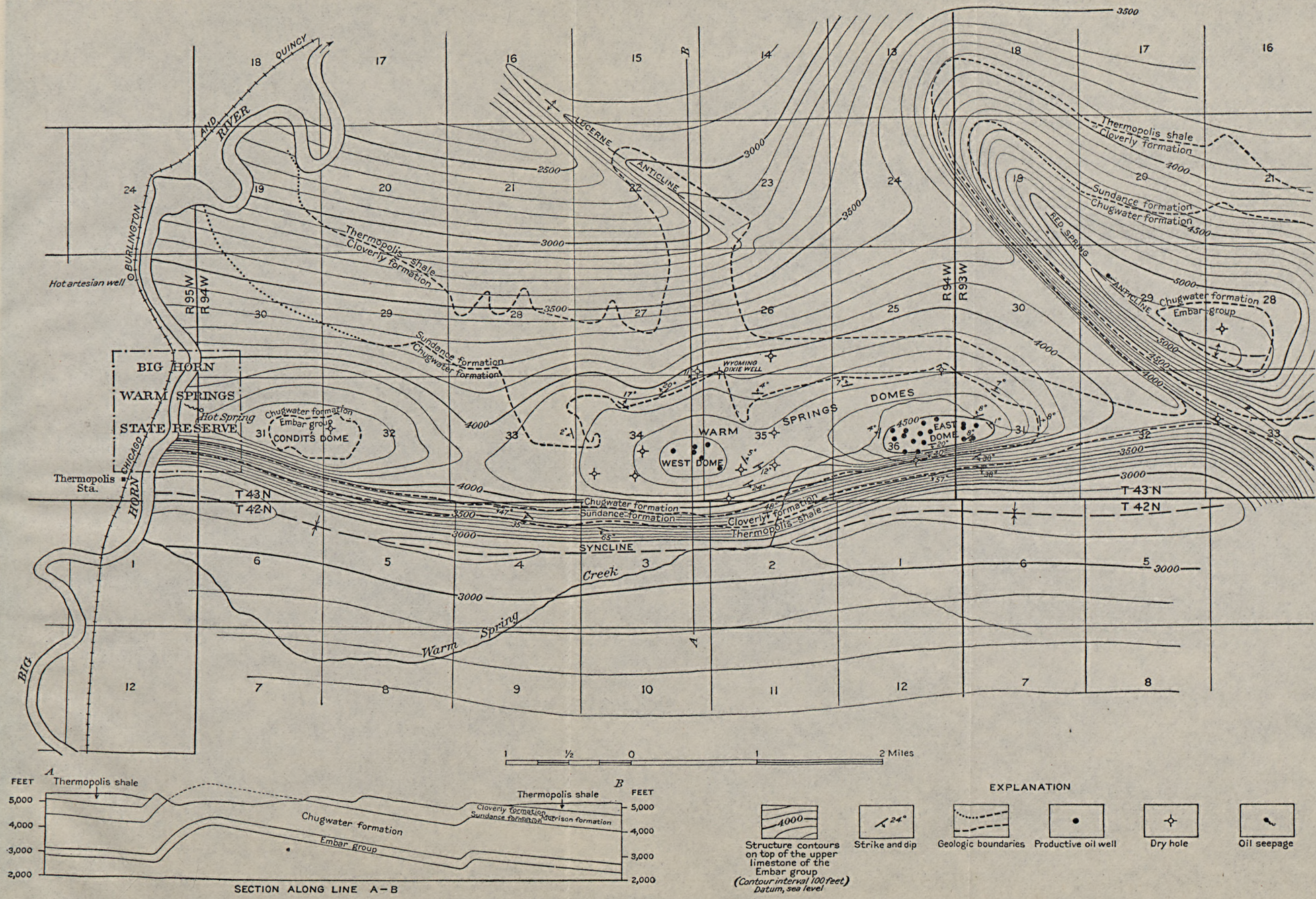
STRUCTURE.

WARM SPRINGS DOMES.

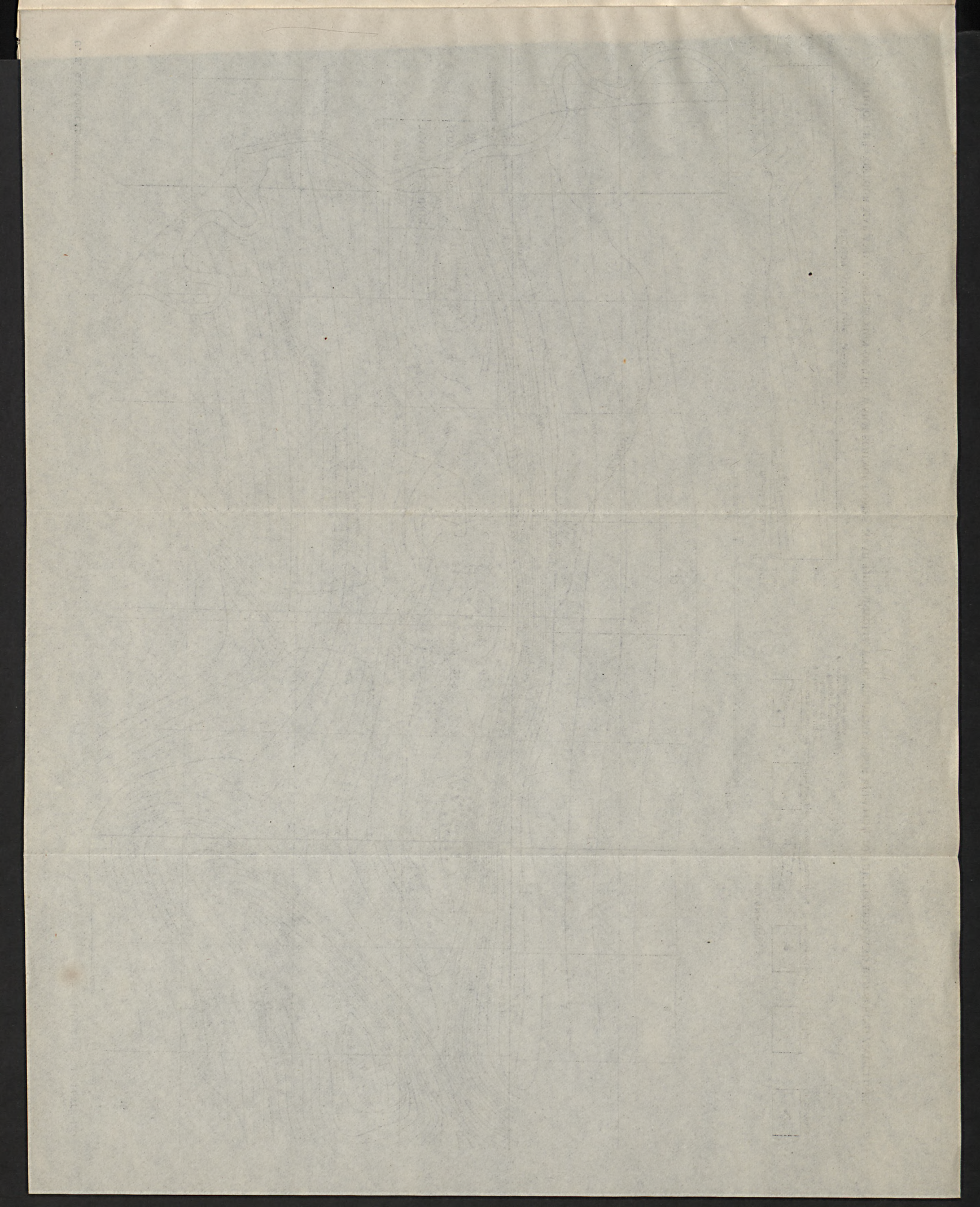
The Thermopolis anticline extends nearly due east from Thermopolis for a distance of about 8 miles. West of Thermopolis its direction changes, and its west end lies about 15 miles N. 55° W. from Thermopolis. It is clearly a mountainward rather than a basinward upfold,[1] as it is the southernmost of a series of such features that lie parallel to the Owl Creek and Bridger mountains on their north side. Between it and the center of the Big Horn Basin there are at least two other anticlines. The structure map of the Warm Springs domes (Pl. IX) covers only the part east of the river. The rocks on the north side dip about 7° N., and those on the south side dip about 48° S. for about a mile, beyond which they rise at a comparatively low angle to the crest of the Owl Creek Mountains. A view of the West Warm Springs dome looking east from a high point near the axis of the anticline in the western part of sec. 34, T. 43 N., R. 94 W., is given in Plate VII. The Carter wells are near the center of the area shown in the picture.

The structure is shown on the map by contour lines drawn on the top of the heavy bed of limestone in the Park City formation. The outcrop of the Embar group as determined by Condit, the top of the Chugwater formation, and the top of the Cloverly formation, marked in the field by the Greybull sand, are also shown. The top of the Chugwater formation is about 1,250 feet and the Greybull sand is about 1,800 feet above the contour elevations. The contours are based on the drillers' reports, dips observed in the field, and positions and elevations determined in the course of the survey. The crest of the anticline is not at a uniform elevation, but on it there are several high parts or domes separated by saddles. Near its east end two such domes have been found. The east dome is crossed by the east line of sec. 36, T. 43 N., R. 44 E., and is surrounded by the 4,500-foot

[1] Hewett, D. F., and Lupton, C. T., op. cit., pp. 44–45. Hewett and Lupton divided the domes and anticlines of the Big Horn Basin into two groups called "basinward" and "mountainward" upfolds. The basinward upfolds are those that lie adjacent to the late Tertiary deposits in the center of the basin, and the mountainward upfolds are those that lie near the mountains and are cut off from the source of oil in the basin by intervening structural features. The basinward upfolds were therefore regarded as much more promising to the driller than the mountainward upfolds.



STRUCTURE CONTOUR MAP AND CROSS SECTION OF THE WARM SPRINGS DOMES, NEAR THERMOPOLIS, WYO., SHOWING THEIR RELATION TO THE LUCERNE AND RED SPRING ANTICLINES.



contour, and the west dome, about a mile farther west, is surrounded by the 4,400-foot contour. Both of these domes are oil bearing, but a well drilled in a third dome found by Condit in sec. 32 has failed to produce any oil. Little information is available regarding this well, and its failure to produce oil may be due to any of the three following causes: The well may not have been drilled far enough to test the beds adequately; the overlying Chugwater formation may have been eroded, allowing the oil to escape; or subterranean channels, through which the waters of the hot spring that issues a short distance to the west have found their way to the surface, may have served also to release the oil.

Although the Embar deposits cap the dome in sec. 32 and also, according to Darton and Fisher, are exposed on the crest of the anticline a few miles northwest of Thermopolis, there must be a structural depression or saddle between these two places. This saddle is probably at the place where the anticline is cut by Big Horn River, for at that place the crest of the arch is not formed by the Embar but by the overlying Chugwater formation. Wells that have been drilled on or near the anticline near Thermopolis have failed to yield oil, but they are reported to have produced hot water.

HAMILTON DOME.

The Hamilton dome resembles the Warm Springs domes in that it is an unsymmetrical fold having a steep slope on its south limb and a gentle slope on its north limb. The structure map forming Hewett and Lupton's Plate XXII is reproduced with slight modification in Plate X. The Thermopolis shale is the lowest formation exposed. The axis of the Hamilton dome, like those of many other upfolds in the neighborhood, is curved. Its convexity is to the south, and it has been traced for about 7 miles in a northwest-southeast direction. Its east end is within about a mile of the west end of the Thermopolis anticline as mapped, and probably it is separated from that fold only by a low structural saddle.

THE OIL.

ORIGINAL SOURCE.

The oil of the Hamilton dome is obtained from a sand near the middle of the Chugwater formation. This formation is thought to be almost devoid of fossil remains of animals that could have produced oil, and for this reason it can be inferred that the oil has filtered into its present position from lower formations. In the process of filtration it has left behind some of the heavier parts, and the resulting oil is of somewhat higher grade than that in the Embar deposits. If this explanation is true it might be carried still further and applied to the very much lighter oil found in the Frontier

formation in the Grass Creek anticline, but in that anticline there is a very probable source in the Thermopolis, Mowry, and Frontier formations from which the greater part of its oil could be derived.

The origin of the oil of the Warm Springs dome may be the animals whose fossil remains are found in the Embar deposits, for no commercial quantity of oil has yet been found in Wyoming below the Embar, but fossil remains of animals that might have yielded oil are also present in the Amsden, Madison, and Deadwood formations, which underlie the Embar. The oil is believed by the writer to have probably moved upward and accumulated under some impervious bed in the Embar, along the bottom of which it has moved to the highest points possible, either collecting in domes or reaching the surface and escaping at such places as the oil seeps noted in the Red Springs anticline and Bea Ogwa Canyon. Very probably the Lucerne anticline (see structure map), whose south end is a short distance north of the productive part of the Warm Springs domes, has served as a channel through which much of the oil has been conducted from the center of the basin to its present position.

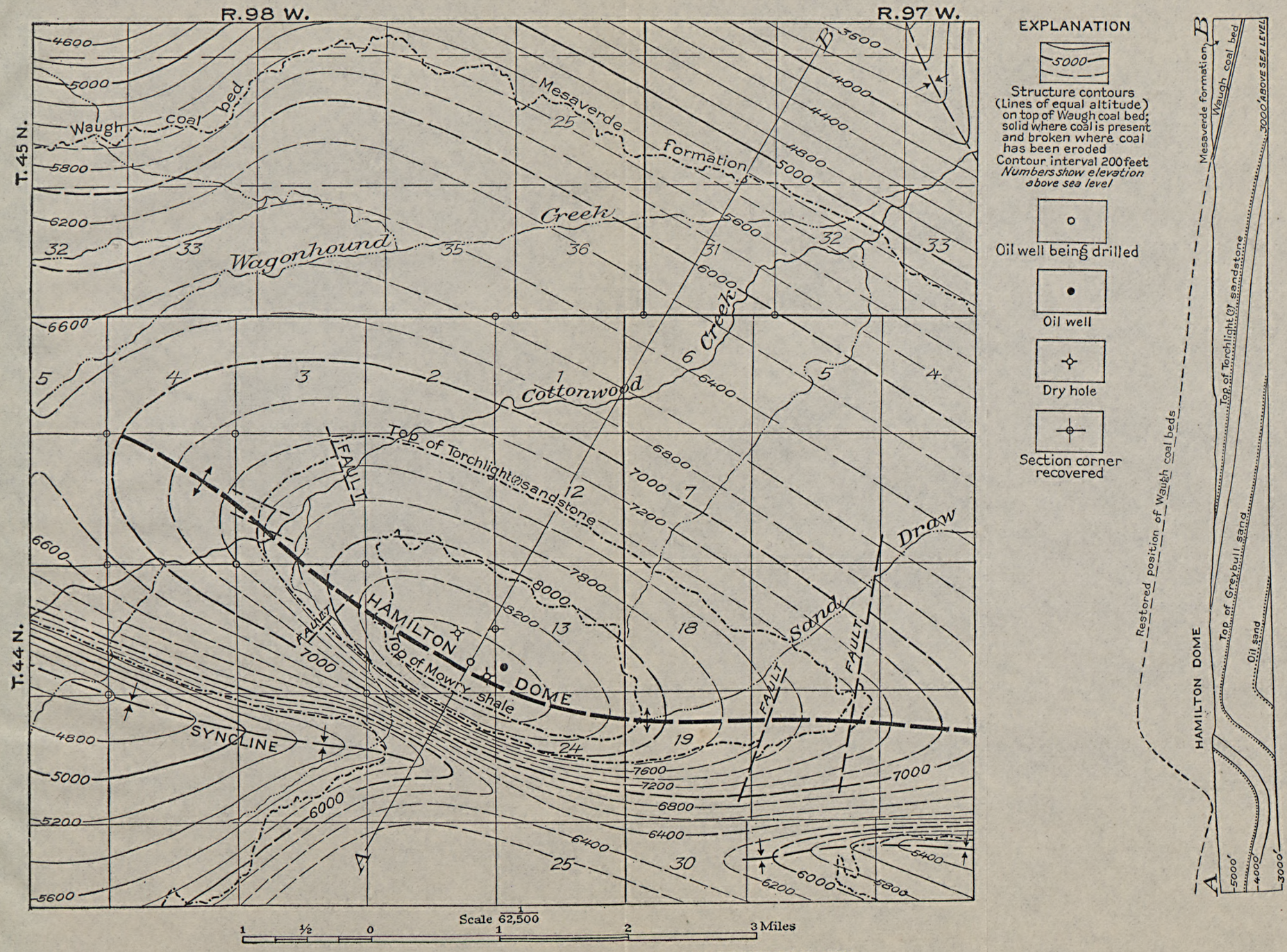
CHARACTER.

The oil from the Warm Springs domes is of about the same character as that produced from the Embar deposits in the Lander oil field.[1] It is a heavy, asphaltic dark-brown oil and has a specific gravity of about 0.91. As it is pumped from the ground it contains water in varying amounts up to about 50 per cent in one of the wells. It may be in the form of an emulsion, though samples, if left standing long enough, show most of the water in the bottom of the containers. The product from the several wells is collected in tanks, where it is heated to separate the water, which is drawn off at the bottom. The oil has a disagreeable odor, which is due, at least in part, to the sulphur it contains. The viscosity of the oil makes it flow through the 4-inch pipe line very slowly, and at the time of the writer's visit the pipe had become temporarily clogged by material carelessly left in it when it was laid. A sample taken from the tanks of the Leslie Co. was analyzed at the Bureau of Mines laboratory with the following results:

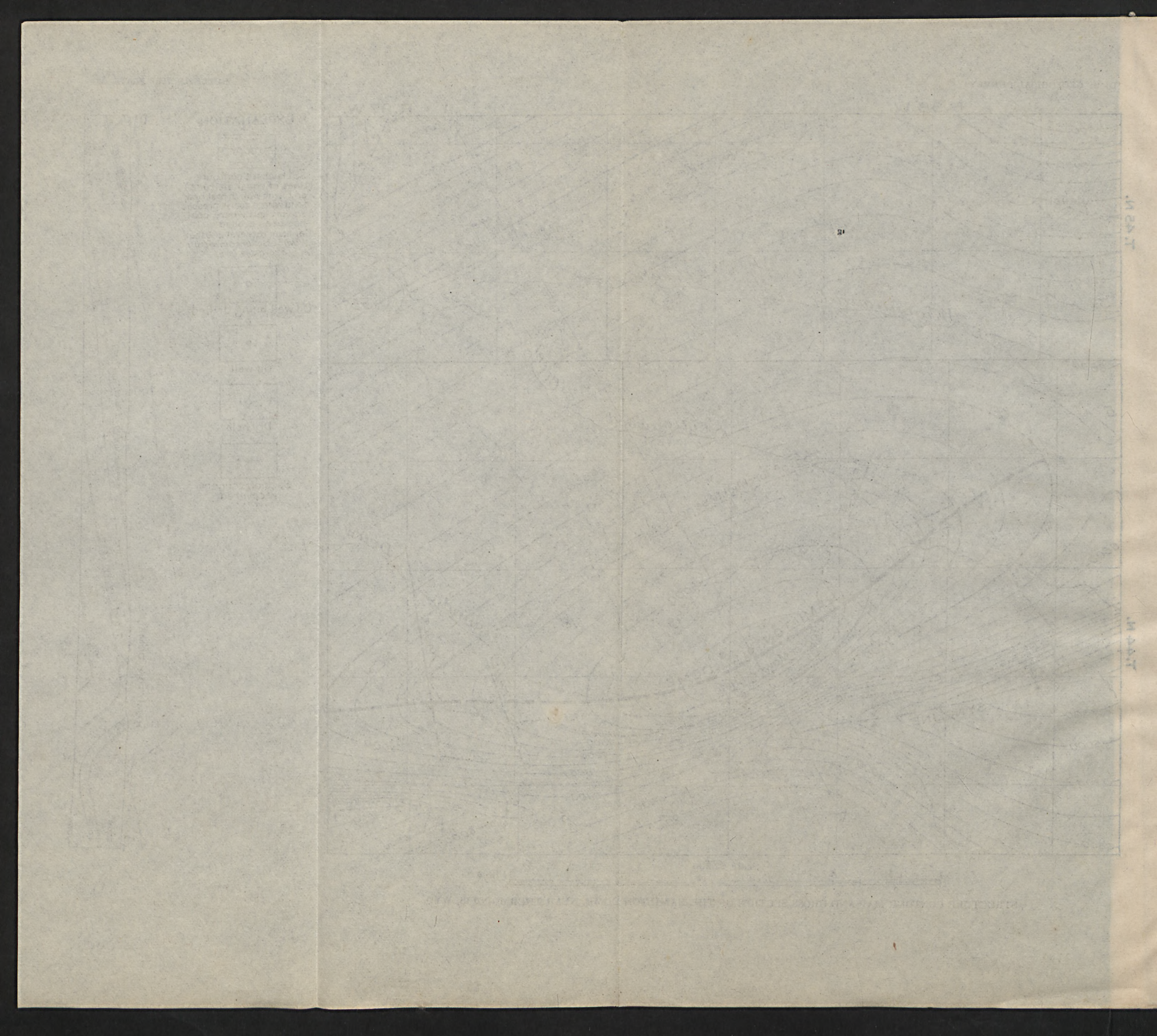
Laboratory No. 00372. Specific gravity at 15° C., 0.939 (19.1° B., modulus 140). This sample is a mixture of oil and water. Dehydrated with a $CaCl_2$, but it still retained a little moisture and a considerable quantity of free H_2S. Dehydrated again with soda lime, but it still retained so much H_2S that it was impossible to distill it.

The oil produced from the Hamilton dome is of somewhat better grade than that from the Warm Springs domes. It is reported to contain about 6 per cent of gasoline and little if any water, and it

[1] Woodruff, E. G., The Lander oil field, Wyo.: U. S. Geol. Survey Bull. 452, pp. 7–36, 1911.



STRUCTURE CONTOUR MAP AND CROSS SECTION OF THE HAMILTON DOME, NEAR THERMOPOLIS, WYO.



lacks the disagreeable sulphurous odor of the Warm Springs oil. A sample taken for analysis from the tank at the well was tested at the Bureau of Mines laboratory with the results stated in the table.

Analysis of oil from the Hamilton dome, Wyo.

[Laboratory No. 00373. Specific gravity at 15° C., 0.917 (22.7° B., modulus 140). Distillation in Bureau of Mines Hempel flask. Amount distilled, 200 cubic centimeters. First drop at 60° C.]

Air distillation, with fractionating column.

Temperature (°C.).	Fractions (per cent by volume).	Total per cent distilled by volume.	Specific gravity.
Up to 50			
50 to 75	0.7	0.7	0.710
75 to 100	.5	1.2	
100 to 125	1.6	2.8	
125 to 150	3.7	6.5	.752
150 to 175	2.3	8.8	.765
175 to 200	4.3	13.1	.791
200 to 225	3.9	17.0	.808
225 to 250	6.7	23.7	.828
250 to 275	5.0	28.7	.840
275 to 300			

Vacuum distillation, without fractionating column, pressure 40 mm.

Temperature (°C.).	Sum per cent of vacuum fractions.	Total per cent distilled by volume.
100 to 125		
125 to 150		
150 to 175	2.0	30.7
175 to 200	6.5	35.2
200 to 225	12.0	40.7
225 to 250	19.0	47.7

Cracked at about 260° C. in vacuum.

DEVELOPMENT.

WARM SPRINGS DOMES.

The first successful well in this area was drilled in 1917 for Dr. Carter, of Thermopolis. It is one of the western group of wells shown on the structure map, in secs. 34 and 35, T. 43 N., R. 94 W. At the time of the writer's visit to the Warm Springs domes he found no one who had authority to furnish detailed information regarding the production of the individual wells. It was claimed that from 100 to 200 barrels a day could be pumped from the six producing wells of the group, but owing to the clogged pipe line they were not then producing at their full capacity. A driller stated that the "Embar sand" was usually reached at a depth of 975 feet. The productive area, which can be defined roughly by the dry holes surrounding it, is probably not greater than 40 acres.

Since this discovery the Leslie Co., operating in the E. ½ sec. 36, T. 43 N., R. 94 W., and the Woods Co., operating in sec. 31, T. 43 N.,

R. 93 W., have drilled about 18 wells, most of which were successful in striking oil at an average depth of about 900 feet. Their maximum production when visited was said to be 850 barrels a day. Drill records of the 13 wells of the Leslie Co., kindly furnished to the writer by the company's agent, are as follows:

Wells drilled by the Leslie Co. in sec. 36, T. 43 N., R. 94 W.

Company No.	Depth of well (feet).	Depth to heavy limestone in Embar group (feet).	Result.	Depth to oil-bearing sand (feet).
1	955	830	Oil.....	955
2	1,025	810	Oil.....	1,025
3	1,021	845	Oil.....	1,021
4	1,735	845	Oil.....	1,043
5	1,020	.....	Oil.....	930
6	1,051	.....	Oil.....	1,032
7	962	.....	Oil.....	941
8	982	.....	Oil.....	965
10	1,325	802	Water sand.	.....
11	1,093	.....	Oil.....	1,080
12	993	.....	Oil.....	980
13	943	.....	Oil.....	943

The productive area, as indicated by the dry holes and by the observed dips of the rocks, covers about 80 acres.

HAMILTON DOME.

At the date of publication of the Hewett and Lupton report on the anticlines in the southern part of the Big Horn Basin, in 1917, three unsuccessful attempts to find oil in the Hamilton dome or Cottonwood anticline, as they called it, had been made with apparatus too light to reach the productive oil sand, though higher sands which have proved dry of oil were penetrated. Since that time the company backed by Dr. Hamilton has been replaced by a stronger company prepared to test the formations as far at least as the Embar sands. One new well in the SW. ¼ SW. ¼ sec. 13, T. 44 N., R. 98 E., was begun in the summer of 1918 and struck oil about the middle of September, in a sand near the middle of the Chugwater formation. At the time of the writer's visit preparations were being made to drill a second well in sec. 14 between the two dry holes shown on Hewett and Lupton's map. (See Pl. X.) The production of the well can not be given definitely because it has never been thoroughly pumped, and only one tank has been built. It can be stated, however, that the pumping that has been done shows that it is surely a commercial well, yielding at least 20 barrels a day. A log of the well, kindly furnished by Mr. Curtis, the manager (see Pl. VIII), shows that it begins about 200 feet above the base of the Thermopolis formation and ends at a depth of 1,445 feet, near the middle of the Chugwater

formation, or "Red Beds." The oil is obtained from a 45-foot sandstone 440 feet below the top of the "Red Beds" and is the first oil ever produced in commercial quantity from that formation.

The well produces a small flow of gas either from the oil sand or from the 10-foot gas sand 95 feet above the oil sand. Arrangements were being made at the time of the writer's visit to use this gas in heating and lighting the buildings of the plant.

UNSUCCESSFUL WELLS NEAR THERMOPOLIS.

Nine wells drilled in and around the Warm Springs domes have been unsuccessful in finding oil, though some of them have been useful in showing the limits of the productive part of the field. The log of one of these wells has been taken as the measurement of thickness of the Chugwater formation. Two miles east of the Warm Springs domes, probably in sec. 33, T. 43 N., R. 93 E., on the south side of the Red Springs anticline, a well has been drilled, but without finding oil, to a depth of 800 feet. At the time of the writer's visit an attempt was in progress to find oil within the Red Springs anticline in sec. 28, T. 43 N., R. 92 W. The well started in the hard yellowish gypsiferous beds of the Dinwoody formation at the base of the Chugwater and had passed through the Embar group and much of the Tensleep sandstone. The drillers reported finding indications of oil at several horizons but nothing of value. They proposed to continue drilling until the Madison limestone was reached. This well will probably demonstrate whether or not the formations below the Embar group contain oil in the Red Springs anticline.

Several wells drilled in the immediate vicinity of Thermopolis have resulted in finding hot water, and they seem to prove beyond doubt that there is little hope of finding oil near the hot springs. One of these wells, on the left bank of the river about $1\frac{1}{2}$ miles below the town of Thermopolis, has a strong flow of hot water, similar to that of the springs, which collects in a long pool in the borrow pit beside the railroad. The well is 498 feet deep; the upper 40 feet is in river gravel, and the remainder in the "Red Beds." The upper 200 feet is cased with $6\frac{5}{8}$-inch pipe, and the pressure of the water is 25 pounds to the square inch. After the drill reached a depth of 166 feet the hole filled with water, but at a depth of 470 feet a great rush of water came from a cavity into which the drill dropped 28 feet, and operations were suspended.

Considerable drilling, as yet unsuccessful, has also been done on the Thermopolis anticline about 6 miles northwest of Thermopolis, in what is called the Otey dome, but this part of the region was not visited and little is known by the writer concerning it.

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