ANTICLINES NEAR MAVERICK SPRINGS, FREMONT COUNTY, WYOMING.

By A. J. COLLIER.

INTRODUCTION.

Owing to the increasing cost of petroleum and the success of wells drilled in Wyoming, every locality in the State which is known to be at all favorable for the accumulation of oil is being tested with the drill, and vigorous search is being made for new localities. During the winter of 1917–18 a well sunk on an anticline or arch of the rocks in the vicinity of Maverick Springs, in Fremont County, reached a depth of 1,125 feet and brought in a flow of dark oil similar in type to the oil produced near Lander and Thermopolis. Since that time several other successful wells have been drilled in this field, but development has not proceeded far enough to justify a prediction of its ultimate production.

The Maverick Springs field (see index map, fig. 4) is in the northern part of Fremont County, in Tps. 5 and 6 N., Rs. 1 and 2 W. Wind River meridian, in the ceded portion of the Shoshone Indian Reservation. It lies in the Wind River Basin just south of the Owl Creek Mountains, about 42 miles a little south of west of Thermopolis on the Chicago, Burlington & Quincy Railroad, 45 miles northwest of Riverton, on the Chicago & Northwestern Railway, and about 20 miles north of the Pilot Butte field, where oil was discovered some time previously and some development has taken place. The Maverick Springs field has no railroad connection, and hence supplies must be hauled a distance of at least 42 miles from the nearest railroad point, and eventually a pipe line must be laid to this point, if oil is discovered in quantity, before the field can be thoroughly developed. It can be reached by automobile from either Riverton or Shoshone.

ACKNOWLEDGMENTS.

The topographic map of the Kirwin quadrangle published by the United States Geological Survey, the field work on which was done in 1904, shows at the southeast corner a portion of a circular ridge surrounding one of the domes of the Maverick Springs field. The presence of a second dome was recognized in 1905 by Darton.[1] The

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

region was again visited in 1908 and 1909 by Woodruff and Winchester[1] for the purpose of classifying the coal lands, and they prepared a more detailed topographic map, including the part already covered by the Kirwin map. Their map, which has not yet been published, is in the files of the Geological Survey, and from it the contours on Plate XXI of this report are taken with only slight modifications.

In preparing this report the writer has also had access to an unpublished report by D. Dale Condit, of the Survey, on the phosphate rock of the Owl Creek Mountains, from which carefully measured sections of the rocks that underlie the lowest formation exposed in the Maverick Springs field are taken. The writer wishes to express his appreciation of the work of Harvey Bassler, who was associated with him in the field and deserves equal credit for this report, and also of the assistance of Frank E. Hunter, Paul S. Parsons, and the late C. B. Barnett, who were employed in various capacities during the field season. Grateful acknowledgments are due to the oil operators and other residents of the field for many courtesies and much valuable information regarding the wells that have been drilled, the distribution and structure of various formations, and the general features of the surrounding country.

FIELD WORK.

In response to reports of successful wells drilled in T. 6 N., R. 2 W. Wind River meridian, in the Maverick Springs field, received by the United States Geological Survey in the winter of 1917–18, Harvey Bassler and the writer made an examination of the field and spent about half of the month of September, 1918, in a study of the rock formations, the mapping of the structure with plane-table and telescopic alidade, and the location and inspection of oil wells and dry holes. Plate XXI (in pocket) presents the data collected in the field supplemented by material compiled from other sources.

SURFACE FEATURES AND CLIMATE.

The Maverick Springs field lies in a belt of hilly country on the northern edge of the Wind River Basin, south of the Owl Creek Mountains. The altitude in this region ranges from 6,000 to 7,400 feet, but most of the roads and settlements are approximately 6,500 feet above the sea. The Wind River Basin, to the south, has an average altitude somewhere between 5,000 and 6,000 feet and is a more or less monotonous plain covered by the flat-lying soft beds of the Wind River formation. The Owl Creek Mountains, to the north,

[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. 516–564, 1910.

rise to altitudes of more than 8,000 feet and very effectually interfere with communication between the Wind River and Big Horn basins.

The average annual rainfall in the Wind River Basin is only about 10 inches. In the Maverick Springs field, owing to its rougher surface and higher altitude, the rainfall is probably a little greater, but the region would still be classed as semiarid. As in many other arid and semiarid regions, the few springs yield alkaline and sulphur water, which is not palatable. Well drillers find it necessary to haul drinking water about 7 miles, from a branch of Little Dry Creek in T. 6 N., R. 3 E., which is supplied from the Owl Creek Mountains. Owing to the dry climate there is a scarcity of vegetation other than the scattered grass and sagebrush and a few cedar trees on the ridges. Cottonwood and willow, however, grow in some of the valleys where there is a subsurface flow of water that can be tapped by their roots.

Owing to the dearth of vegetation the relation of the land forms to the outcrops of the hard rocks, which in a large measure control them, may be plainly seen from any of the higher points. A nearly flat plain 1 to 2 miles wide on the northeast side and half a mile to 1 mile wide on the southwest borders the field, and within this border a number of ridges from 100 to 500 feet high encircle three distinct surface basins. The ridges are unsymmetrical in cross section and have gentle slopes on the outer side and steep slopes or cliffs facing the basins. Such ridges are evidently due to the partial erosion of rocks that have been folded into domes or anticlines, leaving the edges of the hard layers exposed in the ridges.

In the south dome, which is commonly called the Little dome, the inclosing ridge is about 200 feet high. The basin is drained by a valley that finds an outlet on its north side, through which the wagon road enters. The inclosed valley is only a little higher than the surrounding plain, and the hill in the center rises to a somewhat greater elevation than the inclosing ridge, like the cone on a lemon squeezer. The derrick on this hill can be seen from every direction from points on the plain outside of the inclosing ridge. Two small ponds in the inclosed basin can probably be accounted for by its unequal filling of material washed down from the hills.

Around the Big dome, which lies north of the Little dome, there are several encircling ridges that rise about 500 feet above the level of the bordering plain. The drainage of the inclosed basin escapes by three narrow canyons, one near the north end and the other two near the south end. In addition to these, two canyons cutting across the inner ridge admit drainage into the basin. Wagon roads enter through these canyons. The valley in the inclosed basin is at about the same altitude as the plain, and the hill in the center is a little higher than the highest points of the surrounding ridges.

The Circle Ridge dome, which is the most northern of the three, is surrounded by a ridge whose highest point is about 600 feet higher than the lowest point in the inclosed basin. The basin is drained through a narrow canyon cut across the ridge at its southernmost point. This basin differs from the other two in that the hill in the center is not prominent, and to one standing on the inclosing ridge the basin appears like a depression.

STRATIGRAPHY.

GENERAL SECTION.

The rock formations in the vicinity of Maverick Springs are practically identical with the bedded rocks of the Wind River Basin, as described by Darton, Woodruff, Hares, Blackwelder, and Condit, and with those of the Big Horn Basin, as described by Darton, Fisher, Hewett, Blackwelder, and Condit, the only differences being that the beds are locally thinner or thicker than in those basins. The thicknesses of the Chugwater, Sundance, Morrison, Cloverly, Thermopolis, Mowry, and Frontier formations given in the following table were determined in the field and are correct for the Maverick Springs region. The measurements of the formations below the Chugwater, which are not exposed in the area examined, are taken from unpublished reports by Condit on the phosphate resources of the Owl Creek Mountains, which lie a few miles to the north.

General section of formations in the Maverick Springs region, Wyo.

System or series.	Formation or group.	Thickness (feet).	Character of the rocks.
Eocene.	Wind River formation.	Undetermined.	Soft sandy shales with lenticular sandstone.
	—Unconformity—		
Upper Cretaceous.	Mesaverde formation.		Heavy sandstone and shale with several coal beds.
	Cody shale.	±2,500	Dark-gray shale with many interbedded thin sands, the same as the Cody shale of the Big Horn Basin, the upper part of the Mancos shale of Woodruff and Winchester's report on the Wind River region, and the Steele, Niobrara, and Carlile shales of Hares's report on the anticlines of central Wyoming.
	Frontier formation.	553	Three to five sandstones with interbedded shale. A part of the Mancos shale of Woodruff and Winchester's report.
	Mowry shale.	400	Hard siliceous gray shale with several beds of bentonite near top. A part of the Mancos shale of Woodruff and Winchester's report.
	Thermopolis shale.	700	Dark-gray shale softer than the Mowry shale. The lower part of the Mancos shale of Woodruff and Winchester's report.

General section of formations in the Maverick Springs region, Wyo.—Contd.

System or series.	Formation or group.	Thickness (feet).	Character of the rocks.
Lower Cretaceous.	Cloverly formation.	94	Sandstone, conglomerate, and shale.
	—Unconformity—		
Lower Cretaceous (?).	Morrison formation.	292	Variegated beds of shale, sandstone, and conglomerate.
	—Unconformity—		
Jurassic.	Sundance formation.	317	Limestone, shale, and sandstone.
Triassic.	Chugwater formation.	1,300	Red sandstone and shale with gypsum beds.
Permian.	Embar group: Dinwoody formation. Park City formation.	350	Hard yellowish shale, limestone, chert, and brown shale with sandy layers. The phosphate rocks are near the middle of the group, which is divided by Blackwelder and Condit into the Dinwoody formation above and Park City formation below, both of which are identified in this area.
Pennsylvanian.	Tensleep sandstone.	250	Light-colored cross-bedded sandstone.
....	Amsden formation.	300	Red shale and sandstone.
Mississippian.	Madison limestone.	650	Massive limestone.
	—Unconformity—		
Silurian and Devonian.		150	Shale and thin-bedded limestone.
Ordovician.	Bighorn dolomite.	200	Massive cream-colored to white dolomite.
Cambrian.	Gallatin limestone.	150	Oolitic limestone and conglomerate.
	Gros Ventre formation.	600	Clay, shale, and interbedded limestone.
	Flathead sandstone.	250	Gray and brown sandstone.
	—Unconformity—		
Pre-Cambrian.	Metamorphic complex.		Schist, gneiss, basic igneous rocks, and granite.

FORMATIONS.

Formations below the Tensleep sandstone.—The formations below the Tensleep sandstone are not exposed in the Maverick Springs field and have not been reached by the drill, but they undoubtedly underlie the field and may have been the source of some of its oil. The descriptions given below are adapted from unpublished reports by Condit, but the formation names appear in recent reports by Blackwelder [1] and by Schultz.[2]

[1] Blackwelder, Eliot, Washington Acad. Sci. Jour, May, 1918.

[2] Schultz, A. R., A geologic reconnaissance for phosphate and coal in southeastern Idaho and western Wyoming: U. S. Geol. Survey Bull. 680, pp. 17–19, 1918.

The Flathead sandstone, which immediately overlies the metamorphic complex, is about 250 feet thick and consists largely of gray or brown shaly sandstone, several beds of which are quartzitic. It grades upward into the Gros Ventre formation, which consists of clay shale with alternate beds of limestone, making a thickness of about 600 feet, and is overlain by the Gallatin limestone about 150 feet thick. These rocks are of Cambrian age and are identical with the Deadwood formation described in reports on the Big Horn Basin. They are overlain by the Bighorn dolomite, about 200 feet thick, of Ordovician age, and by 100 to 200 feet of beds which are regarded as Silurian and Devonian. The next formation in the ascending series is the Madison limestone, of Mississippian or lower Carboniferous age. It has an average thickness of about 650 feet and is one of the most conspicuous and easily recognized formations in the region. Above the Madison limestone is about 300 feet of cream-colored sandstone, yellowish dolomite, and brick-red shale, making up the Amsden formation, which is at present classified by the United States Geological Survey as of Pennsylvanian and Mississippian age.

Tensleep sandstone.—The Tensleep sandstone, which overlies the Amsden formation, is about 250 feet thick and is of Pennsylvanian or upper Carboniferous age. It is composed mainly of rather coarse grained white to buff sandstone that forms many prominent cliffs and bouldery rounded ridges in the Owl Creek Mountains. In many places where the Tensleep sandstone forms cliffs it shows a great deal of cross-bedding, indicating that it was deposited by swift currents in shallow waters. The texture of this sandstone is open, so that water and other liquids could flow through it rather readily and oil that might be contributed by underlying formations would naturally be carried by the water and collected at favorable localities under more impervious formations.

Embar group.—The Embar group, about 350 feet thick in the Maverick Springs region, contains a number of different kinds of rocks of Pennsylvanian, Permian, and Triassic age. This group is believed by the writer to contain the oil-bearing formation of the productive wells here described. The Embar rocks have since 1916 been divided into two formations, called the Dinwoody and Park City, by geologists searching for phosphate in the Owl Creek and other mountains of Wyoming; but the older name is here retained in a group sense, as it is well known to drillers and oil operators and was used by Woodruff in describing the rocks of the Lander oil field.[1] The upper part of the Embar group, or the Dinwoody formation,

[1] Woodruff, E. G., The Lander oil field, Fremont County, Wyo.: U. S. Geol. Survey Bull. 452, 1911.

is not usually distinguished by the drillers from the Chugwater formation.

Condit found the following complete section of the Embar group well exposed in sec. 9, T. 7 N., R. 2 W. Wind River meridian, a few miles north of the Maverick Springs field:

Section of Embar group north of Maverick Springs, Wyo.

	Ft.	In.
Dinwoody formation:		
Clay shale, gray to greenish, with gypsum bands and limestone in lower parts	28	
Limestone, impure, shaly, weathering a deep brown color	44	
Calcareous shaly beds, ripple marked	30	
Park City formation:		
Limestone, cream or gray, siliceous	8	
Limestone, "upper bryozoan," gray, massive beds	24	
Chert, greenish, in nodular layers	50	
Phosphate, dark, granular	1	4
Limestone, phosphatic	1	
Phosphate, calcareous	1	3
Limestone, dark gray	15	
Limestone, phosphatic, dark gray, with chert nodules	9	
Limestone, dark gray	5	
Limestone, phosphatic	1	5
Limestone, dark gray	4	
Limestone, gray, granular, in single massive layer	20	
Limestone, cream or gray, argillaceous	4	
Brown, shaly, ocherous bed	40	
Limestone, light gray, argillaceous	50	
Tensleep sandstone.		
	234	

In the section given above no sands are noted, but it is the writer's opinion that some of the members must contain sand grains so masked by calcite or clay that they were not readily detected by the geologist. At two of the wells in the Big dome the writer was permitted to inspect samples of the drillings and made the following notes on them:

Log of Carter Oil Co.'s well in sec. 23, T. 6 N., R. 2 W. Wind River meridian.

[Compiled from an inspection of the drill cuttings.]

	Feet.
Chugwater and Dinwoody formations	1,037
Park City formation:	
Limestone, dense, blue	137
Sand (best showing of oil), stained brown with oil	17
Sand composed of well-rounded quartz grains and containing fragments of limestone	6
Limestone fragments	45
Sand, grains well rounded but containing angular fragments of hard siliceous rock and limestone	21
Sand, fine grained, light colored	12
Sand, fine grained, with fragments of limestone and red shale	13

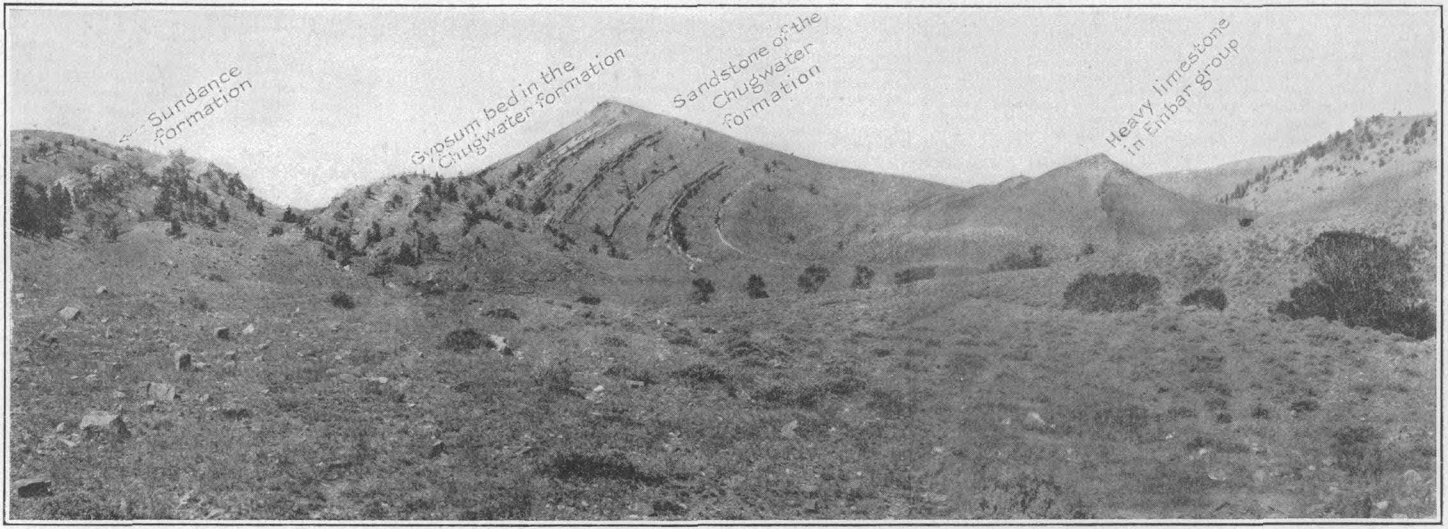
Park City formation—Continued.	Feet.
Sand with fragments of limestone (oil showing)	8
Sand, grayish brown	5
Dense dark-brown rock; may be quartzite	25
Hard gray shale; some particles hard and gritty, remainder soft	12
Limestone, thin, gray	3
Sand, grains of unequal size, stained with oil	2
Sand with flakes of gray mica	6
Shale, light gray	3
Shale, light gray, with hard fragments, either limestone or clay ironstone (?)	4
Shale, light gray; no grit	6
Shale, light gray, somewhat sandy	4
Conglomerate with gray clay binder	7
Depth of well	1,371
Thickness of Park City formation	336

Log of Ohio Co.'s well in sec. 22, T. 6 N., R. 2 W. Wind River meridian.

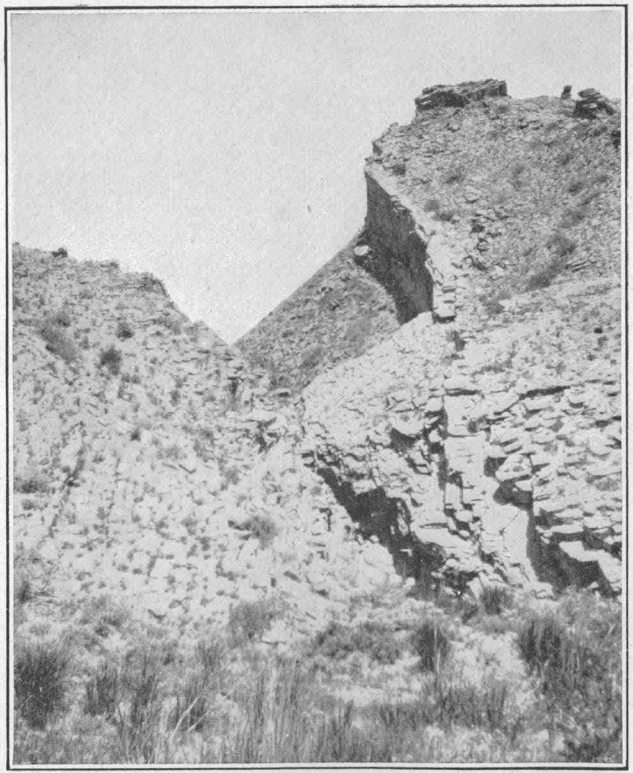
[Compiled from an inspection of the drill cuttings.]

	Feet.
Chugwater and Dinwoody formations	1,185
Park City formation:	
Limestone	90
Sand, yellowish gray	10
Clay, yellowish gray	10
Limestone, light gray	15
Sand with fragments of mica	25
Shale, dark gray, hard	10
Limestone and chert	10
Sand, well-rounded quartz grains, yellow at top, stained dark brown, with oil at bottom; oil sand	25
Hard shale and chert, gray	30
Coarse sand (water-bearing)	3
Depth of well	1,213
Thickness of Park City formation	228

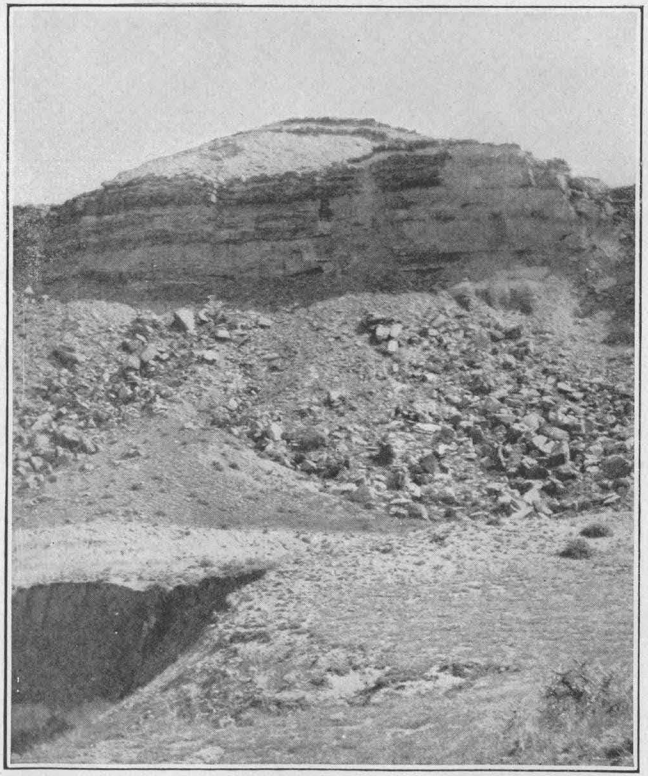
The well drillers are of the opinion that at least some of the oil comes from the Tensleep sandstone, but these two well logs and the report of the findings in the Sheridan well, in the SE. ¼ sec. 22, certainly show that the major part is found near the bottom of the Embar group, in the Park City formation, and lead one to doubt whether any of the wells reached the Tensleep. The lowest sandstone in the Ohio Co.'s well, however, is composed of coarse well-rounded quartz grains, such as might be expected in the Tensleep sandstone.



UPFOLDED EDGES OF THE CHUGWATER FORMATION AND THE EMBAR GROUP, EXPOSED 3 MILES NORTHWEST OF THE CIRCLE RIDGE DOME, FREMONT COUNTY, WYO.



A. UPTILTED LIMESTONE MEMBER OF THE SUNDANCE FORMATION CUT BY A NARROW BOX CANYON ON THE SOUTHWEST SIDE OF THE BIG DOME, FREMONT COUNTY, WYO.



B. CLIFF ON NORTHWEST SIDE OF BIG DOME, FREMONT COUNTY, WYO., SHOWING MORRISON AND CLOVERLY FORMATIONS.

Chugwater formation.—No complete section of the Chugwater formation was measured in the Maverick Springs field, but from partial sections seen and from the logs of wells that start below the top of the formation the thickness is estimated at 1,300 feet. A very striking view showing the whole of the upturned Chugwater formation and a part of the underlying Embar group exposed in Red Peak, about 3 miles northwest of the Circle Ridge dome, may be seen in Plate XIX. The upper part of the following section was measured on the east side of the Circle Ridge dome, and the lower part from the drill holes in the Big dome:

Section of Chugwater formation in Maverick Springs field, Wyo.

Sundance formation.	Feet.
Shale, sandstone, and limestone, prevailingly red but containing some violet and pink members	125
Gypsum	123
Shales, red and yellow	302
Sandstone, reddish gray; forms a prominent cliff	214
Shales and some sandstone, red	540
	1,304

The large bed of gypsum near the top of the formation is unusual, both in purity and thickness, and it forms prominent white cliffs around the Circle Ridge dome and in the Big dome. The thick sandstone noted in the section forms a second almost impassable cliff on the east side of the Circle Ridge dome but is not exposed in the Big dome. At the northwest end of the Circle Ridge dome, on the southwest side of the dome, between the gypsum bed and the cliff-forming sandstone, there is a great mass of sandstone, which is partly impregnated with asphalt and has very irregular and obscure bedding planes. This confused condition, in the writer's opinion, is a result of shearing and squeezing by which either some of the cliff-forming sandstone has been broken off and thrust into its present position or the rocks above the sandstone have been disturbed and crushed. Not far from this mass of rock is a yellow shaly sandstone in about its normal position, which contains a great many bone fragments that have been identified by C. W. Gilmore and J. W. Gidley, of the United States National Museum, as the broken limb bones, vertebrae, and other parts of labyrinthodont reptiles of Triassic age.

Sundance formation.—The Sundance is an easily recognized formation composed in the Maverick Springs field of about 317 feet of greenish shale, sandstone, and limestone and containing many beds of marine fossils, oysters, and belemnites of Jurassic age throughout its thickness. A characteristic view of one of the lime-

stone beds, taken on the southwest limb of the Big dome, is shown in Plate XX, *A*.

Morrison formation.—The Morrison formation in Wyoming is variable. On the north side of the Big dome it has a thickness of 292 feet and consists of about 210 feet of greenish sandy shale at the base, 30 feet of conglomerate and sandstone, 47 feet of red and maroon shale, and 5 feet of sandstone at the top. It contains the remains of fossil dinosaurs in many places, and in this region it may be recognized by the presence in it of gastroliths—that is, highly polished pebbles thought to have come from the gizzards of the dinosaurs. For about 4 miles on the northeast side of the Big dome it forms an almost impassable cliff from 100 to 200 feet in height, as shown in Plate XX, *B*. The formation is believed to be a continental deposit laid down when this part of Wyoming was above the level of the sea, in late Jurassic or early Cretaceous time.[1]

Cloverly formation.—The Cloverly formation, part of which is called in some reports the Dakota sandstone, overlies the Morrison formation and is generally described as consisting of two massive sandstones separated by variegated shale. It can usually be distinguished readily from the Morrison formation, for the two sandstone members stand out as definite ledges and form ridges that can be traced over a large part of Wyoming. The upper sandstone, commonly called the Greybull sand by well drillers, is oil bearing in several places. The formation was deposited in fresh water during Lower Cretaceous time. It was measured on the northeast side of the Big dome, where its total thickness was found to be only 94 feet.

Thermopolis shale.—Overlying the Cloverly formation is about 1,100 feet of shale, of which the lower part is chiefly soft and bluish black, forms valleys, and is called the Thermopolis shale; the upper part is a harder, siliceous shale that weathers nearly white in places, forms ridges, and is called the Mowry shale. The line between these formations has not been definitely determined in the Maverick Springs field, but from the observations made in 1918 it is thought to be about 700 feet above the upper sandstone of the Cloverly formation and is so represented in the stratigraphic column. The Thermopolis shale is homogeneous with the exception of 50 to 100 feet of "rusty shale" immediately above the base, and a sandstone members 50 feet thick 150 feet above the base, which is presumably equivalent to the Muddy sand of the Big Horn Basin. The position of the formation is shown at the surface by the en-

[1] Schuchert, Charles, Age of the American Morrison and East African Tendaguru formations: Geol. Soc. America Bull., vol. 29, pp. 245–280, 1918.

circling valley of the Little dome and the second valley from the center on the northeast side of the Big dome.

Mowry shale.—The Mowry shale is about 400 feet thick and is nearly homogeneous throughout except for two beds of bentonite, each about 5 feet thick. These beds are white and are very sticky when wet. One of them lies about 75 feet and the other 25 feet below the top of the formation, and a 1-foot bed of sandstone is present about halfway between them. This shale has been recognized throughout much of eastern Wyoming by its content of fish scales and other fish remains. Heretofore these have been the only recognizable fossils found in it, but in the summer of 1918 a number of mollusk and brachiopod fossils were found in the shale at two horizons immediately above the bentonite beds, and T. W. Stanton reports that they constitute a new faunule. He recognized the following undescribed species:

Avicula sp. related to A. nebrascana.
Callista sp.
Corbula sp.
Fish scales.
Lingula sp.
Lunatia sp.
Modiola sp.
Nucula sp.
Ostrea sp.
Tellina sp.
Thracia sp. a.
Thracia sp. b.

Frontier formation.—The Frontier formation in the Maverick Springs field consists of at least four ridge-forming sandstone members ranging in thickness from 1 to 20 feet, with interbedded shales, the whole thickness being about 553 feet. The shales associated with the lower sandstones are nearly black and resemble the Thermopolis shale, whereas that between the upper two sandstones is dark gray. The third sandstone from the bottom was found to be very fossiliferous at one place, and from the collection made Mr. Stanton has been able to recognize the following species, several of which are new and undescribed.

Lot 10175, northwest flank of Big dome, Maverick Springs, Wyo.:

Ostrea soleniscus Meek.
Ostrea anomioides Meek.
Ostrea sp.
Ostrea sannionis White.
Exogyra sp.
Lima sp.
Camptonectes platessa White.
Mytilus sp.
Avicula gastrodes Meek.
Inoceramus acuteplicatus Stanton.
Pedalion sp.
Crassatellites sp.
Cardium pauperculum Meek.
Cyprimeria sp.
Tellina sp.
Mactra sp.
Pholadomya coloradoensis Stanton.
Thracia sp. C.
Actaeon sp.
Shark teeth, either Lamna or Otodus.
Placenticeras sp.

In the upper sandstone, which lies about 50 feet above the bed from which the fossils listed were collected, there are in some places beds

of oyster-shell fragments. The following collection was made from one of these beds:

Lot 10179, northeast flank of Big dome, Maverick Springs, Wyo.:

Ostrea sannionis White.	Pedalion sp.
Ostrea sp.	Cardium sp.
Inoceramus erecta Meek.	

Formations above the Frontier formation.—The marine Cody shale, which lies above the Frontier formation, is estimated to be from 2,000 to 3,000 feet thick. Nowhere in the Maverick Springs field is it well exposed, but it is known to underlie the nearly level plain surrounding the Maverick Springs domes. North of the Owl Creek Mountains, in the Big Horn Basin, the name Cody shale[1] was first applied to the formation lying between the Frontier and Mesaverde formations. Hares[2] divided the series in central Wyoming into the Steele, Niobrara, and Carlile shales. Woodruff[3] in his examination of the coal beds of the Wind River Basin used the term Mancos shale to designate the whole series of formations from the Cloverly to the Mesaverde.

The Mesaverde formation, which overlies the Cody shale, owes its origin to deposition in fresh water and is described by Woodruff and Winchester[4] as consisting of a mass of sandstone and shale ranging in thickness from 1,000 to 3,000 feet, the lower portion characterized by thick-bedded sandstone and the upper portion composed chiefly of shale; both members contain coal.

In the region southwest of Maverick Springs the underlying rocks are unconformably overlain by the Tertiary Wind River formation, which conceals their structure.

STRUCTURE.

General features.—The structure of the Maverick Springs field is shown on the structure contour map (Pl. XXI, in pocket) and the three cross sections which are published with it. The structure contours are lines of equal altitude drawn, as nearly as the position can be determined, on the top of the massive "upper bryozoan" limestone bed in the lower formation (Park City) of the Embar group. The structure in general may be characterized as that of an irregular anticline extending about 12 miles in a northwesterly direction. Its southwest limb is very steeply inclined, and in some places it is over-

[1] Hewett, D. F., and Lupton, C. T., Anticlines in the Big Horn Basin: U. S. Geol. Survey Bull. 656, pp. 24–25, 1917.

[2] Hares, C. J., Anticlines in central Wyoming: U. S. Geol. Survey Bull. 641, table facing p. 238, 1916.

[3] Woodruff, E. G., and Winchester, D. E., Coal fields of the Wind River region, Wyo.: U. S. Geol. Survey Bull. 471, pp. 522–523, 1910.

[4] Idem, p. 523.

turned and faulted, but the detail of its structure could not be determined in the time at the writer's disposal, and the contours shown on the map for that part of it are only rough approximations. Its northeast limb dips at a comparatively low angle. The crest of this anticline is divided by low structural saddles into three well-marked domes, called the Circle Ridge dome, the Big dome, and the Little dome, as shown by the structure map.

Circle Ridge dome.—The northwest dome, which is surrounded by Circle Ridge, is about 1 by 2½ miles, its longer axis extending northwest-southeast. The rocks near the quarter corner on the west side of sec. 6, T. 6 N., R. 2 W., dip about 12° E., but on its northeast limb, the position of which is indicated by Circle Ridge, in the E. ½ sec. 6, the dips are from 30° to 48°. On the southwest limb the rocks are slightly overturned, showing a dip in one place of 65° NE. Several faults having throws of less than 50 feet were noted in the field, and the irregularity of outcrops observed near the north end of the dome can be accounted for, in the writer's opinion, only by faulting. The lowest rocks exposed are believed to belong to the Dinwoody or upper formation of the Embar group.

Big dome.—The north end of the axis of the Big dome lies about a mile east of the south end of the axis of the Circle Ridge dome, the two domes being separated by a saddle whose lowest point is about 700 feet below the highest point in the Big dome, as may be seen from the structure contour map. The longer axis of this dome extends for about 7 miles and lies parallel to the zone of steeply dipping rocks to the southwest. The dips of the northeast limb average about 10°. On the southwest limb the dip averages about 30° for about a mile from the crest; then it becomes much greater. The lowest rocks exposed are in the Chugwater formation, about 100 feet below the large gypsum bed and 400 feet below the top of the formation. Several faults trending across the axis were observed but were not considered of great importance as affecting the accumulation of the oil, because of their small displacement and the great thickness of shaly beds above the oil horizon. Owing to the shortness of the time at the geologists' disposal, the faults were not carefully mapped, though their approximate positions are indicated. The highest part of the dome, as shown by the survey of its surface and the location of the productive wells, is in sec. 22, T. 6 N., R. 2 W., not far from the quarter-section corner on the east side.

Little dome.—The Little dome lies southeast of the south end of the Big dome, from which it is separated by a saddle 2,000 feet lower than its highest point. Its axis is not parallel with that of the Big dome but trends nearly due east, and it can be traced eastward for at least 6 miles. Its highest point and therefore its valuable portion is

in the N. ½ sec. 15, T. 5 N., R. 1 W. The dips on the north limb are as high as 45°; those on the south limb are about 27° for half a mile from the crest and then become nearly vertical or slightly overturned. A fault trending parallel with the longer axis was observed at one point on the south limb, where the dip changed abruptly. The outcrops of the Thermopolis formation near the east end of the dome are somewhat irregular and show that the rocks have been more or less crushed. The lowest rocks exposed in secs. 10 and 15, T. 5 N., R. 1 W., belong to the Morrison formation.

Other possible domes.—A narrow anticline southwest of the Big dome extends southeastward into secs. 17, 20, and 21, T. 6 N., R. 2 W. It was not examined by the writer, and whether or not the rocks are folded into a dome is not known. This anticline, however, is not considered promising, because it is surrounded by rather closely folded rocks and has only a small area from which oil could be collected.

About 3 miles southwest of the Big dome the Cody shale is partly exposed and suggests a series of anticlines extending in a northwesterly direction parallel to the Maverick Springs upfolds. These features are so largely covered by the Wind River formation as to make any statement of their probable positions hazardous, and the writer, who made only a hasty reconnaissance in that direction, has not attempted to work out the structure. If an anticline or anticlines can be located, it is probable that oil will be found in the Frontier formation and will be of much higher grade than that now produced in the Maverick Springs field.

An extension of the main anticlinal structure to the southeast of the Little dome is also possible, though if it is present it is covered by the Wind River sandstone and can be located only by the drill.

The writer's attention was called to a supposed dome about 4 miles northeast of the center of the Big dome, in sec. 31, T. 7 N., R. 1 W., and sec. 5, T. 6 N., R. 1 W. This was found to be the south end of a long anticline which has been mapped by Condit in his explorations for phosphate in the Owl Creek Mountains and which does not encourage the search for oil, for the Tensleep sandstone is exposed in its crest, several miles to the northwest. This anticline extends for about 5 miles southeast of the point where it was inspected by the writer, and it may be a dome, with the Cody shale exposed in its apex somewhere in that distance. In sec. 6, T. 6 N., R. 1 W., there is a fault extending northwest, by which the Cody shale is brought into contact with the Thermopolis shale. No attempts are known to have been made to locate or prospect any structural feature in the vicinity other than the three domes first described.

PRESENCE AND CHARACTER OF ARTESIAN WATER.

Rather strong springs yielding "alkali water" occur on the west side of the Big dome, reaching the surface through the Sundance and Morrison formations in secs. 22 and 36, T. 6 N., R. 2 W., and sec. 6, T. 5 N., R. 1 W.; and sulphur water seeps out of the Chugwater formation in secs. 23, 25, and 26, T. 6 N., R. 2 W. Nearly all the deep wells produce more or less water, which usually flows from the top, and in some of the wells water was struck at several horizons before the oil sands were reached. Little attention was given in the field to these occurrences, and no samples were taken for analysis, but the following notes may have some suggestive value.

In at least four of the wells drilled on the Big dome, in secs 23, 24, and 25, T. 6 N., R. 2 W., and sec. 31, T. 6 N., R. 1 W., flows of "sulphur water" were encountered in passing through the Chugwater formation, and in one of these wells in sec. 25, T. 6 N., R. 2 W., a strong flow of water described as "fresh" was brought in either from the Embar group or from the Tensleep sandstone. The well on the Little dome, in sec. 15, T. 5 N., R. 1 W., has a flow of "salt water" which has polluted the lake west of it, but whether this flow is from the Sundance or the Chugwater formation was not learned. The very porous nature of the outcrop of the large gypsum bed noted in the Chugwater formation suggests that it has been partly dissolved, and if so an analysis of the water from these wells might throw some light on the composition of the gypsum bed at greater depth.

THE OIL.

Origin.—The oil found in the Big dome at Maverick Springs was probably derived from organisms whose fossil remains are found embedded in the Embar group or possiby the formations which underlie that group. Since the formations were warped and folded water has caused the oil to move upward and to collect locally in anticlines and domes beneath some impervious shale of the Embar group.

Character.—The oil produced in this district is a heavy asphaltic dark-brown oil having an odor of hydrogen sulphide. A sample taken from the tank at the Carter well, in sec. 23, T. 6 N., R. 2 W., which was analyzed at the Pittsburgh laboratory of the Bureau of Mines, had a specific gravity at 15° C. of 0.921, or 22° Baumé. In distillation it began to boil at 90° C. and yielded 3.1 per cent of gasoline which distilled below 150° C., 36.1 per cent of kerosene which distilled between 150° and 300° C., and 39.2 per cent, mainly asphalt, which could be distilled at higher temperatures.

A detailed statement of the analysis is as follows:

Results of distillation of oil from Maverick Springs field, Wyo.

[Distillation in Bureau of Mines Hempel flask. Amount distilled, 200 cubic centimeters. First drop, 90° C.]

Air distillation, with fractionating column.

Temperature (° C.).	Fractions (per cent by volume).	Total per cent distilled by volume.	Specific gravity.
Up to 100	0.2		
100 to 125	.9	1.1	0.739
125 to 150	2.0	3.1	
150 to 175	2.6	5.7	.763
175 to 200	3.2	8.9	.789
200 to 225	3.9	12.8	.806
225 to 250	5.2	18.0	.822
250 to 275	6.1	24.1	.840
275 to 300	15.1	39.2	.859

Vacuum distillation, without fractionating column; pressure 40 mm.

Temperature (° C.).	Sum per cent of vacuum fractions.	Total per cent distilled by volume.
Up to 175	1.5	40.7
175 to 200	2.5	43.2
200 to 225	3.5	46.7
225 to 250	6.5	53.2
250 to 275	11.0	64.2
275 to 300	17.0	81.0
Residue	23.0	104.0

No wax; much tar. Sulphur, 2.73 per cent.

The oil is of practically the same grade as that produced in the Lander field, where the specific gravity of five samples averages about 0.913, or 23.3° Baumé, and fractional distillation of the same samples yielded an average of 2.1 per cent gasoline distilled below 150° C. and 22.7 per cent kerosene distilled between 150° and 300° C.[1]

The oil from the Embar group in the Maverick Springs region is not so valuable as the oils found in higher formations in other Wyoming fields—for example, the Grass Creek oil, a sample[2] of which had a specific gravity of 0.798, or 45.3° Baumé, and yielded 35 per cent gasoline distilled below 150° C. and 32 per cent kerosene distilled between 150° and 300° C.

DEVELOPMENT.

Developments in the Maverick Springs field have not proceeded far enough to justify a prediction of what it will produce. Though three well-marked domes containing some oil and gas are known,

[1] Woodruff, E. G., The Lander oil field, Fremont County, Wyo.: U. S. Geol. Survey Bull. 452, p. 29, 1911.

[2] Hewett, D. F., and Lupton, C. T., Anticlines in the southern part of the Big Horn Basin, Wyo.: U. S. Geol. Survey Bull. 656, p. 51, 1917.

in only one, the Big dome, have commercial quantities of oil yet been found. Other domes, not well marked and partly concealed by Tertiary deposits, both to the southeast and southwest, may contain oil of a higher grade than the Maverick Springs oil. The field is not yet connected with the railroad by pipe lines.

Big dome.—The first successful well in this field, in the NE. ¼ sec. 22, T. 6 N., R. 2 W. Wind River meridian, was drilled by the Sheridan Oil Co. Probably the coal for firing the boilers was dug along the Mesaverde outcrop a few miles to the southwest and hauled in wagons to the scene of operations. In 1917 this well was reported to have struck oil in a crevice in the Embar rocks at a depth of 1,125 feet and to have had an initial production of about 240 barrels a day.

After this discovery was made the drilling of other wells went on more rapidly, oil from the Sheridan well being used as fuel. A well 1,400 feet deep, drilled by the Carter Co. in sec. 23, is reported to have struck a strong flow of sulphur water at a depth of 150 feet. Indications of oil were found at several horizons in the Chugwater formation, but the first oil sand, from which most of the output comes, is a 17-foot sand in the Embar rocks, about 137 feet below the top of the massive "upper bryozoan" limestone and 1,192 feet from the surface. Although other oil sands were found at greater depth, the drilling was discontinued at 1,400 feet for fear that a strong flow of water might be encountered that would interfere with the production of the oil. The Carter Co. is drilling another well in the SE. ¼ sec. 26, in which it has struck a flow of gas at a depth of 400 feet. The Ohio Co. has two wells in the W. ½ sec. 22 that produce from 10 to 15 barrels of oil a day. In one of these wells the oil sand is about 190 feet below the top of the massive limestone. In September, 1918, the Sheridan Co. had drilled two wells, one in the NW. ¼ sec. 31, T. 6 N., R. 1 W., and one in the SW. ¼ sec. 25, both of which failed to find oil. The well in sec. 31 is reported to have been drilled as far as the Tensleep sandstone, and from it there is a strong flow of sulphur water. The well in sec. 25, said to be 1,600 feet in depth, probably reached the Tensleep sand. It first struck sulphur water and later fresh water, both of which are flowing at the surface. A well drilled by the Northern Petroleum Co. near the west side of sec. 24, T. 6 N., R. 1 W., to a depth of 515 feet, and a well 735 feet deep in the NW. ¼ sec. 6, T. 5 N., R. 1 W., are thought to be too far down on the slope of the dome to be productive.

When the camp was visited, in September, 1918, derricks were erected and wells were being drilled at several localities in the W. ½ sec. 23, T. 6 N., R. 2 W., where it seems evident that oil will be found. From the discoveries that have been made it is the writer's

opinion that the productive wells of the Big dome will be within the area outlined by the 5,600-foot contour on the structure map. The latest report furnished to the writer by Mr. M. S. Durril, of Pavillion, Wyo., owner of the well in the NE. ¼ sec. 22, T. 6 N., R. 2 W., is that on April 2, 1919, nine productive wells had been drilled in secs. 22 and 23, one of which yielded 1,000 barrels a day, and that some of these wells had been pumped for 30 days into earthen tanks without decreasing the rate of production.

Little dome.—The Carter Co.'s well in sec. 15, T. 5 N., R. 1 W., is near the apex of the Little dome. In September, 1918, this well had reached a depth of 1,500 feet, where it had encountered a rather strong flow of gas from the Chugwater formation, which on being ignited destroyed the derrick. Operations could not be resumed before winter set in, but in April, 1919, the well was reported to have reached a depth of 1,950 feet. The depth at which the oil sand would be reached was estimated at about 2,200 feet.

In September, 1918, the Sheridan Co. was also preparing to drill in sec. 10, a short distance away from the center of the dome.

Circle Ridge dome.—The Circle Ridge dome is, in the writer's opinion, the most unpromising of the three domes here described, as it is eroded down to the Embar rocks, is more crushed on its southwest side, and shows the asphalt left behind where some of its oil has escaped. No deep wells have been drilled in this dome, but should future developments in the other domes prove that they contain an exceptional amount of oil, a small number of test wells on this dome will be justified.

INDEX.

A.

Page.

Abram Creek-Stony River coal field, W. Va., Barton coal in, altitude of 99, 100–102
Barton coal in, occurrence and thickness of 97–98
tonnage of 102
coal in, altitude of beds of 99–102
analyses of 87–89
character and quality of 87–91
distribution of 99–102
occurrence of 85
resources of 102
sections of, plate showing 88
thickness and position of beds of 92–98
Davis coal in, altitude of 99, 100–102
occurrence and thickness of 95–96
tonnage of 102
distance of, from market 102–103
Falls coal in, altitude of 99
occurrence and thickness of 95
Little Clarksburg coal in, altitude of 100
location and surface of 85–86
mapping of 86–87
Pittsburgh coal in, altitude of 100
Red Creek coal in, position of 102
Sixfoot coal in, occurrence and thickness of 96–97
sketch map, key map, and columnar sections of 86
structure of 98–99
Thomas coal in, altitude of 99, 100–102
occurrence and thickness of 97
tonnage of 102
Upper Freeport coal in, altitude of 99
Acknowledgments for aid 105, 149–150
Arrow Creek valley, Mont., faults and folds east of 139–140
faults and folds west of 137–139
Asphalt, occurrence of, south of the Rozel Hills, Utah 13

B.

Bea Ogwa Canyon, Wyo., location and name of 63
Bearpaw shale in the Huntley field, Mont. 124
Beaverhead County, Mont., improbability of oil pools in 21–22
Big dome, Fremont County Wyo., cliff on northwest side of, plate showing 157
description of 151
drilling of oil wells on 165–166
structure of 161
Sundance formation on southwest side of, plate showing 157
Big Sand Draw anticline, Wyo., field work on 76
gas flows obtained on 82–83
gas in, composition of 81–82
geography of 75, 76
map and hypothetical cross section of 76
stratigraphy of 76–79
structure of 79–81
surface features of 76
Billings, Mont., log of oil well at 142
section of Eagle sandstone near 119
Black-gum and bald-cypress swamp on the shore of Lake Drummond, plate showing 44
Bowen, C. F., cited 114
Bridger, Mont., section of Morrison formation near 112–113
Broadview dome, Mont., log of well in 143

C.

Calvert, W. R., cited 113
Carter Oil Co.'s well in the Maverick Springs field, Wyo., log of 155–156
Chinle formation, nature of, in the Green River Desert region, Utah 5–6
Chugwater formation, occurrence of, in the Maverick Springs field, Wyo 157
plate showing 64
section of, near Thermopolis, Wyo 66
upfolded edges of, plate showing 156
Circle Ridge dome, Maverick Springs field, Wyo., description of 152
oil in, evidence of 166
structure of 161
Claggett formation, occurrence of, in the Huntley field, Mont 119–121, 135, 136, 138, 139
Cloverly, Wyo., section of Morrison formation near 112

Page.

Cloverly formation, occurrence of, in the Maverick Springs field, Wyo---- 158
Cody shale, occurrence of, in the Maverick Springs field, Wyo---------- 160
Colorado shale in the Huntley field, Mont ---------- 115–117
oil sands in, in Wyoming---- 141–144
Condit, D. Dale, acknowledgment to---------- 150
Conglomerate capping a ridge in the Huntley field, Mont--- 128
Cooper, H. M., analyses by---------- 49
Cottonwood anticline. *See* Hamilton dome.

D.

Dakota sandstone, nature and distribution of, in the Farnham anticline, Utah-- 1, 2
Dall, W. H., fossils determined by-- 79
Darton, N. H., cited---------- 112, 115
Deformation, forces producing----- 130
Dillon-Dell area, Mont., generalized section of ---------- 20–21
geology of---------- 20–21
improbability of oil pools in--- 21–22
map of---------- 20
phosphatic oil shale in, commercial value of-------- 34–35
Dirty Ninefoot coal bed, position of- 98
Dismal Swamp, Va.-N. C., flora of-- 42–44
geography of---------- 41
geology of---------- 41–42
peat-forming plant associations in, plates showing---- 44
peat in, distribution of-------- 46–49
distribution of, map showing---------- 42
Driggs, Idaho, section in coal tunnel west of---------- 32

E.

Eagle sandstone in the Huntley field, Mont---------- 118–119
in the Huntley field, Mont., plates showing----- 118, 119
Embar group, occurrence of, in the Maverick Springs field, Wyo ---------- 154–156
plate showing---------- 64
section of, near Thermopolis, Wyo ---------- 66–67
north of Maverick Springs, Wyo ---------- 155
Emery, W. B., cited---------- 112–113
Erickson, E. T., work of---------- 16

F.

Farnham anticline, Utah, Cretaceous formations in -------- 1–3
faults in---------- 7–8
geography of---------- 1, 7
geologic map of---------- 2

Page.

Farnham anticline, locations suggested for test drilling in---------- 8–9
oil and gas in, possibility of---- 9–10
stratigraphy of---------- 1–7
structure of---------- 7–9
terrace on, in Cat Canyon------ 7
Farnham fault, plate showing------ 8
"Flat tops" near Yellowstone River, Mont., occurrence and origin of---------- 128
Flaxville gravel, occurrence and age of---------- 128–129
Fort Union formation in the Huntley field, Mont--------- 126–128
Fossil, Wyo., section near--------- 33
Fossils, occurrence of---- 119, 120, 128, 159
Frontier formation, occurrence of, in the Maverick Springs field, Wyo ---------- 159
oil and gas in, in Wyoming---- 77

G.

Gas, natural, accumulation of, anticlinal theory of----- 144–146
natural, possibility of, in the Farnham anticline, Utah---------- 9–10
prospecting for, in Utah--- 10–13
Grant County, W. Va., position of coal beds in-------- 100–102
Great Salt Lake, prospecting for oil and gas near--------- 12–13
Green River, Utah, prospecting for oil and gas near------ 11
Green River Desert, Utah, formations exposed in---------- 3–7
thickening of formations north and south from------- 7

H.

Haanel, E., cited---------- 56
Hailstone Basin, Mont., log of oil well in---------- 143
Hamilton dome, near Thermopolis, Wyo., field work on--- 64
geography and structure of---- 63, 69
location of---------- 62
oil in, character of---------- 70–71
development of---------- 72–73
source of---------- 69–70
stratigraphy of---------- 64–66
structure contour map of------ 70
Hares, C. J., cited---------- 117
Hewett, D. F., cited--------- 111–112, 114
Hoskins Basin, Mont., section in the Lance formation near- 125
Huntley, Mont., faults and folds near ---------- 135–137
Huntley field, Mont., Bearpaw shale in---------- 124
Claggett formation in-------- 119–121, 135, 136, 138, 139
Cloverly formation in and near- 113–115

Page.

Huntley field, Colorado shale in 115–117
Cretaceous formations in 111–124
drainage of 108
Eagle sandstone in 118–119
faults in 134–135
field work in 105–106, 106–107
folds in 134
Fort Union formation in 126–128
geologic map of In pocket.
geology of 109–140
Judith River formation in 121–124, 135–140
Kootenai formation in 113–115
Lance formation in 124–126
location of 105
mapping of 107–108
Miocene (?) or Pliocene (?) sandstones and gravels in 128–129
Montana group in 117–124
Morrison formation near 111–113
oil and gas in, possibilities of 140–148
surface indications of 144
Pleistocene (?) deposits in 129
proximity of, to fields producing oil and gas 140–141
Quaternary formations in 129
Recent deposits in 129
section of 109–111
stratigraphy of 109–129
compared to that of neighboring fields producing oil and gas 141–144
structure of 130–140
features of, favorable to the accumulation of oil and gas 146–148
Tertiary formations in 126–129
topography of 108
uplifts, major and minor, of the region 131–132

J.

Juab Valley, Utah, prospecting for oil and gas in 12
Judith River formation in the Huntley field, Mont 121–124, 135–140

K.

Knowlton, F. H., fossils determined by 78
Kootenai formation in the Huntley field, Mont 113–115

L.

Lake Basin field, Wyo.-Mont., oil sands in 141–144
Lance formation in the Huntley field, Mont 124–126
Lebo shale member of the Fort Union formation, composition of, in the Huntley field, Mont 126–127
Leslie Co., oil wells drilled by, near Thermopolis, Wyo 71–72

Page.

Lignite, oil and gas from 27, 37
Little dome, Maverick Springs field, Wyo., description of 151
drilling for oil on 166
structure of 161–162
Logan, Mont., geologic section near 19

M.

McElmo formation, nature and distribution of, in the Farnham anticline, Utah 1, 2
structure and character of, in the Farnham anticline, Utah, plate showing 8
Mancos shale, nature and distribution of, in the Farnham anticline, Utah 1–2
Mansfield, W. C., fossils determined by 50
Map, geologic, of the Farnham anticline, Utah 2
geologic, of the Huntley field, Mont In pocket.
of southwestern Montana and parts of Idaho and Wyoming 20
of the Big Sand Draw anticline, Wyo 76
structure contour, of the Hamilton domes, near Thermopolis, Wyo 70
of the Warm Springs domes, near Thermopolis, Wyo 68
Maverick Springs field, Wyo., artesian water in 163
development in 149
field work in 150
formations in, descriptions of 153–160
general section of 152–153
geography of 150–152
location of 149
oil in, development of 164–166
source and composition of 163–164
possible dome structures in 162
stratigraphy of 152–160
structure of 160–162
topographic and structure map and cross sections of In pocket.
Mesaverde formation, exposure of, on the Big Sand Draw anticline, Wyo 78
Mineral County, W. Va., position of coal beds in 99–100
Miocene (?) sandstone and gravels in the Huntley field, Mont 128–129
Moenkopi formation, nature of, in the Green River Desert region, Utah 6
Monarch Oil & Gas Co.'s well at Billings, Mont., log of 142

Page.

Montana, south-central, stratigraphic sections in ..... In pocket.
west-central, generalized section in 16
oil shale in 15, 16–20
Montana group in the Huntley field, Mont 117–124
Morrison formation, occurrence of, in the Maverick Springs field, Wyo 158
on side of Big dome, Fremont County, Wyo., plate showing 157
Mowry shale, occurrence of, in the Maverick Springs field, Wyo 159
Muddy Creek, Mont., oil shale on 26–27

N.

Navajo sandstone, nature of, in the Green River Desert region, Utah 5
North Carolina, peat in, test borings for 48–49

O.

Ohio Co.'s well in the Maverick Springs field, Wyo., log of 156
Oil. *See* Petroleum.
Oil shale, occurrence of, in Montana, Idaho, Wyoming, and Utah 15–34
Otey dome, Wyo., drilling for oil on 73

P.

Peat, ammonium sulphate from 58–59
"black-gum," nature and composition of 49–50
fertilizer from 52–54
fuel blocks of, spread for air drying, plate showing 50
fuel from, preparation of 56–58
value of 54–56
gas from 58
in Dismal Swamp, Va.-N.C., map showing distribution of 42
origin of 42, 44–46
test borings for 47–48
"juniper," nature and composition of 49–50
"marl" underlying, in the Dismal Swamp, Va.-N. C 50
plant association forming, plates showing 44
planting on 51–52
uses of 50–59
wheat grown on, plate showing 50
Pennsylvanian (?) sandstone, nature of, in the Green River Desert region, Utah 6
Petroleum, accumulation of, anticlinal theory of 144–146

Page.

Petroleum, from shale, cost of distilling 39–40
process of distilling 37–39
occurrence of, near Thermopolis, Wyo 61–73
possibility of, in the Farnham anticline, Utah 9–10
prospecting for, in Utah 10–13
Phosphate rock, analyses of 36
processes for making fertilizers from 36
Phosphoria formation in southeastern Idaho, low content of oil in 29, 31
in southwestern Montana, nature and distribution of 20–21
oil shale in, properties of 22
sampling and yield of 23–26
Plants, peat-forming, in the Dismal Swamp, Va.-N. C 42–44
Pleistocene (?) deposits in the Huntley field, Mont 129
Pliocene (?) sandstones and gravels in the Huntley field, Mont 128–129
Pompeys Pillar, Mont., plate showing 128
Producers & Refiners Corporation, operations of 76, 81, 82–83

Q.

Quadrant formation, sampling of oil shale in 17–18
Quaternary formations in the Huntley field, Mont 129

R.

Recent deposits in the Huntley field, Mont 129
Red Springs anticline, Wyo., drilling for oil in 73
Ross Peak, Mont., geologic section on 19

S.

Salkover, Benedict, work of 16
San Juan field, Utah, oil in 10–11
San Rafael Swell, Utah, prospecting for oil and gas in 11–12
San Pete Valley, Utah, prospecting for oil in 12
Sands, oil-bearing, in Wyoming 141–144
Sections, stratigraphic, in north-central Wyoming and south-central Montana ..... In pocket.
79 Oil Co.'s drill hole No. 1, Huntley field, Mont., log of 143
Shale, extraction of oil from 34
Shales, Tertiary, oil content of 37
Shinarump conglomerate, nature of, in the Green River Desert region, Utah 6

Page.

Shoshone River, Wyo., section of Morrison formation on ---------- 111–112
Stanton, T. W., fossils determined by ---------- 159
Steele, Niobrara, and Carlile shales, gas in, on the Big Sand Draw anticline, Wyo-- 77
Structure, features of, methods of mapping ---------- 133–134
Sundance formation, occurrence of, in the Maverick Springs field, Wyo-- 157–158
plate showing---------- 64
uptilted limestone member of, plate showing-------- 157

T.

Tensleep sandstone, occurrence of, in the Maverick Springs field, Wyo---- 154
Tertiary formations in the Huntley field, Mont--------- 124–129
Tertiary shale beds in the Dillon-Dell area, Mont., extent and character of ---------- 26–27
yield of oil, phosphorus, and nitrogen from-------- 28
Thermopolis, Wyo., logs of three wells near, plate showing ---------- 66
section of formations near, plate showing-------- 66
Thermopolis anticline, Wyo., location of---------- 61
Thermopolis shale, occurrence of, in the Maverick Springs field, Wyo--------- 158–159
Threeforks formation, sampling of oil shale in---------- 18–20
Todilto (?) formation, nature of, in the Green River Desert region, Utah--------- 5

Page.

U.

Uplifts, major and minor, relation of, to structure of the Huntley field, Mont-- 131–132

V.

Van Hise, C. R., cited---------- 55
Virgin River field, Utah, prospecting for oil and gas in- 12
Virginia, peat in, test borings for-- 47–48

W.

Warm Springs domes, near Thermopolis, Wyo., dry wells near ---------- 73
field work on---------- 64
geography of---------- 63, 68–69
location of---------- 62
oil in, character of---------- 70
development of---------- 71–72
source of---------- 70
stratigraphy of---------- 64–66
structure of---------- 63, 68–69
plate showing---------- 64
structure contour map of------ 68
Wells, R. C., work of---------- 16
White River formation, nature of, on the Big Sand Draw anticline, Wyo------- 79
Winchester, D. E., acknowledgment to---------- 37
Wind River formation, deposition of, on the Big Sand Draw anticline, Wyo------- 78–79
Wingate sandstone, nature of, in the Green River Desert region, Utah--------- 5
Wyoming, north-central, stratigraphic sections in------- In pocket.
southwestern, yield of oil-shale samples from -------- 32

O