Charles M Rath

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The Basin and Greybull Oil and Gas Fields

Bighorn County, Wyoming

By F. F. HINTZE, Jr.

1914

L. W. TRUMBULL, STATE GEOLOGIST

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INTRODUCTION

EARLY DEVELOPMENTS

The occurrence of oil and natural gas at various localities in the Bighorn Basin has been known for several years. Reconnaissance surveys have been made by the U. S. Geological Survey to ascertain the general geological facts connected with these occurrences, of which those by Mr. C. A. Fisher* and Mr. C. W. Washburne† are of the most importance. Mr. Fisher reports that gas had been discovered in a well that was being dug for that purpose a short distance east of Basin, Wyoming‡. Oil had been known to exist near Bonanza for a long time previously, but all attempts to get commercial quantities had failed. In the vicinity of Byron, Wyoming, natural gas was escaping from alluvial sands at a point near the center of an anticline in the low valley of the Shoshone River, and plans had been perfected for sinking a deep well to ascertain details as to amount and depth, etc. Up to this time (1906) success had not attended the drillings for oil and gas, but it is now known that the early locations were poorly made, and later

*C. A. Fisher, Geol. and Water Res. of the Bighorn Basin, Wyo., U. S. Geol. Surv., Prof. Paper 53, 1906.

†C. W. Washburne, Gas Fields of Bighorn Basin, Wyo. Bulletin 340, pp. 348-363, 1908.

‡Op. cit. p. 59.

attempts have been more encouraging. Mr. Washburne reports the existence of nine anticlines that may be considered as favorable to gas or oil accumulation.* These are all located along the western flank of the Bighorn Mountains in Wyoming and its northwestern continuation into Montana.

The first of these structures to be successfully tested by deep boring is known as the Peay Hill anticline and is situated a short distance southeast of Greybull, Wyoming, at the junction of the Bighorn and Greybull Rivers. In July, 1907, the Peay Hill Oil & Development Co. obtained a high pressure gas well on the east bank of the Bighorn River, in Sec. 21, T. 52 N., R. 93 W., which, from its ability to maintain a strong, steady flow of gas for months without visible signs of diminution was the first good proof of the existence of appreciable quantities of gas, and possibly also oil, in these anticlinals.

PRESENT CONDITIONS IN THE BIGHORN BASIN

Since the drilling of the first successful well near Greybull, others have been put down both near it and at widely separated places in the basin, wherever favorable structures have been found, and development work is continuing in the most likely areas. The past year has seen the greatest activity in drilling, the climax having come in the spring of the year following the announcement in the press of the successful operations for oil and gas in the Basin field. A decided check, however, was put upon prospecting in the various fields through the withdrawal of much of the best oil and gas land from entry on the part of the federal government at Washington. The land entered previous to the withdrawal has been vigorously prospected, and many tracts, privately owned, have been leased or acquired by purchase for the purpose of drilling for oil and gas. Interest has been so keen that the state geologist, Mr. L. W. Trumbull, felt impelled to order a survey made of the Basin and Greybull field which includes several productive dome

*Op. cit. p. 352.


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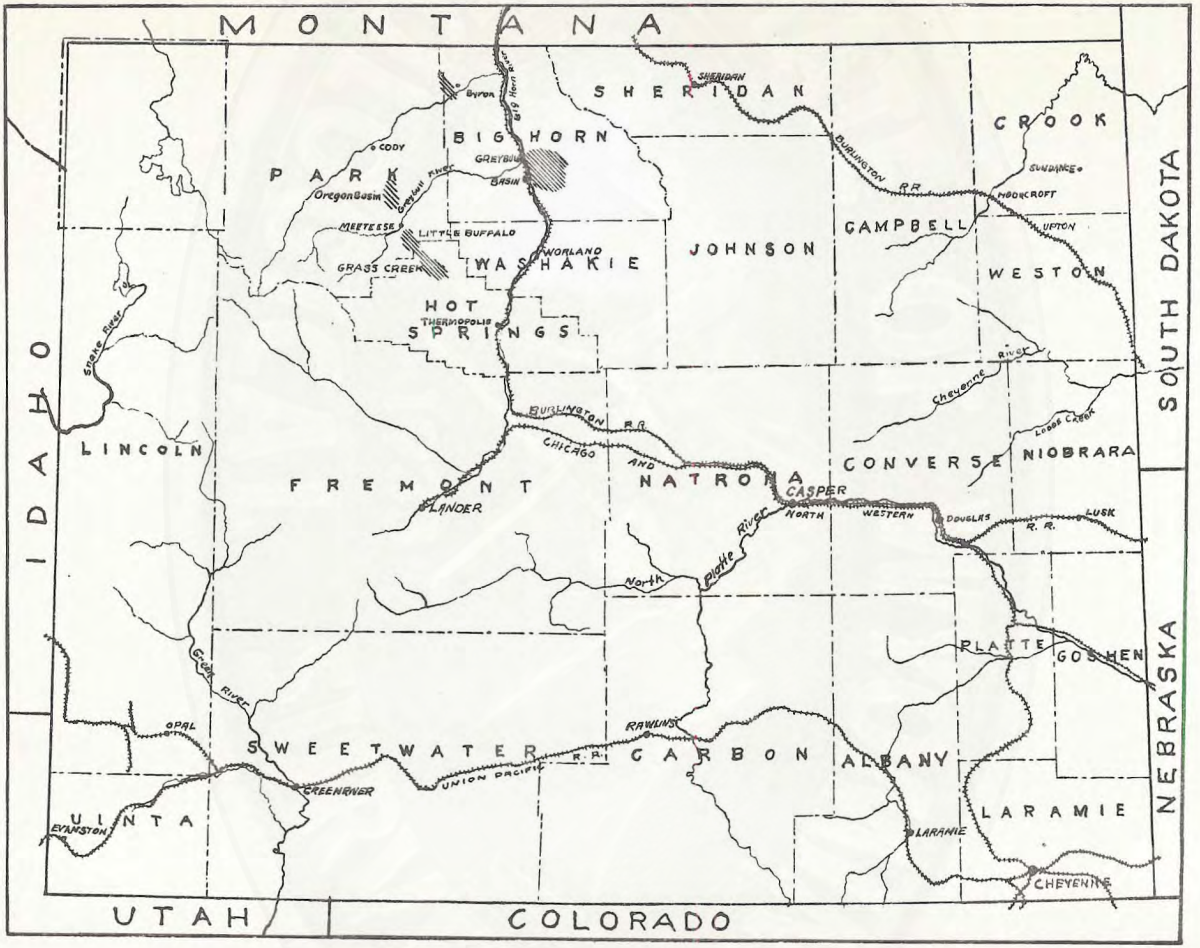
PLATE I.


MONTANA
SHERIDAN
CROOK
BIG HORN
PARK
JOHNSON
CAMPBELL
WESTON
HOT SPRINGS
LINCOLN
FREMONT
NATRONA
CONVERSE
NIOBRARA
PLATTE
GOSHEN
SWEETWATER
CARBON
ALBANY
LARAMIE
UINTA
IDAHO
SOUTH DAKOTA
NEBRASKA
UTAH
COLORADO
Byron
Cody
Greybull
Basin
Meeteese
Little Buffalo
Grass Creek
Worland
Thermopolis
Snake River
Lander
Casper
Rawlins
Green River
Evanston
Opal
Laramie
Cheyenne
Sheridan
Sundance
Upton
Douglas
Lusk
Burlington R.R.
Chicago and North Western R.R.
Union Pacific R.R.
North Platte River
Green River
Big Horn River
Cheyenne River
Lodge Creek

structures, and of the Little Buffalo and Grass Creek anticlines on the west side of the Bighorn Basin, where considerable success has attended the drilling from the very beginning. The field work was done during the last summer, and the present report is based on observations made during June and July by the author and his associates. The report on the Little Buffalo and Grass Creek domes will appear separately. The location of these fields is shown on the accompanying outline map.

ACKNOWLEDGMENTS

The writer was assisted in the field by Mr. H. L. Kennedy who acted in the capacity of instrument man, and to whom is due the credit for making plane table traverses and supplying topographic details used in the construction of the maps. He was assisted in this work by Mr. W. F. Hadsall, Mr. Gerald Coons, and Mr. Walter Storrie. To all of these men the author is greatly indebted for their conscientious work during the whole season. Thanks are due to Mr. Homer T. Lamb for supplying several well records and for the privilege accorded to the writer of examining the maps of the Bighorn Oil and Gas Company, and of the Greybull Oil Company, and of obtaining from them data concerning the location of the claims and the wells of these companies. To Mr. Atherly, of the firm of Nowell-Atherly Company, Engineers, Basin, Wyoming, the author is indebted for the use of his map of the Basin and Greybull Oil Field, showing the local land subdivisions and a number of the claims and wells of different development companies. To Mr. W. L. Walker, Geologist, Basin, Wyoming, thanks are due for data relating to certain wells of the Fullerton Oil Company, and for personal interviews and discussions concerning special problems of the Basin and Greybull field. Finally, the author wishes to express his appreciation of the interest in the work shown by the State Geologist, Mr. L. W. Trumbull, under whose direction the field work and preparation of this report have been undertaken.

METHOD OF FIELD WORK

The mapping was done with a Gurley plane table and telescopic alidade. The base map used in the field was drawn to a scale of two inches to the mile. Township, section, and quarter section lines were drawn in accordance with the most recent land survey, the original subdivisions of lots, especially along Bighorn River, being neglected. Roads, streams, bridges, etc., were sketched on as accurately as possible from information obtained in the county clerk's office, and from Mr. Atherly's map. A preliminary system of triangulation was established covering the southern half of the area to be mapped which served the two-fold purpose of horizontal and vertical control, original elevations being taken from bench marks of the U. S. Geological Survey, at Basin and along the Hyattville road. The base line from which the triangulation stations were laid out was measured with a steel tape and consisted of a line 7,600 ft. long measured along the level ground from the northwest corner of the N. W. ¼ of Section 22, T. 51 N., R. 93 W., north to the northeast corner of the N. E. ¼ of the S. W. ¼ of Section 10, of the same township. From the two points at the opposite ends of this base line sights were taken and lines were drawn on the plane table sheet to flags that were set on the prominent points along the bad-land hill to the eastward. Checks were taken frequently on land corners where they could be found to test the accuracy of the original land-net drawn on the base map. From the first set of points thus determined, others were established until a sufficient number had been located to enable the plane-tableman to use at least three known points for orientation purposes at any point in the field.

Traverse lines were run out along formation boundaries with the use of the plane table and telescopic alidade, and the location of all the wells in the field was made with the plane table. Profile lines were run with a light mountain transit, frequent ties being made to section and quarter-section corners. The transit was also used for differential leveling to obtain the elevation of all of the wells, care being taken to make the fore- and back-sights of about equal


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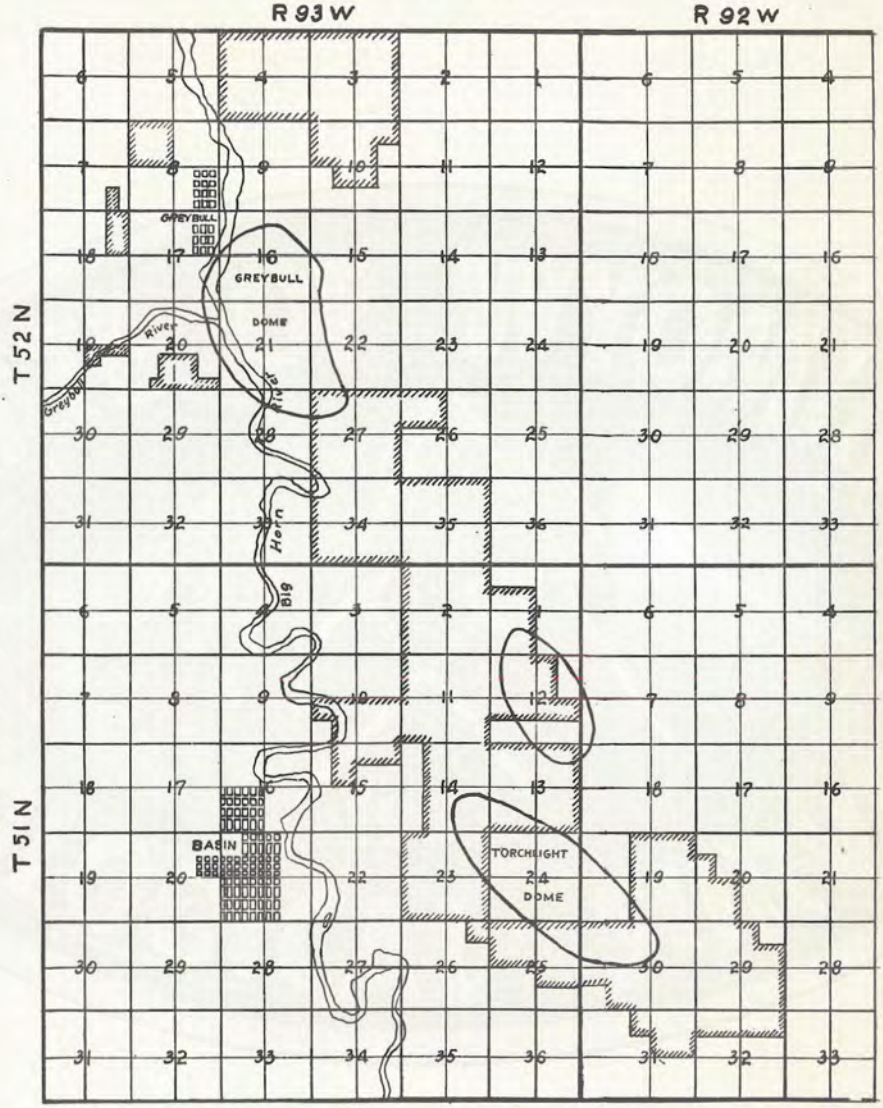
PLATE II.



Lands Withdrawn by the Federal Government for Oil and Gas

lengths to avoid error. Frequent dip and strike determinations were made by means of a Brunton clinometer and compass, but satisfactory outcrops were often difficult to obtain without excavating considerable soil or talus. Fossils were collected from as many points over the field as possible, the more important fossil-bed outcrops being located by plane table traverses, with elevations for each point given. A reconnaissance of the whole area showed the most complete sections of the Cretaceous strata to be located immediately to the north of the oil and gas fields, along Shell Creek. Several sections were carefully measured by running profiles with the transit and stadia directly across the strike of the beds, beginning at the top of the Cloverly, a well-defined horizon, dips being taken at as many points as possible. From the data thus gathered the thickness of the different sandstone and shale members was calculated. Careful observations were made on the lithologic characters of the different strata, so that they could be recognized when encountered in the area to be mapped, or when reported in the logs of wells, thus furnishing a valuable means of interpreting well records. Unfortunately the latter have not been freely given out by the different companies doing development work in this field, but in those submitted there is no difficulty in the matter of interpretation. Finally, after all traverse lines had been run on the various known formation boundaries and the stations along them were plotted on the map with their respective elevations, the same being done in the case of section lines, structure contour calculations were made for each station and eventually the contour lines were drawn.

LOCATION AND EXTENT OF FIELDS

The productive areas of the Basin and Greybull oil and gas fields comprise but a few square miles situated in townships 51 and 52 N., and ranges 92 and 93 W. Three anticlines, all relatively small, have been found to contain gas and oil in commercial quantity. The most southerly of these, the Torchlight dome, is located about three miles east of Basin. The most northerly one occurs just southeast

of the little town of Greybull, and is commonly known as the Peay Hill dome. The third one, usually referred to as the Lamb anticline, is smaller than the other two and lies between them but nearer to the Torchlight dome. Their locations are shown on the accompanying township map.

GEOLOGY

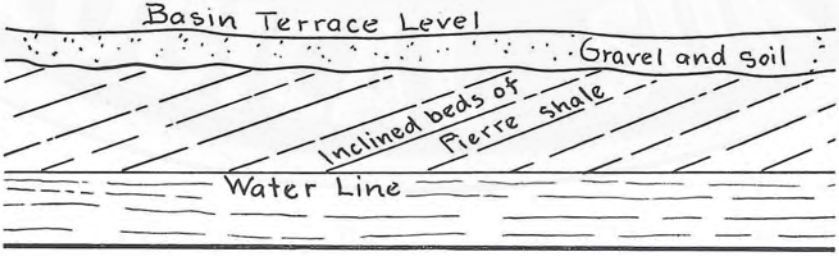
PHYSIOGRAPHIC RELATIONS

The area is situated on the western flank of the Bighorn Mountain uplift, and on the eastern edge of a broad structural valley, the Bighorn Basin. Locally, along the margin of this valley, the simple basin structure is complicated by minor folds which are generally of very gentle curvature, but in a few instances pronounced anticlines and synclines have been formed. One of the largest of these is Sheep Mountain, just north of the Basin and Greybull oil and gas field. Most of the large domes have been deeply dissected so that they expose in their central parts rocks of Paleozoic age, surrounded by those belonging to the later systems.

There is evidence in the broad terraced valley of the Bighorn River of rather long periods of erosion during which the river has developed several times a nearly smooth floor through the processes of planation. They might be regarded as partial peneplains, for the upturned edges of the different formations are beveled off in a very pronounced manner. There are many of these "peneplain" levels recognizable on the sides of the present valley of the Bighorn River, giving the appearance of ordinary river terraces, but evidently formed in a different way, by partial planation of the valley floor to successively lower levels. It is clear that at some past time the Bighorn River had a much broader valley floor upon which it meandered than the present one. During more recent time the river has been rejuvenated, and has lowered its meander plain more rapidly, producing a narrow valley bottom. Tributary streams have likewise been rejuvenated, though on account of the arid climate these are few in number. Torrential rains have

PLATE III.

"Terrace" of Pierre Shale covered with thin layer of soil and gravel. Bank of Bighorn River just north of bridge at Basin

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been the means of developing rather extensive bad-lands in many parts of the basin where the surface rocks are soft sandstones and shales. This is especially true just east of Basin, where the soft mud-shales of the Cretaceous period are dissected into typical bad-lands.

TOPOGRAPHY

Topographically the area falls into three parts: (1) The valley of the Bighorn River, including the lower terrace levels, on the west, (2) the bad-lands which occupy the greater part of the area southeast of Greybull and east of Basin, and (3) a broad structural valley north of the bad-lands, in the northeastern part of the area. The highest point is in the northeast corner of the southeast quarter of Section 25, T. 52 N., R. 93 W., where the elevation is 4825 ft. above sea level. The valley floor ranges from 3895, in the southern portion, to 3770 in the northern. The bad-lands range from 4100 to the maximum given above, most of the higher hills rising but slightly above an elevation of 4600 feet.

A noticeable feature of the larger hills facing the Bighorn River is the presence of distinct terrace levels considerably above the present river level. Many of these constitute level stretches of very slightly dissected, and in places gravel-covered surfaces, which suggest their origin, stream planation. These gravels have been observed at as great an elevation as 4550, capping some of the bad-land hills, notably in the northern part of Sec. 11, T. 51 N., R. 93 W. Some of the lower terraces, but little above the present level of the river are covered with thin layers of soil or gravel, and on the west side of the Bighorn these level stretches have been utilized for farming. The townsite of Basin is located on such a terrace. (See Plate 3.)

To the east and southeast of the town of Greybull, the surface rock is composed of a rather resistant sandstone which has withstood erosion considerably better than the soft shales that occur above and below it so that it has weathered into relief. The dome structure of the Peay Hill anticline, as it is called, is shown by the surface contours

of this sandstone, except to the north where the Bighorn River has slightly truncated the down-folded layers. The east bank of the river at this place is a cliff of from 40 to 60 feet in height, capped by the hard sandstone.

The dome structure two miles east of Basin, is exposed in a wash that cuts directly across it in a north-south direction. Small tributaries to this wash have been developed on some of the weaker layers of shale. These subsequents curve with the dome structure and appear as a number of roughly concentric stream channels that lead around the dome from the east and the west, half on the north side of the dome, and half on the south, to the main wash which has a central position and cuts directly across the dome, as above stated. The harder layers show themselves on the intervening ridges which, invariably cuesta-like, have a steep slope toward the center of the dome and a more gentle back slope in the opposite direction. Thus the topography is closely related to the structure and though the soft shales, and even the more resistant members, give but poor exposures on which to measure dip and strike, the dome structure can often be inferred from a consideration of the topography. This is true in all of the larger anticlines and domes, but some were found to be so gentle that they seem to have no expression in the topographic forms developed on them.

STRATIGRAPHY

INTRODUCTION

The formations of greatest importance to those engaged in drilling in the Basin and Greybull oil and gas fields are of Lower and Upper Cretaceous age. The lowest productive horizon is the Cloverly (locally called the Dakota, or Greybull sand), but important occurrences of oil and gas have been found in the Benton. Formations of the Colorado and Montana groups are widely distributed on the surface where the wells are located and immediately adjacent to the productive areas. A knowledge of their thickness and lithologic character is, therefore, of the utmost importance to those engaged in development work.

The oldest of these formations is exposed on Shell Creek along the northern margin of the area studied, where folding was very pronounced, bringing up the lower beds in dome and anticlinal structures. Many of these have been deeply dissected whereby the older formations have become exposed. Chief among these eroded anticlinals is that of Sheep Mountain which is deeply incised through the central part by the Bighorn River, and at its southern end is truncated by Shell Creek. Here the Cloverly as well as the older Morrison and Sundance formations may be seen, and farther out on the flanks of the fold lie the dark shales of the Colorado group. These occupy the surface for eight or ten miles to the south, including the area of the oil and gas fields, and at the southern limits of the area are overlain by the Pierre and later Montana formations. The succession of beds thus displayed together with their thickness and chief characteristics is given in the following table of formations:

TABLE OF FORMATIONS

SYSTEM	GROUP	STAGE OR FORMATION	THICKNESS IN FEET	CHARACTERISTICS
Lower Eocene		Fort Union	1000 to 2000	Massive sandstone and dark-colored shale, with coal.
Upper Cretaceous		Ilo	150 to 700	Massive sandstone with some shale, also coal-bearing.
	Montana	Undifferentiated Montana	850 to 1000	Dark-colored shales and massive buff and brown sandstone.
		Eagle sandstone	400	Massive fresh and brackish water sandstones and shales, coal-bearing
		Pierre shale	1600 to 1800	Alternating light and dark marine shales, lighter colored beds often sandy. Lower third fossiliferous.
	Colorado	Basin shale	900 to 1000	Marine shales, dark-colored, weathering into bad-land forms, containing calcareous concretions and many fossils in upper half. Large brown sandy concretions at base, highly fossiliferous.
		– DISCONFORMITY– Torchlight sandstone.	20 to 30	Light gray, often white, saccharoidal sandstone, often strongly cross-bedded. Always capped by a layer of black and gray pebbles, poorly cemented together.
		Upper Benton shale	350 to 400	Black adobe shale and sandy shales, and Bentonite.
		– DISCONFORMITY– Peay sandstone	150 to 200	Light gray and light brown sandstone, with large sandy concretions in central part. Top layer conglomeratic.

TABLE OF FORMATIONS—Concluded

SYSTEM	GROUP	STAGE OR FORMATION	THICKNESS IN FEET	CHARACTERISTICS
Upper Cretaceous	Colorado	Lower Benton shale	850 to 900	Hard blue sandy shale (Mowry) near the top, underlain by black adobe shale and thin layers of Bentonite. White saccharoidal sandstone 25 to 40 ft. thick near the central part. Lower 75 to 125 ft. light brown and yellow sandy shale, the "Rusty Beds."
		—DISCONFORMITY—		
Lower Cretaceous		Cloverly	75 to 125	Bright-colored clays and argillaceous sandstones, with massive sandstones at the top and bottom. Upper layer sometimes wanting.
Lower Cretaceous or (?) Jurassic		Morrison	250 to 350	Bright variegated, terrestrial, clays and soft sandstones.

*The formations above the Eagle sandstone together with their thicknesses, characteristics, and ages are given here as reported by Mr. C. W. Washburne, Bull. 341, Pt. II, 1909, p. 167, U. S. Geol. Surv., and by Mr. C. A. Fisher, Econ. Geol., Vol. 3, 1908, pp. 77-79, except that the term Ilo(?) has been used in place of Laramie (?) as suggested by Mr. T. W. Stanton, and Undifferentiated Montana has been substituted for Bearpaw, Judith River and Claggett, which formations have not been definitely recognized so far south of the Montana-Wyoming line. The age of the Cloverly is also taken as that given by Fisher and others.

Description of Formations

Jurassic(?) or Lower Cretaceous System

Morrison Formation. On the north side of Shell Creek, at the southern end of Sheep Mountain may be seen the bright-colored shales and soft sandstones of the Morrison formation in an outcrop of roughly elliptical form passing around the base of the mountain. Various shades of blue and purple, with some red and white colored bands, serve to call immediate attention to the Morrison. It rests on the Sundance formation, of Jurassic age, with apparent conformity, though there is a very distinct lithologic change which makes the dividing line sharp and easy to draw. The age of the Morrison has been a question of dispute for many years, and though considerable investigation has been made of its distribution and fossil content with a view of determining its exact age, there is still a difference of opinion among the different men who have worked on the problem. It is now held to be of very late Jurassic, or early Lower Cretaceous (Comanchean) age. The thickness of the formation on Shell Creek is but little more than 100 feet. It is not known to carry oil or gas in this region.

Lower Cretaceous System

Cloverly Formation. Overlying the Morrison shales in the Shell Creek section at the northern margin of the district, may be seen the ridge-making sandstones of the Cloverly formation. A striking feature of the outcrop is the almost universal occurrence of pine trees and other vegetation which is conspicuously lacking on the bare surfaces of the underlying and overlying formations. The Cloverly consists of sandy shales and clays, often bright-colored, tan, maroon, or purple, lying between two sandstone members, in typical sections. It is to be noted, however, that the upper one of the sandstones is often wanting, and in such sections the outcrop is apt to be less conspicuous. This condition is noticeable on the south side of Shell

Creek three miles east of the Sheep Mountain section above referred to, where the "Rusty Beds" of the lower part of the Colorado rest directly upon the variegated shales and clays of the central part of the Cloverly. The absence of the upper sandstone may be due to nondeposition or to erosion previous to the deposition of the Colorado sediments. The constancy of the Rusty Beds in their occurrences at widely separated places is favorable to the view that they are basal members of the overlying marine Cretaceous. This view is further strengthened by the finding of waterworn pebbles of Paleozoic rocks along the outcrop in such a position as to indicate that they came from a bed of conglomerate in place. Whether this be true, or not, observation proves that the Cloverly varies in its character from place to place, sometimes showing a well developed sandstone member as the highest layer, and at other times this is absent. If this upper sandstone represents the Dakota sandstone, which it closely resembles, it was most likely desposited as a continuous layer over the whole area, and may have been removed by erosion, as suggested by Washburne.* Again, if the Cloverly is altogether of Lower Cretaceous (Kootenai) age, as worked out by Fisher,† more time would be given for the erosion interval, and the upper sandstone member might have been removed over certain areas and left unchanged at others before the deposition of the Rusty Beds.

The thickness of the Cloverly beds as measured on Shell Creek about two miles above the junction of the creek with the Bighorn River is 105 feet. At the next exposure, about three miles up the creek, it is absent. From a comparison of carefully measured sections with the well records obtained, it is the belief of the writer that the "Greybull" sand of the drillers is the upper sandstone of the Cloverly formation. The absence of this member at certain places where it was expected to be found by drilling explains the absence of oil and gas at those places in those instances

*Op. cit. p. 350.

†C. A. Fisher, Southern Extension of the Kootenai etc., Econ. Geol., Vol. III, 1908, pp. 77-79.

where the holes were properly located. The well records show further that the depth from the top of the Peay sandstone* to the oil and gas horizon is very constant, which throws doubt on the occurrence of the oil and gas in "stray sands", and lends weight to the view that the productive stratum lies immediately below the Rusty Beds.

Upper Cretaceous System

COLORADO GROUP

The formations to be described under the group name Colorado have been mapped and discussed by Fisher in his report on the geology of the Bighorn Basin as belonging to the Colorado and Montana groups, the division line having been drawn at the top of the formation here called the Peay sandstone, and in Washburne's report on the gas fields of the Bighorn Basin referred to as the "A" sandstone. Fisher's Pierre formation was regarded by Washburne as belonging to the Colorado group and was accordingly mapped as the "Upper part of the Colorado formation". The "Lower part of the Colorado formation" according to Washburne was the same as the "Colorado formation" of Fisher. Thus the top of the Peay sandstone was taken as a formation boundary by both of these authors, in the one case dividing the Colorado from the Montana, and in the other separating the "Upper" from the "Lower" Colorado.

The writer agrees with Messrs. Washburne and Fisher on the lower boundary of the Colorado but has found it necessary to make new divisions of the Colorado group of formations as well as to shift the dividing line between the Colorado and Montana groups. The following table serves to show the relation of these newly established boundaries to those previously drawn:

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*The sandstone member referred to in this report as the Peay sandstone is the same as that called the "A" sandstone by Washburne.

COMPARATIVE TABLE OF FORMATIONS

<table>
<tr><th></th><th></th><th colspan="2">THIS REPORT</th><th>FISHER 1905</th><th>WASHBURNE 1909</th></tr>
<tr><th>SYSTEM</th><th>GROUP</th><th colspan="2">FORMATIONS</th><th>FORMATIONS</th><th>FORMATIONS</th></tr>
<tr><td rowspan="8">Upper Cretaceous</td><td rowspan="4">Montana</td><td colspan="2">Ilo</td><td rowspan="3">Laramie and associated formations</td><td>Laramie (?)</td></tr>
<tr><td colspan="2">Undifferentiated Montana</td><td rowspan="2">Bearpaw
Judith River
Claggett
Eagle</td></tr>
<tr><td rowspan="2">Pierre</td><td>Eagle</td></tr>
<tr><td>Pierre</td><td rowspan="2">Pierre</td><td rowspan="2">Upper Colorado</td></tr>
<tr><td rowspan="3">Colorado</td><td>Niobrara</td><td>Basin
DISCONFORMITY</td></tr>
<tr><td>Upper Benton</td><td>Torchlight
U. Benton shale
DISCONFORMITY</td></tr>
<tr><td>Lower Benton</td><td>Peay
L. Benton shale
DISCONFORMITY</td><td>Colorado</td><td>Lower Colorado</td></tr>
<tr><td>Lower Cretaceous</td><td></td><td></td><td>Cloverly</td><td>Cloverly</td><td>Cloverly</td></tr>
</table>

The proposed dividing lines have been determined on physical and paleontological data obtained by the writer during nearly two months of field study. Satisfactory fossils were not obtained from the lower part of the Colorado group, but the Basin shales afforded abundant forms of Niobrara age, particularly in the upper part of the formation. The base of the Basin shales is marked by a persistent conglomerate which varies from a few inches in thickness at some places to two feet in others. It consists of poorly cemented chert, quartzite, and granite, pebbles that are well rounded by water action, of prevailingly dark color, but there are also many light colored ones in some places, the individual pebbles varying in size from half an inch to three inches with an average of size about an inch. The dark color is due to the presence of a large number of black and dark brown pebbles with unusually smooth surfaces. Within the area studied this thin bed

of conglomerate is everywhere present and is one of the most easily recognizable horizons. It is succeeded above by sandy layers of brown color, in places concretionary, and often highly fossiliferous. The sandy layers are but a few feet in thickness and gradually give way to dark adobe shales. The conglomerate, therefore, is the basal member of a transitional series of beds. It lies disconformably upon the Torchlight sandstone, the surface of erosion being devoid of major irregularities. The thickness of the Torchlight varies considerably within the district, and Washburne has failed to find it in the districts to the north so that it seems slowly to disappear in that direction, probably due to erosion. There seems, therefore, to be good reason for selecting this erosion surface as a dividing line between the upper and lower Colorado formations, or as they are most commonly known, the Niobrara and the Benton.

Lithologically the Benton is divisible into four members, two of which are prevailingly shales and the other two sandstones. The lowest formation has been designated the Lower Benton shale. It is succeeded above by the Peay sandstone, the Upper Benton shale, and finally, the Torchlight sandstone. The relation of the Peay sandstone to the underlying Lower Benton shale seems to be one of normal succession as the shaly layers gradually replace the sandstone by intercalation. This condition also holds for the contact between the Upper Benton shale and the overlying Torchlight sandstone. But an important difference was noted for the contact of the Peay sandstone and the Upper Benton shale. A layer of conglomerate was found capping the sandstone in several places, similar to that above described overlying the Torchlight sandstone, but it is finer and less conspicuous. It should be noted, however, that the Peay sandstone shows no interbedded conglomerates, so that the pebbly layer at the top is an indication of changed conditions of sedimentation. The conglomerate is followed by coarse sandstone layers which give way rapidly to finer sediments passing into black adobe shale. The transitional series is not more than two or three feet thick, and is not seen at all in any

except the best exposures. It is well shown along the escarpment on the west side of Bighorn River about a mile and a half above Greybull, but in almost all other places where this contact is exposed it is covered with the loose shale which easily weathers off and rolls down the slopes. There seems to be evidence here of a disconformity, though the time interval represented is not known on account of the paucity of fossils in the rocks immediately above and below. It is, however, thought to be of sufficient importance to be regarded as a dividing line between what may be called the Upper and Lower Benton. It is evident that the transitional character of the beds between the Lower Benton shale and the Peay sandstone, and the Upper Benton shale and the Torchlight sandstone is not comparable to the sudden change in the beds at the contact between the Peay sandstone and the Upper Benton shale. For stratigraphic reasons, therefore, it seems necessary to divide the Benton into Upper and Lower sub-groups.

BENTON FORMATIONS

Lower Benton Shale. Overlying the Cloverly in this field is a succession of sediments 850 to 900 ft. thick consisting chiefly of dark shale, but containing at least three zones in which sandstones or sandy shales predominate. No fossils were found in these shales and sandstones except fish scales, but from their stratigraphic position they are referred to the Benton. From the scarcity of locality names in this region, the name Lower Benton shale has been adopted for use in this report. The lowest of the sandy zones is characterized by a rusty brown color from which character the name "Rusty Beds" has been obtained and used by different writers. Mr. C. A. Fisher has described these beds as follows: "At the base (of the Colorado formation), lying on buff sandstone of the Cloverly formation are about 100 feet of dark gray to black shale, with thin brown sandstone layers, weathering to a rusty color. The shales usually begin abruptly on top of the Cloverly formation, but apparently there is no unconformity."* Mr.

*C. A. Fisher, Prof. Paper 53, U. S. Geol. Surv., p. 29, 1906.

Washburne also mentions the "Rusty Beds" but regards them differently from Mr. Fisher. The following lines taken from his report on gas in the Bighorn Basin summarize his views: "The 'Rusty Beds' are a constant feature of the base of the marine Cretaceous. Seemingly they are as a group of true basal sandstone, resting upon a rather smooth surface of erosion. Beneath this erosional surface at some localities is a heavy sandstone, probably the lowest sandstone of the Cloverly formation; but at most places the Cloverly sandstone is absent and the 'Rusty Beds' rest upon maroon, pink or bright-green shales which are regarded as a part of the Morrison formation, though they may belong to the Cloverly".† The writer is inclined to agree with Mr. Washburne in regarding the "Rusty Beds" as basal to the marine Cretaceous of this region. In one exposure on Shell Creek (already mentioned in connection with the Cloverly) fragments of a conglomerate were found along the outcrop near the top of a rather steep slope, suggesting that they were near to the parent ledge, but the true basal conglomerate was not found in place. It is true, however, that these "Rusty Beds" are more constant in their character and distribution than the underlying Cloverly formation, which lends considerable weight to the view that they are basal beds. It is believed that there is a disconformity, or very low angular unconformity between the Cloverly and these "Rusty Beds".

Slightly below the central part of the Lower Benton shale is a sandstone member from 25 to 40 feet thick, and easily recognized on account of its white color which is in bold contrast with the black shales that lie above and below it. The sand grains are small and uniform in size, poorly cemented together, making the stone porous and altogether ideal as a reservoir for water, oil, or gas. In some of the wells of the district water, and in others gas, has been found in a sand at about this horizon referred to as the "Muddy Sand", while in others it is reported as being dry. The term "Muddy Sand" would seem to be a misnomer when the sandstone is examined at its outcrop,

†C. W. Washburne, Bull. U. S. Geol. Surv., p. 350, 1908.

because of its almost pure-white color, but it is probable that in drilling the soft shales above and below it are so intimately mixed with the white sand grains that the mixture has a muddy appearance. The "Muddy Sand" has no special importance in the district but it is nearly always recognized in drilling. Its exact position is very close to 800 feet below the top of the Peay sandstone.

The uppermost of the sandy zones above referred to occurs about 124 to 130 feet below the top of the Lower Benton shale. It consists of hard, blue, sandy shale carrying an abundance of fish scales in nearly all of the exposures in this region, and is usually known as the Mowry shale. The thickness of the Mowry beds in this region is rather indefinite and difficult to state exactly for the reason that there is an alternation of sandstones and shales beginning with the typical Mowry sandy shale carrying abundant fish scales, and continuing upward to the base of the overlying Peay sandstone. This last member might even be included in this succession of sandy beds except for the fact that it is much more massive than the rest and contains no fish scales. The thickness of the sandy beds containing fish scales amounts to about 50 feet, and their position in the section is about 325 feet below the top of the Peay sandstone, or about 725 feet above the top of the Cloverly. Although no exact data has been obtainable for publication regarding the position of the oil producing sand known as the Kimball sand in this field, it is the belief of the writer that it corresponds closely to that of the Mowry beds, so that they have considerable economic importance.

Peay Sandstone. Overlying the Lower Benton shale is a sandstone of somewhat variable thickness, ranging from 150 to 200 feet. Its lower limit is not sharply defined, there being a gradual transition from all sandstone above to the sandy shales of the underlying formation. The Peay sandstone, therefore, seems to lie conformably on the Lower Benton shale.

The upper limit is sharply defined from the overlying black shales of the Upper Benton division. A thin layer of conglomerate caps the sandstone as already mentioned

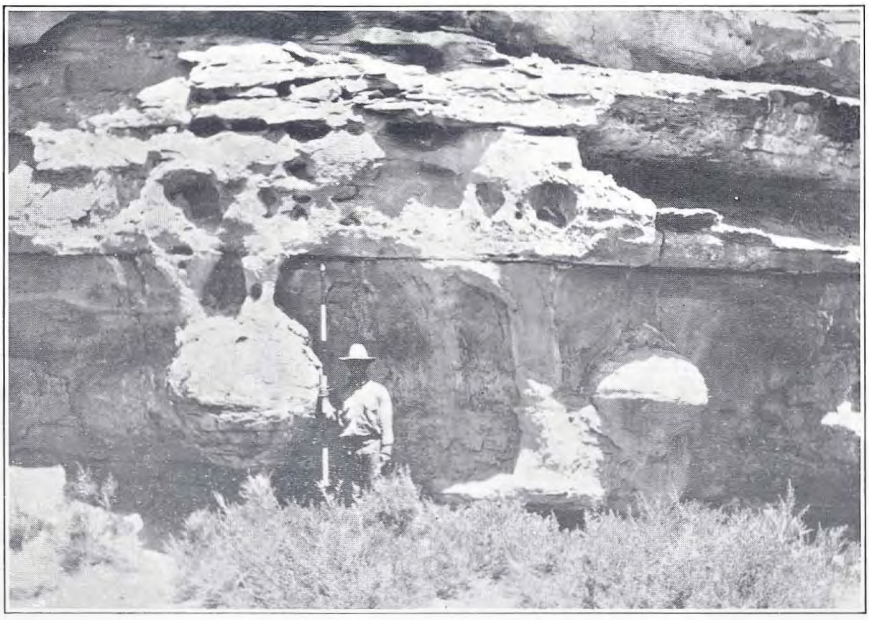
(P. 18) and is taken to indicate a disconformity, though the time value of the break is indeterminate on account of the lack of fossils. It is thought to be of slight value, since it occurs within the Benton group which, in spite of this break, is still about 1500 feet thick. But it is thought to be of sufficient importance to serve as a dividing surface between the sub-groups of the Upper and Lower Benton.

The Peay is a heavy, light-brown to yellow, sandstone in its upper part, the massive portion varying in thickness from 45 to 65 feet. Below this massive layer are numerous intercalations of thinner sandstones and shales, with shales increasing in depth. The sandstone layers are well indurated and vary from a few inches to three feet in thickness. The upper massive member varies in its character from place to place, becoming less massive and more finely stratified in some places than in others. Near the town of Greybull, the most massive phases shown in this field are exposed along the banks of the Bighorn and Greybull Rivers, while in the northeastern part of the district the Peay sandstone is much more thinly bedded. In the central part of this massive member there are frequently found brown ironstone concretions of very large size (see Plate IV). These are quite a constant feature of the Peay sandstone in this field, and often serve to identify it in exposures where it is not in its typical form.

The Peay sandstone is distributed over most of the area shown on the maps of this report. It is covered everywhere except on Peay Hill east of Greybull where it has a rather extensive outcrop covering many square miles. It is the most conspicuous sandstone member of the Colorado group, and as the productive horizons for oil and gas all lie below it, in this field, it has to be penetrated in drilling everywhere except in the river bottom near Greybull where it has been removed by erosion. On account of the ease with which it can be identified in drilling, it was regarded as the most suitable formation to be contoured for structural purposes.

Upper Benton Shale. Above the Peay sandstone are beds of black adobe shale intercalated with many thin layers of bentonite making up a succession of strata from

PLATE IV.



A.—Peay Sandstone

B.—Torchlight Sandstone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350 to 400 feet thick. These are well exposed in an irregular outcrop along the north and northwest slope of the hills southeast of Greybull (see Section C-C, and Plate V). The basal bed of this formation is a rather fine conglomerate of slight thickness that is followed by sandstone layers altogether making up not more than three feet of strata. Black shales follow immediately, and unless a clean contact is examined the transitional beds may easily be overlooked. The upper limits of the formation cannot be so well defined on account of the transitional character of the shaly beds to the sandstone formation above. In the central part of the formation, there is in some exposures a sandstone layer from ten to fifteen feet thick, rather ideally situated as a reservoir for oil or gas, but none has been reported from this horizon, though the sandstone has often been recognized by drillers. The formation seems to be entirely barren of fossils in this field.

Torchlight Sandstone. The highest member of the Benton is a fine-grained, light-colored sandstone, in some places well indurated but in others it crumbles easily and is very porous due to a lack of cementing material. It has this nature near the top of the Torchlight dome where it is well exposed on both sides of a deep gulch that cuts directly across the center of the dome. It is from its prominent exposure at this place that it gets its name. As seen along the line of section C-C, the Torchlight sandstone is a hard and resistant layer that forms a prominent escarpment all along the west face of the hill for a distance of several miles. Like the rest of the Benton it has furnished no fossils, but that it belongs to the lower series rather than the upper is shown from the fact that it is compact and hard while the conglomerate and sandy beds which rest upon it are loose and almost without cement. It is, moreover, everywhere in this field overlain by this conglomerate which is regarded as the basal bed of the higher marine series of the Upper Colorado. (See Plate IV.)

The Torchlight sandstone is the member commonly known as the "B" sandstone. According to Washburne it is not present in the sections which he examined in the northern part of the Bighorn Basin. This may be ex-

plained as due to erosion prior to the deposition of the following marine series which represents the Niobrara; or, it may be a lenticular bed that thins to the north and may then be absent by non-deposition. Inasmuch as there is evidence of erosion in all of the exposures in this field, it is sure that some of the formation was removed in this way and it is most likely that the variations in thickness within the field are to be explained in this way rather than by non-deposition.

NIOBRARA

Basin Shale. Above the Torchlight sandstone in the southern part of the field there is exposed between 900 and 1000 feet of dark-colored, marine shales that are very fossiliferous at several horizons. An almost continuous section is exposed along the east side of the gulch which runs south from the Torchlight oil field to the Hyattville road, following closely the dip of the beds. Small tributary strike valleys interrupt the section in a few places, but they do not usually follow the strike continuously for great distances so that the whole series can be seen in this way. A better partial section is shown of the west slope of the high hill southeast of Greybull (see section C-C). Here the lower 750 feet is well shown as a dark, in places black, shale, interrupted in a few places by sandy or calcareous layers. Some of these, notably in the middle portion, on exposure become warped, or curled in spiral forms. Toward the top, numerous fossil-bearing calcareous concretions are to be found, and at one horizon broken plates of fibrous aragonite occur abundantly, suggesting the fibrous layer of the thick shell of *Inoceramus*, probably *I. deformis.*

The lower limit of the Basin shale is marked by a persistent conglomerate which lies upon an erosion surface at the top of the Torchlight sandstone. In sandy concretions a few feet above the conglomerate layer are found the following fossil forms:

Inoceramus fragilis H. & M.
Prionotropis sp. (new)
Mortoniceras shoshonense Meek
Gyrodes conradi Meek

PLATE V.

A.—View from the top of Peay Hill looking east, showing Upper Benton Shale, Torchlight Sandstone and Basin Shale

B.—View of Bad Lands looking north from the southern limits of the district. Hyattville road in the foreground. Torchlight Dome in central position.


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At a horizon about 450 feet above the conglomerate, in more sandy concretions, fossils were abundant. The following is a partial list of the forms collected from this horizon at Sta. 8314 on section C-C:

Scaphites cf. ventricosus
Baculites sp. (small compressed forms)
Inoceramus cf. problematicus Schlot.
Crassitellites cf. excavata
Inoceramus deformis (?)
Placenticeras sp. (smaller than placenta)
Gyrodes sp. (probably new)
Fusus (?) *sp.* (probably new)
Aporrhais sp. (probably new)
Turritella sp. (probably new)

A third fossil horizon occurs 650 feet above the base of the Basin shale, in two black shale layers, each about 5 feet thick and separated from each other by 10 to 15 feet of lighter colored shale. In these black shales were found numerous specimens of a large *Inoceramus*, almost invariably covered by the small shells of *Ostrea congesta*. This horizon can be seen from a distance as the shale bands are distinctly darker in color and so soft that they weather away faster than the underlying shales producing a bench or terrace, often 10 to 25 feet wide. In red sandy layers about 15 feet above the highest dark shale band carrying the large *Inoceramus* were found abundant examples of a flattened *Inoceramus* having numerous fine, concentric growth lines on the larger concentric plications of the shell, closely resembling *I. labiatus*, or *I. problematicus*, except for the flatness of the shell.

At a still higher level, 775 feet above the base of these shales a most prolific fossil horizon occurs. The following species are abundantly represented:

Scaphites ventricosus
Baculites anceps Lam.
Baculites asper Morton
Baculites gracilis (?)
Inoceramus exogyroides
I. acutiplicatus Stanton
I. sp. (small)

Of these *Baculites anceps* and *B. asper* are the most abundant species and have the widest distribution, being found at all the exposures of this horizon in this field.

Scaphites ventricosus is also common in most outcrops, and *Inoceramus exogyroides* occurs locally in great quantities. A large collection was made from the discarded calcareous concretions at the plant of the Basin Brick and Tile Co., 2½ miles north of Basin, where the shales of this horizon are being worked for brick making. As discovered in the quarry that has been opened up here the concretions in which the fossils are found are usually small and very hard, but occasionally they are cracked and the openings filled with amber-colored calcite crystals exhibiting numerous perfectly formed flat rhombohedrons. As seen in the outcrops the concretions are always much broken, occurring as small heaps of angular fragments, or scattered over the surface in small pieces. In such places the fossils are usually found lying loose on the surface or among the broken pieces of the concretions where they are heaped up together.

The forms belonging to the earliest of these faunas are identical with those commonly ascribed to the top of the Benton in the Black Hills and southern sections, except *Prionotropis sp.*, which appears to be an undescribed form. It shows stages of development beyond those of the adult forms of *P. woolgari*, its closest relative, which suggests that it is somewhat younger. From their stratigraphic position immediately above the basal conglomerate of the Upper Colorado they undoubtedly came into the Basin region with the first marine invasion after Upper Benton time. The fact that identical species occur in the Upper Benton of the more southern sections does not preclude their appearance at a somewhat later time in the northern region. They evidently migrated with the shore facies of the Upper Colorado transgression as it moved northward. Some time should be allowed for the transgression to take place, and it may well be the case that this fauna indicates later time in the northern sections than in the southern. Accordingly, in spite of the Benton aspect of this fauna, the writer has felt justified in drawing the line between the Niobrara and Benton at the base of the conglomerate a few feet below the beds in which this fauna occurs.

A careful examination of the beds above this horizon failed to show any discontinuity in marine sedimentation until late in Montana time. The second fauna here given appears to be a mixture of Benton and Niobrara types as might be expected in a region of continuous deposition. The last two faunas appear to be more distinctly Niobrara in aspect, containing forms that are widely known in the Niobrara of the eastern and southern regions. A comparison of these forms with those listed by Mr. Hewett* from the base of the upper member of the Colorado formation, Shoshone River section of Northern Wyoming, shows them to be identical so far as the important species are concerned and they undoubtedly represent the same horizon.

MONTANA GROUP

Only the lower part of the Montana group is represented in the area covered by this report. Overlying the Basin shales on the southern and western borders of the district is a sandy shale series, followed by a massive sandstone, and still more shales. The sandy shales together with the underlying Basin shale were mapped by Mr. Darton as Pierre shale and the sandstone as the Parkman. Mr. Fisher followed Mr. Darton in the use of the name Pierre for these same shales, and referred to the sandstone as the Fox Hills. Later workers have generally doubted the Pierre age of the shales, assigning them to the Upper Colorado and making the sandstone the base of the Montana. Mr. Washburne makes the Eagle the lowest Montana formation, followed by the Claggett, Judith River and Bearpaw. Mr. Hewett has used the term Gebo formation for the coal-bearing lower Montana sandstones and shales, beginning at the Eagle sandstone. These various usages are set forth in tabular form for easy comparison on page 17.

Pierre Shale. On the basis of fossils found in the sandy shales below the Eagle sandstone, the writer refers these shales to the Pierre, bringing the base of the Mon-

*Hewett, D. F., The Shoshone River Section, U. S. Geol. Surv., Bull. 541-C., p. 53.

tana down approximately 1800 feet below the base of the Eagle sandstone. No fossils were collected from the Eagle nor the higher horizons, so that the exact extent of the Pierre and its separation from the upper Montana is not attempted in this report. It would be better to use some other name than Pierre for this sandy shale series inasmuch as the Eagle sandstone may also be of Pierre age, but the difficulty of finding locality names has necessitated the adoption of the old name.

The separation of the Pierre shale from the underlying Basin shale is difficult to accomplish as there exists no natural dividing line. Both shale series are marine and fossiliferous, but the fossil horizons between which the line must be drawn are separated stratigraphically by nearly 800 feet of non-fossiliferous shales and it is a somewhat arbitrary matter as to where the divisions should be made. The Basin shales are almost wholly lacking in sandy sediments, while the Pierre is characterized by sandy zones especially toward the top, but there are some light yellow sandy shales also near the bottom. As drawn on the map the line separating the Basin and Pierre shales, or the Colorado and the Montana, includes the lowest of these sandy zones in the Pierre and lies just above the highest fossil horizon in the Colorado. It is thus as low as it can well be drawn but, when so placed, it includes most of the dark adobe shales in the Colorado and all of the lighter-colored sandy shales go with the Pierre.

In one of the sandy zones, about 800 feet above the base of the Pierre, the following fossil forms were found along section A-A, at station 1457:

Placenticeras whitfieldi
Baculites compressus
B. ovatus
Scaphites hippocrepis var.
Scaphites sp. (new)
Ammonites sp.
Pholadomya sp. (new)

These fossils are all common Montana types, characteristic of the Pierre. *Scaphites hippocrepis* var. is a small form and, except for size answers the description and

compares with figured specimens of *S. hippocrepis* DeKay. *Scaphites sp.* (new) is a larger form, of which Mr. T. W. Stanton, who has kindly made a study of it for purposes of identification, has the following to say:

"I find on comparison that the same species is represented in the Geological Survey collections from the east side of the Bighorn Mountains, in the neighborhood of Parkman, Wyoming, where it occurs at approximately the same horizon from which your specimens were obtained, and is associated with *Scaphites hippocrepis* DeKay to which it is pretty closely related. Dr. Stephenson has made direct comparisons of your specimens with the figured specimens of *S. hippocrepis* from New Jersey, in the collections of the New Jersey Survey, and of the Philadelphia Academy of Sciences. My statement that your specimens are specifically distinct from the New Jersey species and that *S. hippocrepis* is actually represented in the collections from near Parkman, is based on the results of Dr. Stephenson's comparisons. I think that your species has not been described, at least not from American localities, and that its nearest American relative is the New Jersey species just mentioned."

The New Jersey species occurs in the lower part of the Ripleyan, which corresponds in a general way with the horizon at which the Wyoming forms occur.

Lithologically the Pierre shale in the Basin region consists essentially of light yellow to brown sandy shales, in zones from 10 to 50 feet thick, and bluish-gray to black shales, most common near the lower part. Occasional sandstone lentils occur in the central portion, but they are rarely more than a foot or two in thickness. The most prominent one occurs about a thousand feet above the base of the formation and in a few places along the slope south of the Hyattville road, southeast of Basin, it is expressed in the topography as low hog-backs. Sandy layers are most abundant in the upper part of the formation where the sandy beds appear to increase in importance until the first massive layer of the Eagle sandstone is reached. This character is constant in most parts of the Bighorn

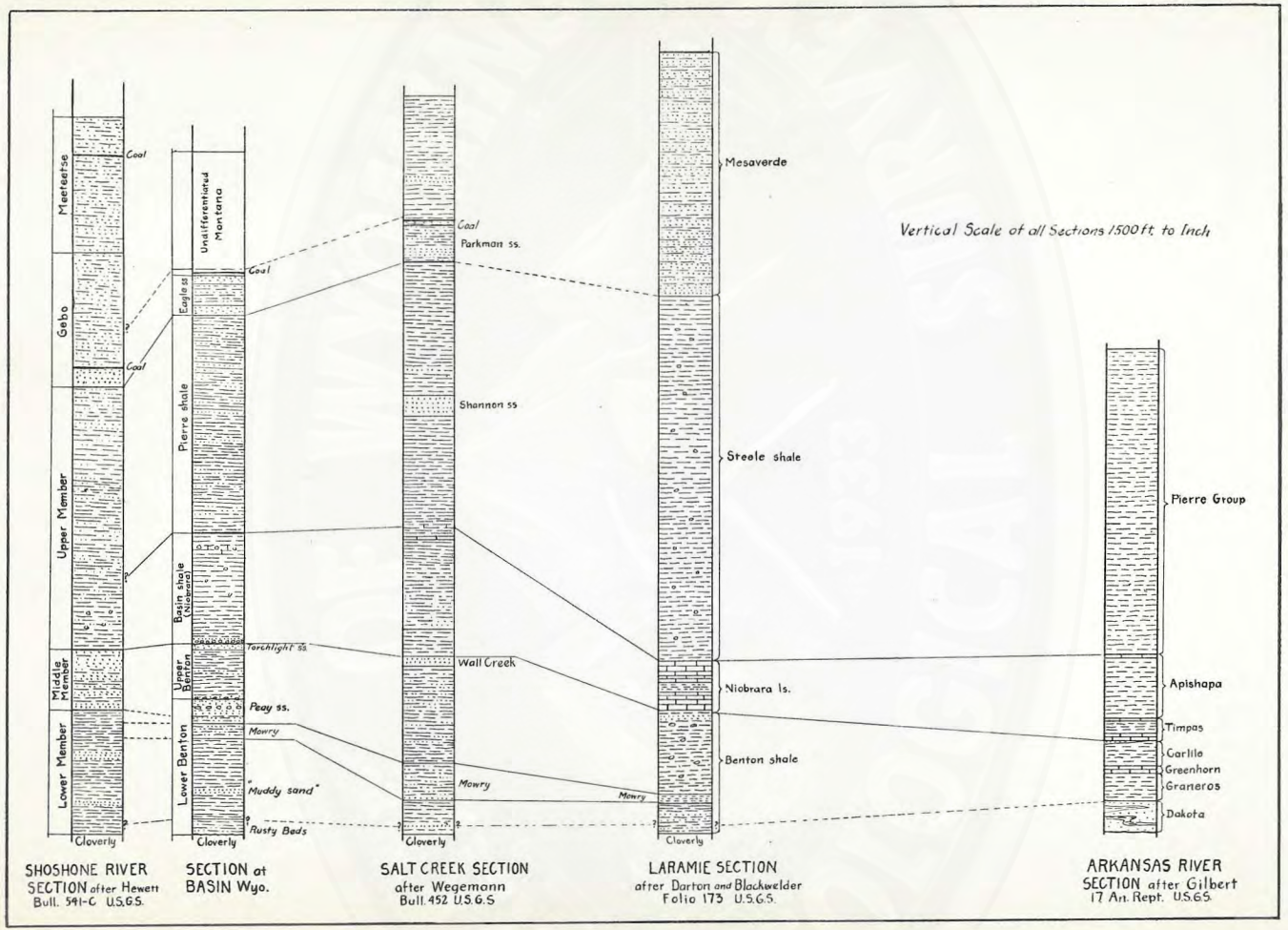
Basin, with the sandy layers locally becoming 10 or 15 feet thick, as in the Little Buffalo and Grass Creek basins.

Eagle Sandstone. The Eagle sandstone consists of a massive layer of light brown sandstone, about 50 feet thick, followed by 350 feet of sandy shales in which thin coal seams frequently appear. Near the top, a second massive sandstone layer occurs, and just above it is a four-foot bed of coal. According to the coal reports of Messrs. Washburne and Woodruff of the U. S. Geological Survey, the Eagle sandstone of Montana has been traced all the way from the Montana-Wyoming line south to the southern end of the Bighorn Basin, and the use of the name Eagle in this report is based on their usage. It should, however, be said that since the discovery by the author of unquestionable Montana fossils in the Pierre shale, about 1,000 feet below the base of the Eagle in the Basin region, the use of the term Eagle for a sandstone so high up in the Montana is technically incorrect as its original definition refers to a sandstone at the base of the Montana, unless the Eagle of Montana should later prove to be underlain by considerable Pierre shale as seems to be true on Shoshone River, in northern Wyoming, as well as at Basin. It is retained in this report, however, for the reason that no local name has been found to replace it and the name Eagle has become known to many local workers in the Basin region and is therefore practicable. It is believed to represent approximately the horizon of the Parkman sandstone with which it is correlated.

GEOLOGIC HISTORY AND CORRELATION

In order to be able to compare the formations in the Basin and Greybull oil and gas field with those of other regions, particularly to the north and south, several columnar sections as given by different geologists have been placed side by side on Plate III-A. These sections are all drawn to the same vertical scale and they are spaced proportional to their horizontal distances from Basin, Wyoming. Those to the right are south of Basin, while the Shoshone section is north of that place. As arranged,

PLATE III A.


Meeteetse
Gebo
Upper Member
Middle Member
Lower Member
Coal
Coal
Cloverly
Unaifferentiated Montana
Eagle ss
Pierre shale
Basin shale (Niobrara)
Upper Benton
Lower Benton
Coal
Torchlight ss
Peay ss.
Mowry
"Muddy sand"
Rusty Beds
Cloverly
SHOSHONE RIVER SECTION after Hewett Bull. 541-C U.S.G.S.
SECTION at BASIN Wyo.
Coal
Parkman ss.
Shannon ss
Wall Creek
Mowry
Mowry
Cloverly
SALT CREEK SECTION after Wegemann Bull. 452 U.S.G.S
Mesaverde
Steele shale
Niobrara ls.
Benton shale
Cloverly
LARAMIE SECTION after Darton and Blackwelder Folio 173 U.S.G.S.
Vertical Scale of all Sections 1500 ft. to Inch
Pierre Group
Apishapa
Timpas
Carlile
Greenhorn
Graneros
Dakota
ARKANSAS RIVER SECTION after Gilbert 17 An. Rept. U.S.G.S.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they present a line of sections from southeastern Colorado to northwestern Wyoming. It is the writer's purpose to discuss the geologic history and correlation of the Colorado and lower part of the Montana groups.

COLORADO TIME

The Dakota which is so prominent in the Arkansas section is not recognized in its typical form in the Wyoming sections here given. The Cloverly was thought by some to represent the Dakota but it has more recently been proved to be of Lower Cretaceous age, and as such, forms the sub-formation upon which the Upper Cretaceous rests. In the Basin region the Rusty Beds have been thought to be the possible equivalents of the Dakota. In nearly all of the sections there are sandy layers near the base of the Benton which may be regarded as representing the Dakota. It is with this possibility in mind that the broken line has been drawn to suggest the correlation of the lower sandy shales of the Benton with the Dakota of the Arkansas section. There is no fossil evidence to bear out this view and as will be shown later these beds are capable of another interpretation.

The Benton sub-group, as shown in the Arkansas River section, falls readily into two shale series, separated by the Greenhorn limestone. The total thickness is 400 to 450 feet, which is slight as compared with the more northern sections. The Greenhorn limestone disappears in the southern part of Wyoming, being present in the Laramie region as a layer a few inches thick and showing there its characteristic fossil, *Inoceramus labiatus*. Still farther north the Benton becomes arenaceous, limestone disappearing altogether, and there is a progressive increase in thickness, with a maximum of about 1500 ft. in the Basin region. In the Laramie section, near the base, occurs the so-called Mowry fish-scale shales. These are sandy in character, and have been identified in practically all of the northern sections. It is pertinent to note that the Mowry becomes thicker and rises to a higher horizon within the Benton toward the north. It is not reported from the

Shoshone River section as Mowry, but gray shales carrying fish scales are reported from the upper part of the "Lower Member" of the Colorado and it is presumably the true Mowry. There can be no doubt as to the marine origin of these beds because of their lithologic character, their slight thickness, and great lateral distribution. The age of the Mowry is determinable in the Laramie section where the Mowry beds occur about 350 feet below the Greenhorn limestone member, and about 200 feet above the base of the Graneros shale member, of which it forms a part. It is, therefore, presumably of the same age as the Graneros. But it should be noted that the true Dakota is not reported in the Laramie section, the Benton shale resting directly on the Cloverly. There seems to be a complete lack of diagnostic fossils in that part of the Benton below the Mowry shale so that it is not possible at present to state whether the Mowry in the northern sections is very different in age from that in the south. The Greenhorn limestone fossil, *I. labiatus*, is also singularly wanting in the north so that it cannot be told how far below that horizon the Mowry occurs in those sections. When the distance below the top of the Benton is observed in all of the sections, it appears that the Mowry maintains its position approximately uniform throughout, being about 700 feet below the top, except at Basin and Shoshone River, where it is somewhat less. The interpretation of the origin and history of this interesting member is thus seen to incur some difficulties. If the Dakota is represented in the north by the lower part of the Benton shale series as the "Rusty Beds", then some explanation should be offered for the great thickness of black shale below the Mowry beds in the north. This might be explained as due to more rapid deposition in that region, following the Dakota transgression. Or, these lower Benton shales might be regarded as of Lower Cretaceous, or Comachian age, in the absence of direct evidence to the contrary. If this last assumption be correct, the Mowry beds could be considered as the possible equivalent of the Dakota. This explanation has a great advantage in the south, where the Mowry approaches the base of the Benton, and where

it would be difficult to explain how the Dakota sea came in from the south, depositing sandy layers directly on the Cloverly, followed in the north with thick black shale deposits that are not represented in the south by shales, nor limestones nor any kind of material. A complete explanation is possible by assuming that the Cloverly, or the Rusty Beds and other sandy layers at the base of the Benton in the northern sections, represent an earlier transgression from the north which made itself felt as far south as southern Wyoming, or northern Colorado, and which was completed at about the beginning of Dakota time, when the southern transgression began and the two seas from the north and the south became confluent. The slow subsidence in the south was accompanied by a shallowing of the northern sea which resulted in the deposition of the sandy shales of the Mowry. This view would make the Mowry everywhere about the same age, and not far different from that of the southern and eastern Dakota. The water deepened from the south, finally resulting in the deposition of the Greenhorn limestone, while in the north the water was shallower and the darker shales and sandy beds were laid down. The shore of this sea was somewhere in the northern part of Wyoming, or southern Montana, where, as shown by the Shoshone River and Basin sections, the sandy phase predominates. There seems to have been several minor oscillations of the sea in this region, while to the south the sediments all have a more uniform character, indicating more constant conditions.

Toward the end of Benton time there was a shallowing of the sea in the north by which sandy sediments were spread over the darker shales, forming the Torchlight sandstone in the Basin region. Farther south, at Salt Creek, the Wall Creek lentil was formed, while still farther south the unnamed sandstone at the top of the Benton in the Laramie region was deposited. The extreme southern limit of this shoaling was probably central Colorado where it is marked by the Pugnellus sandstone which rests upon the Carlile shale, a deeper water deposit. In the north there was an emergence of the land, and some erosion by

which the sandstone was swept completely away in some places; while at other places, as at Basin, the sandstone was only partly eroded away. In the Salt Creek field and farther south this gentle movement was only felt in the shallowing of the. waters whereby the Wall Creek and equivalent sandstones were deposited.

The fauna of these sandstones is that of the uppermost Benton and is characterized particularly by such forms as *I. fragilis*, *Prionocyclus wyomingensis*, *Prionotropis woolgari*, *Mortoniceras shoshonense*, *Gyrodes conradi*, etc. Some, or all of these forms are reported from the Wall Creek sandstone and from the unnamed sandy beds at the top of the Benton in the more southerly sections, so that their correlation seems to be well-founded so far as similarity of fossils is concerned.

The shallowing of the Benton sea, and the emergence in the north was followed by the Niobrara invasion which produced limestones and calcareous shales in the south, and more sandy beds in the extreme north. The emerged land was again covered by the sea and the shallow water marine fauna characteristic of the upper Benton sandstones of the southern sections migrated northward and are found in the Basin region, in sandy beds, a few feet above the basal conglomerate which marks the base of the overlapping Niobrara sediments. The presence of these forms in beds having such stratigraphic relations shows that there was a diastrophic movement at the end of Benton time by which the somewhat contracted Benton sea became greatly expanded northward, and the Benton fauna migrated northward as the shore facies moved in that direction. If such an important movement is to be given any rank in determining where to divide the lower Colorado, or Benton, from the upper Colorado, or Niobrara, then the age of this fauna must be given as upper Benton and lower Niobrara, for it seems to bear out this relation stratigraphically. It is to be regarded as upper Benton in the southern sections, and lower Niobrara in the northern ones.

It should be noted that in the Salt Creek section the limit of the Benton was placed by Mr. Wegemann about 220 feet above the top of the Wall Creek sandstone lentil,

so as to include all of the darker shales in the Benton. On the basis of the fossils of the Wall Creek sandstone, especially *Prionocyclus wyomingensis*, the Wall Creek correlates with the Torchlight sandstone, or the sandy layers immediately above it. It has therefore seemed to the writer advisable to suggest putting the dividing line lower down, at Salt Creek, inasmuch as there are good physical reasons for placing the dividing line at the top of the Torchlight sandstone, at Basin, as already mentioned.

The Niobrara of the southern sections consists to a large degree of limestone and calcareous shales. To the north it is made up of shales that are often interspersed with sandy layers and calcareous concretions. *Inoceramus deformis* and *Ostrea congesta* are the leading index fossils found in all of the sections.

In the Shoshone River section the lower part of the "Upper Member" of the Colorado carries the Niobrara fauna, and on the basis of these fossils the whole of the "Upper Member" was placed in the Colorado. The lithological character of the sandy beds in the upper two-thirds of that division as given by Mr. Hewett corresponds so closely with the character of the Pierre shale in the Basin section that the writer feels fully justified in concluding that these higher beds belong in the Montana group, and not with the Upper Colorado.

In the Salt Creek section the top of the Niobrara has been placed a little higher than the dividing line set by Mr. Wegemann, to include certain thin beds of reddish calcareous shale which are also found at the top of the Niobrara in the Basin region, as well as at Little Buffalo Basin, and Grass Creek. These shales are fossiliferous at Basin, carrying small and large *Baculites*, *Scaphites ventricosus*, *Crassitellites*, etc., that are common in the Niobrara below that horizon.

In the southern sections deposition was continuous from Benton time into Niobrara time, but at Basin there was an interruption marked by an abrupt change from white sandy sedimentation to fine black shale. At Shoshone River the sandy beds of the "Middle Member" contain several layers of chert pebbles and the whole "Middle

Member" is made up to a large extent of light colored, well hardened sandstone. The lower part of the "Upper Member" is fine, black shale, free from sand, so that there is a very decided change, and possibly some interruption of sedimentation occurred there, as at Basin. Elsewhere in the Bighorn Basin this abrupt change from sandy and conglomeratic sediments to fine black shales has also been observed, so that there was a pronounced change in conditions of sedimentation throughout the region of the Bighorn Basin at the beginning of Niobrara time.

MONTANA TIME

The beginning of Montana time was not marked by any pronounced diastrophic movement, though there is evidence of a shallowing of the sea in the Bighorn Basin region where sandy sediments follow upon the argillaceous Niobrara deposits. To the south the sea in which the Niobrara limestone was deposited became turbid with black mud, and at intervals sands were laid down, showing shallow water conditions. This gentle movement of the sea bottom seems not to have produced an emergence in any of the sections under discussion, so that deposition was apparently continuous.

In the northern sections, especially in the Bighorn Basin, the upper part of the Pierre shale is largely sandy shale, and this is followed by the Eagle sandstone which is mostly well indurated sandstone. The Eagle in the Bighorn Basin correlates with the Parkman sandstone of the Salt Creek section, and with some part of the Gebo, most likely the lower portion, of the Shoshone section. On the basis of a meager flora and a few invertebrate fossils, the lower part of the Gebo has been correlated with the Eagle formation containing the coal at Bridger, Montana, and the upper part of the Gebo is said to correspond with the marine Claggett formation.* The Meeteetse formation, of fresh water origin, is correlated with the Mesaverde and Belly River on the basis of its flora.† The presence

*Bull. 541-C, U. S. Geol. Surv., 1914, p. 54.
†Ibid. p. 56.

of coal in these sandstones betrays their fresh water origin and marks the beginning of continental sedimentation which periodically displaces the marine type during the rest of Montana time in these northern sections.

The Steele shale of the Laramie section correlates with the Pierre below the Parkman, in a general way, since fossils obtained from the basal portion of the shale above the Parkman are similar to those found in the Mesaverde of the Laramie Plains, and the Claggett of Montana.* From this it appears that the Parkman sandstone, a fresh-water formation, thins out and disappears south of the Salt Creek section and is thus confined to the more northern region. At Basin it is represented by 400 feet of coal-bearing sandstones and shales, and on Shoshone River it is present in the lower portion of the Gebo, and still farther north in Montana it is known as the Eagle.

The Mesaverde of the Laramie Plains and its equivalent in the Salt Creek region are likely represented in the "Undifferentiated Montana" of the Basin section, since corresponding shales are recognized in Montana as the Claggett formations. But according to Hewett, the Shoshone section shows only fresh-water deposits of this age, so that the marine sediments cannot be continuous all the way from Laramie to central Montana, along the line of sections here given. From a superficial examination of the "Undifferentiated Montana" at Basin the writer can say that they correspond in a general way with the upper part of the Gebo, and the Meeteetse formations. Saurian bones are reported to occur in sandstones and shales at this horizon two miles southeast of Basin, but these were not seen by the writer.

STRUCTURE

METHOD OF REPRESENTATION

The structure of the Basin and Greybull oil and gas fields is shown in two ways in this report. Structure sec-

*Bull. 542, U. S. Geol. Surv., 1911, p. 48.

tions accurately constructed from profile lines run with transit and stadia measurements show the altitude, character, and thickness of the beds along the lines A-A, B-B, C-C, D-D, and E-E. The structure is, however, represented for the area as a whole by structure-contours. These are seen on Plate VIII as blue lines, and are to be interpreted as contour lines on ordinary topographic maps. They represent lines of equal elevation on the upper surface of the Peay sandstone, which, over most of the area, is concealed beneath the cover of the later shales. The contour interval is 100 feet for most of the area with only 500-foot contours used where the dips are great, and where the lines would otherwise be closely crowded together.

GENERAL STATEMENT

Structurally the Basin and Greybull oil and gas fields consist of a number of small and gently flexed domes and basins of rather unsymmetrical form arranged along a general northwest and southeast direction parallel with the axis of the Bighorn uplift. At the northern end of the district, the beds are folded more prominently into an anticline of considerable proportions, known as Sheep Mountain. This fold is in reality an elongated quaquaversal whose southern end terminates in the northwestern part of the area of this report, where the axis plunges down at an angle of about 15 degrees.

Northeast of this line of smaller folds is a broad synclinal the bottom of which shows several small wrinkles or very gentle anticlines and synclines. It is terminated on the northeast by a very abrupt turning up of the beds, giving a strike having a northwest direction, approximately along the northwest diagonal of township 52 N., R. 93 W. This depression continues to the southeast for a considerable distance beyond the limits of the district, but is terminated by the Sheep Mountain fold to the northwest, where the strike changes to the southwest and passes around the southern end of Sheep Mountain, giving the structure contours the form of a letter S.

PLATE VI.

A.—View of the Torchlight Dome, looking east, showing the gentle curvature of the beds. Buildings of the Bighorn Oil and Gas Company in the foreground

B.—Bighorn Oil and Gas Company Rig in Section 25, T. 52, R. 93.


STATE OF WYOMING
1933
GEOLOGICAL SURVEY

Torchlight Dome. The most pronounced one of the smaller domes of the district is the so-called Torchlight dome, located about 2½ miles directly east of Basin. In form it is much elongated, having its center a little east of the center of section 24, T. 51 N., R. 93 W., and its long direction about N. 50 degrees W. The southeastern end of the fold is somewhat sharper than the northwestern end, which is in reality much more blunt than represented on the map. Due to an error in tracing the contours the true form of this part of the dome is not shown on the map. The 3500-foot and 3600-foot contours have been extended toward the northwest to include most of section 14, which should not have been done. Contour 3500 should not extend beyond the position now occupied by contour 3600, at this end of the dome.

On the southwest side of the Torchlight dome the Peay sandstone descends to sea level, or below, within the limits of the district. On the northeast it descends to elevation 3500 with a dip not exceeding 7½ degrees, and then becomes horizontal for a distance of a mile along the line of section A-A, after which another drop of 200 feet occurs. Farther along section A-A there are several gentle anticlines and synclines, not represented on the map by contours. The top of the dome is thus seen to be between 600 and 700 feet above the bottom of the broad syncline valley to the northeast.

THE LAMB ANTICLINE

North of the Torchlight dome is a smaller dome structure, known locally as the Lamb anticline. The top of the Peay sandstone on the center of this dome has an elevation of a little over 3700 feet while the surface elevation varies from 4100 to 4300. As compared with the Torchlight dome the Lamb anticline is smaller and does not rise to as great an elevation. It is separated from the Torchlight dome by a syncline which has a sag of about 250 feet in its deepest portion.

PEAY ANTICLINE

Southeast of Greybull is a prominent anticlinal elevation known as Peay Hill on which the contoured sandstone member (Peay sandstone) outcrops and forms a vertical cliff 60 to 75 feet high along the river-front. This structure lies close to the southern end of the Sheep Mountain anticline, the depression, or syncline, separating them being only about 200 feet deep. The northern end is rounded while the southern end is much more pointed and is drawn out into a long curved anticlinal ridge which terminates just north of the Lamb anticline. The end of this ridge seems to be broader than that portion which connects it with the Peay anticline. This condition led to the belief on the part of drillers in the existence of a pronounced dome which has its center somewhere in section 25. It is known locally as the Crescent dome, but in reality it is not a dome, but merely the broad end of the attenuated southeastern extension of the Peay anticline. It is separated from the north end of the Lamb anticline by a shallow structural depression a little more than 100 feet in depth.

On the east side of the Peay anticline the dips are gentle toward the great syncline. On the west along the Greybull River, the dip is stronger, increasing to a maximum of nearly 40 degrees within two miles from the center of the dome. To the north the direction of the contours is controlled for a short distance only by the Peay anticline, coming rapidly under the influence of the larger Sheep Mountain fold.

By way of comparison of these anticlines it might be said that the Torchlight dome rises higher on all sides than do the other two, having thus an independent dome structure of greater size than the others. The Lamb anticline comes next, and finally the Greybull, or Peay anticline. They are all, however, of comparatively small size.

FAULTS

Faulting on a large scale was not observed in this district. It is hardly to be expected that faults would be

detected in a great part of the district owing to the soft shales and obscure bedding, but along the harder sandstone outcrops southeast of Greybull several faults can be seen. Southwest of Greybull, along the escarpment of Peay sandstone between the railroad shops and the Greybull River a small fault can plainly be seen. Still farther south along this escarpment near the southern boundary of Section 28, township 52 N., R. 93 W., a small fault has been reported. It is not believed that faulting on a large scale exists in the proximity of the oil or gas structures, though the minor slips above referred to undoubtedly exist.

Along the northeast margin of the great syncline where the dip is observed in some places to be as high as 60 degrees and the change from the almost level floor of the syncline is very abrupt some faulting probably took place. The beds are thinned greatly due to stretching during the folding. Evidence of considerable faulting, however, is altogether lacking.

THE OIL AND GAS HORIZONS

There are two productive horizons in the Basin and Greybull field. The lowest is that from which the oil and gas are obtained in the Peay anticline, near Greybull. This is known among drillers as the Greybull sand and is the same as the Cloverly according to a comparison of very carefully measured sections on the surface, with drill records. The second horizon is commonly called the Kimball sand and corresponds as nearly as can be determined from the meager well records obtainable, with the Mowry sandy shale member. This horizon is approximately 600 feet above the "Greybull sand", and 450 feet below the top of the Peay sandstone ("A" sandstone of Washburne). The oil of the Torchlight dome, and the oil and gas of the Lamb anticline come from the Kimball sand.

The Occurrence of the Oil and Gas

TORCHLIGHT DOME

The distribution of the productive wells in the Torchlight field shows plainly that the oil exists in the very

top of the dome structure. Very little gas has been obtained from this area, and from the presence of the oil in the top of the dome it is not to be expected that gas in any important quantity will be found here. Gas is, however, generally present in the productive domes of the Bighorn Basin, and it is quite likely that it was present here at some time in the past, but due to the deep erosion that has brought the productive stratum so near the surface the gas may have escaped.

THE LAMB ANTICLINE

Both gas and oil are obtained from this structure, the wells on the northeast side near the top producing gas, while on the opposite side of the dome and at a somewhat lower level oil was obtained. A small amount of oil was also obtained at the northern end of the anticline, but up to the time of completing the field work no oil had been found on the northeast side. A dry hole was drilled in section 7, T. 51 N., R. 92 W., near the township line, which location is well up on the dome and if the oil occurred on this side as it does on the opposite side this well should have given gas or oil. The absence of oil or gas on the northeast flank of the anticline, except near the top where gas is obtained, shows that special conditions not provided for by the anticlinal theory must prevail here.

It should also be remarked that in well T. 7 a flow of gas was obtained only after pumping out considerable water, while a free flow of gas at a high pressure was obtained at wells T. 5 and T. 6, located in section 12, T. 51 N., R. 93 W., and structurally lower on the dome than T. 7.

It should further be stated that fresh water was obtained from the Peay sandstone in well T. 7, while on the Torchlight dome the Peay water was black and stinking. Details relating to these wells were withheld by the drilling companies, pending adjustment of various claims, so that the explanation of these special conditions is rendered difficult, if not impossible, by the incomplete data at hand.

A possible explanation for the difference in the water

encountered in the Peay sandstone on the two domes may be found in the eastern source of the water supply. The intake of these waters is along the slopes of the Bighorn Mountains at an elevation somewhat, though not greatly, above the level of the sandstone in this part of the district. An outlet for the water occurs along Bighorn River, near Greybull, where the Peay sandstone is exposed by erosion. The steep slope of the beds on the southwest side of the Torchlight dome prevents any outlet of the waters in that direction and causes stagnation in the top of the dome. The same condition would occur at the top of the Lamb anticline, while on the flanks, as at well T. 7, there would probably be some circulation, inasmuch as the waters would flow toward the outcrop of the Peay sandstone on Peay Hill, to the northwest. It may also be that the pressure of the waters from the northeast has caused the oil to migrate to the other side of the dome. These explanations are to be regarded as suggestions rather than demonstrations.

THE PEAY ANTICLINE

The first well drilled within the district was the Miner gas well located on this anticline in Sec. 21, T. 52 N., R. 93 W., on the east bank of the Bighorn River. Subsequent prospecting has developed a considerable number of both gas and oil wells on this structure. The gas wells are located near the top of the dome, east of the Bighorn River, while the oil wells are singularly found only on the west side of the dome, along the Greybull and Bighorn Rivers. All attempts to obtain oil on the east slope of the anticline have failed. Wells G. 15 and G. 16 in section 22 were water wells, in spite of their favorable location on the basis of the anticlinal theory. G. 16 might be counted doubtful, since it occurs on the same elevation as the bottom of the trough between the Peay anticline and the Sheep Mountain uplift, about a mile north of the well site. But G. 15 is above that level and should have produced oil or gas under normal anticlinal conditions.

The distribution of the oil wells on the west side of

the dome may be accounted for in a large measure by the relation of the Peay anticline to the Sheep Mountain fold. North of the east-west line passing through the bottom of the trough separating the two anticlines, the slope of the beds is continuous up the side of Sheep Mountain. South of that line the slope up along the beds leads to the top of Peay anticline. A few of the wells are so high up that they are within the independent dome structure of Peay anticline, that is, above the level of the bottom of the syncline between Peay and Sheep Mountain anticlines, but a great many are below that level and must, therefore, be treated as though they occurred on a monocline, or on the slope of Sheep Mountain.

The preservation of the oil in such a position can be accounted for by assuming that the water in its descent from the upper part where it enters the oil sand, (along Shell Creek is the nearest exposure of this horizon) effectively seals off the lower portion by the force of capillary attraction and thus prevents the escape of the oil. Another explanation may also be offered, based on the discontinuity of the productive stratum due to faulting, whereby the oil-bearing sands are brought opposite impervious shales. This condition may well be considered at Greybull, since faults of sufficient magnitude occur there to have this effect. Still another explanation has been offered, viz., the discontinuity of the productive horizon, because of erosion previous to the deposition of the overlying beds. In this case an unconformity exists, and, to the writer, it appears that the basal sands of the upper series would furnish a passageway for the oils though which they might migrate and escape. The writer is inclined to ascribe considerable weight to faulting, as a cause for sealing up the oil on the west side of the dome.

PROBABLE FUTURE DEVELOPMENTS

The small size of the oil and gas producing structures of this field precludes the possibility of large scale production. The Torchlight dome yields oil only, and the wells are

confined to a relatively small area at the top of the anticline so that the quantity of oil that may be expected is not great. The Lamb anticline will produce gas enough to supply the small local consumption for a number of years, but, on account of the small size of the dome, the gas supply is surely limited. The quantity of oil on the productive side of this dome is hard to estimate in the absence of any data regarding the pressure at the wells and its behavior after continuous pumping or flowage for some time. Such tests have never been made to the knowledge of the writer. The gas and oil of the Peay anticline are likewise difficult to measure, because of lack of testing data, but, in the case of the gas, it is safe to say that the supply is rapidly being exhausted. The first well which was allowed to flow uncapped for months apparently exhausted the supply to a great extent, as the present gas pressure is so low that the wells will not "feed" when the higher pressure gas from the Lamb anticline is turned into the mains.

The quantity of oil in the Greybull field seems to be somewhat greater than in the other two cases, with the possible exception of the Torchlight dome. The wells seem to show oil at a great depth in this structure, and this will of course increase the available quantity. No tests have been made to ascertain the capacity of any of the wells, according to a statement of Mr. H. T. Lamb, and without this data it is impossible to make a definite estimate of available supply.

CHARACTER OF THE OIL AND GAS

The oils obtained in the Basin and Greybull field are of a paraffin base, and generally of light gravity. Mr. Lamb reports that the oil from Well No. T. 4 gave a test of 28° Baume, and of Well No. T. 14 the gravity was 34°, while that from Well No. T. 2 tested 46°. The oils are all of a greenish color and have a strong odor of gasoline.

No analysis has been made of the gas from this field, but it may be remarked that it has a strong odor of gasoline and burns with a long, luminous, smoky flame.

The oil and gas of this field resemble those of the other fields of the Bighorn Basin.

ORIGIN OF THE OIL AND GAS

The oil and gas of this region are believed to be of organic origin, coming from the slow distillation of the carbonaceous shales of the Benton. Whether they are of animal or of vegetable origin can hardly be determined without complete analyses of the oil and gas, as well as of the rocks, but there seems to be an abundance of dark carbonaceous matter in the shales of the lower part of the Colorado from which these products might be derived. It might be stated that beds of fossilized animal remains are apparently totally lacking in this region, the only indication of former animal life being the fish scales of the Mowry shales. These are relatively abundant, however, and the Mowry has a great lateral distribution as well as thickness ranging from 50 feet to several hundred feet, so that there seems to be evidence of a rather plentiful supply of fishes in the early Benton sea, and these may have contributed to a large degree toward the oil and gas supply.

The lowest horizon (stratigraphic) from which oil and gas have been obtained in this region is the top of the Cloverly. Practically all of the dark shales of the region lie above this formation, the layers below being those of the variegated Morrison beds. It would be difficult to conceive how the oils could have originated below this horizon and migrated to the Cloverly, and higher productive strata, without producing some visible effect upon the highly colored shales and sands that are characteristic of the Morrison. From this kind of reasoning it seems clear that the oil has not come up from below but that it must have originated within the dark shales of the Colorado, and particularly of the Benton.

The accumulation of the oil and gas seem to be closely connected with the structure of the rocks, since commercial quantities of either, or both, are only found in association with domes or anticlines, in this field. The raw materials

which furnished the elements of the oil and gas are widely disseminated, but concentration of the distillates has been restricted to certain localities having favorable structures in which they became stored. Concentration of the oil and gas involves transportation of the small portions that were formed, in place, from the disseminated organic remains to these structures. Such movement may be downward, under the influence of gravity, or it may be upward from hydrostatic pressure, due to circulating waters. The retention of the oil or gas when under pressure is only possible when some impervious cover is available. In this field there is an abundance of shale which has effectually closed off all avenues of escape and held the oil and gas confined in the lower more porous strata.

LOCATIONS AND DEVELOPMENT

Numerous locations of oil and gas claims have been made by different parties, among which the following are more or less prominent: A. S. Mercer, *et al.*; Elmer Todd, *et al.*; W. S. Lenix, *et al.*; H. H. Hime, *et al.*; Homer T. Lamb, *et al.*; Greybull Oil Company; Bighorn Oil & Gas Company; Fullerton Oil Company.

Of these only the last four have succeeded in getting productive ground, and nearly all of the development work in these fields has been done by them. Mr. Homer T. Lamb represents the Greybull Oil Co., Bighorn Oil & Gas Co., Bighorn Drilling Co., and Bighorn Supply Co., which brings the interests of these companies under one management. All of the drilling operations of these companies as well as a number of others for smaller companies, have been supervised by Mr. Lamb. The Fullerton Oil Company has also done considerable drilling in this region, particularly on the Torchlight dome.

THE OIL AND GAS WELLS

More than 60 wells have been drilled in the Basin and Greybull oil and gas field to date. The present report

deals with 58 of these, showing the location and results of drilling, together with the elevation at the mouth of each well. Log data has been withheld, on most of the wells, pending litigation which is now in progress, but partial logs have been obtained for some of the wells. In the following pages all the data at hand is presented for each individual well, and the order of treatment is by fields, and operating companies, except in a few cases.

WELLS IN THE KIMBALL SAND

The following is a list of the wells located on the Torchlight and Lamb anticlines, and belonging principally to the Lamb interests, and to the Fullerton Oil Company.

Well No. T. 1. Owned by the Greybull Oil Company. Located in the northeast corner of the northeast quarter of the southwest quarter of section 24, T. 51 N., R. 93 W. Elevation at the mouth of the well, 4128. Data regarding this well has been withheld, but it is known to be an oil well of shallow depth. Sulphur water and a small showing of oil and gas was encountered in the Peay sandstone, which is here about 200 feet below the surface. The oil obtained from the Kimball sand is said to be of light gravity. Drilled in the spring of 1914.

Well No. T. 2. Owned by the Greybull Oil Co.; located in the southeast corner, southeast quarter, northwest quarter, section 24, T. 51 N., R. 93 W. Elevation at the mouth of the well, 4128. Data withheld, but it is reported to be an oil well similar to T. 1. Drilled in the spring of 1914.

Well No. T. 3. Owned by Greybull Oil Company. Located in the northeast corner of the northeast quarter of the northwest quarter of section 24, T. 51 N., R. 93 W. Elevation at the mouth of the well is 4225. The hole was started at the base of the Torchlight sandstone, but data regarding the formations passed through have been withheld, but it is known that oil was obtained in the Kimball sand.

Well No. T. 4. Greybull Oil Company, owner. The well situated in the southwest corner of the southwest

quarter of section 12, T. 51 N., R. 93 W. The elevation at the mouth of the well is 4260. The well was started in the middle portion of the Basin shales and oil was obtained presumably in the Kimball sand. Log data withheld. Up to the end of the field season this was the only good oil well located on the Lamb anticline.

Well No. T. 5. Greybull Oil Company, owner. The well situated in the south half of the southeast quarter of the southeast quarter of section 12, T. 51 N., R. 93 W. Elevation at the mouth of the well, 4178. The well was started at the top of the Torchlight sandstone and gas was obtained from the Kimball sand. Details regarding the formations passed through were withheld.

Well No. T. 6. Greybull Oil Company, owner. Well located in the southwest corner of the northeast quarter of the southwest quarter of Section 7, T. 51 N., R. 92 W. Elevation at the mouth of the well, 4228. This well was started at a point about fifty feet above the top of the Torchlight sandstone, and was continued to the Kimball sand in which gas was obtained. Log data withheld.

Well No. T. 7. Greybull Oil Company, owner. Well located in the southwest corner of the southeast quarter of the northeast quarter of Section 12, T. 51 N., R. 93 W. Elevation at the top of the casing, 4278. This well was started at a point about 100 feet above the base of the Basin shale. Water was encountered in the Greybull sand and gas and water in the Kimball sand. After pumping the water for some time the gas began to flow. Log data withheld.

Well No. T. 8. Greybull Oil Company, owner. Well located in the southeast corner of the southwest quarter of the northwest quarter of Section 7, T. 51 N., R. 92 W. The elevation at the mouth of the well, 4595. This well was started in the Basin shale about 400 feet above the top of the Torchlight sandstone, and was drilled presumably to the Kimball sand, where water was obtained. Log data withheld.

Well No. T. 9. Greybull Oil Company, owner. The

well is situated in the northwest corner of the northwest quarter of the southeast quarter of Section 18, T. 51 N., R. 92 W. The hole was started at a point about 300 feet above the top of the Torchlight sandstone and was drilled to the Kimball sand. The hole was reported dry. Log data not given.

Well No. T. 10. Well drilled by Holdridge & Champion, of Denver, Colo. Located in the southwest corner of the southwest quarter of section 18, T. 51 N., R. 92 W. Elevation at the mouth of the well, 4110. The well was started at a point about 150 feet above the top of the Torchlight sandstone. Data regarding the formations passed through was not obtainable. The well was drilled during July and August, 1914. Oil was later reported.

Well No. T. 11. Well drilled by the Greybull Oil Company, on Government land. Located in the northwest corner of the northeast quarter of the northeast quarter of section 19, T. 51 N., R. 92 W. Elevation at the mouth of the well, 4395. The well was started at a point about 650 feet above the top of the Torchlight sandstone. Log data was withheld. The hole was reported to be dry.

Well No. T. 12. Owner unknown. Well situated in the northwest corner of the southwest quarter of the southeast quarter of Section 35, T. 51 N., R. 92 W. The elevation at the mouth of the well, about 4240. The well was drilled near the top of a small anticline, with negative results.

Well No. T. 13. Owner unknown. Drilling has never been done, but a standard derrick marks the location of this well site, which is in the northeast corner of the northwest quarter of the northeast quarter of Section 35, T. 51 N., R. 92 W. The elevation at the surface at this point is 4263. The formation here exposed is approximately the top of the Basin shale.

Well No. T. 14. Greybull Oil Company, owner. Well located in the southwest corner of the northwest quarter of the northwest quarter of Section 1, T. 51 N., R. 93 W. The elevation at the top of the casing is 4419.

The well was started at a point about 650 feet above the top of the Torchlight sandstone, and was drilled to the Kimball sand, in which a heavy lubricating oil and salt water were found. The well was drilled during July, 1914. Log data withheld.

Well No. T. 15. Greybull Oil Company, owner. Well was located in the northwest corner of the southwest quarter of the southeast quarter of section 25, T. 52 N., R. 93 W. The elevation at the mouth of the casing is approximately 4500. This well was still being drilled when the party left the field, and the results of the drilling have not been ascertained. The well was started in the Basin shale at a point about 700 feet above the top of the Torchlight sandstone. Finally reported dry.

Well No. T. 16. Elmer Todd, *et al.*, owners. The well is located in the northeast corner of the northwest quarter of the southwest quarter of Section 25, T. 51 N., R. 93 W. The elevation at the mouth of the well is 9385. The well was drilled during the spring of 1914. The hole was started at a point near the top of the Basin shale and was continued to the Kimball sand with negative results. Log data not obtainable.

Well No. T. 17. Elmer Todd, *et al.*, owners. The well was located at the northwest corner of the southeast quarter of the southwest quarter of section 25, T. 51 N., R. 93 W. The elevation at the mouth of the well was 4055. The hole was reported to be dry. It was drilled during the spring of 1914.

Well No. C. 1. The Fullerton Oil Company, owner. Well was located in the northeast corner of the southeast quarter of the northeast quarter of Section 10, T. 51 N., R. 93 W. The elevation at the mouth of the well is 3880. The well was started at a point about 225 feet above the top of the Torchlight sandstone. The well was drilled to the Greybull sand, where water was encountered. The well was drilled during June and July, 1914. Log data withheld.

Well No. C. 2. Fullerton Oil Company, owner. Well is located in the northwest corner of the southeast quarter

of Section 24, T. 51 N., R. 93 W. The elevation at the mouth of the well, 4107. The well was started in the Upper Benton shale at a point about 200 feet above the Peay sandstone. Details regarding the formations passed through have not been furnished for publication, but it is known that oil was obtained at a comparatively shallow depth in the Kimball sand.

Well No. C. 3. The Fullerton Oil Company, owner. Well is located in the northwest quarter of the southeast quarter of Section 24, T. 51 N., R. 93 W. Elevation at the mouth of the well, 4072. The well was started in the Upper Benton shale, at a point about 200 feet above the top of the Peay sandstone. Data regarding the formations passed through in drilling were not furnished for publication, but it is known that oil was obtained at a comparatively shallow depth, presumably at the same horizon as the well No. C. 2.

Well No. C. 4. The Fullerton Oil Company, owner. Well was located very close beside well No. C. 3. and the same conditions were found in this well as in C. 2 and C. 3. The elevation at the mouth of the well, 4072. Log data have been withheld, but it is known that oil was obtained at a shallow depth of a few hundred feet, presumably from Kimball sand.

Well No. C. 5. The Fullerton Oil Company, owner. Well was located in the southeast corner of the northeast quarter of Section 24, T. 51 N., R. 93 W. The elevation at the mouth of this well is 4126. This well was started in the Upper Benton shale at a point about 200 feet above the Peay sandstone. Log data was withheld, but it is known that oil was obtained at a shallow depth, presumably from Kimball sand.

Well No. C. 6. Hiatus well, owned by the Fullerton Oil Company. Located in the northwest corner of the northwest quarter of Section 30, T. 51 N., R. 92 W. Elevation at the mouth of the well, 4185. The well was started at a point near the top of the Torchlight sandstone, and was drilled through the Kimball sand where oil was

obtained. Details regarding the formations passed through have been withheld.

Well No. C. 7. Greybull Oil Company, owners. Well is located in the southeast corner of the southwest quarter of the southwest quarter of Section 19, T. 51 N., R. 92 W. Elevation at the mouth of the well is 4208. Log data withheld. This well was drilled in the spring of 1914, and oil was obtained at a comparatively shallow depth. Well started at a point near the top of the Torchlight sandstone, and the well was drilled through to the Kimball sand, where oil was obtained.

Well No. C. 8. Due to an error in transferring data gathered in the field to the map, a small pump house was represented as an oil well. There is no well corresponding to C. 8.

Well No. C. 9. Greybull Oil Company, owners. Well was located in the west half of the northwest quarter of the southwest quarter of Section 19, T. 51 N., R. 92 W. Elevation at the mouth of the well, 4145. The well was started at a point near the base of the Torchlight sandstone and was continued down to the Kimball sand, where oil was obtained. Log data have been withheld.

Well No. C. 10. Greybull Oil Company, owners. Located in the northwest corner of the northwest quarter of the southwest quarter of Section 19, T. 51 N., R. 92 W. Conditions in this well were the same as in C. 9.

Well No. A. 1. The Sherard well. Located in the northwest corner of the northwest quarter of Section 11, T. 51 N., R. 93 W. Elevation at the mouth of the well, 3905. This well was drilled several years ago and details regarding the formations passed through have not been obtainable.

WELLS IN THE CLOVERLY, OR GREYBULL SAND

Well No. G. 1. The Node well. Located at the southwest corner of the northeast quarter of the northeast quar-

ter of Section 8, T. 52 N., R. 93 W. A partial log of this well is as follows:

Peay sandstone (A)	21 ft.	
Top of Cloverly (Greybull sand)	1092 ft.	Water
Bottom of well (Red beds)	1106 ft.	

Well No. G. 2. Located in the southwest corner of the northeast quarter of the southeast quarter of Section 9, T. 52 N., R. 93 W. Elevation at the top of the well is 3828. This well is said to be dry by Mr. H. T. Lamb, but laymen about Greybull say that oil was obtained from this well. Well was started near the top of the Peay sandstone and was drilled to the Greybull sand. Log data withheld.

Well No. G. 3. Greybull Oil Company, owners. Located in the southeast corner of the northeast quarter of section 18, T. 52 N., R. 93 W. The elevation at the top of this well is 3830. Partial well record is as follows:

Top of Peay sandstone (A) reached at depth of	680 ft.	Water.
"Muddy" sand reached at	1410 ft.	
Top of Cloverly	1730 ft.	
Bottom of well	1965 ft.	

The bottom of this well was approximately 200 feet below the top of the Cloverly, (Greybull sand) in the red beds. No water or gas was obtained in any sand below the Peay sandstone.

Well No. G. 4. Bighorn Oil and Gas Company, owners. Located in the southeast corner of the southwest quarter of the northeast quarter of Section 17, T. 52 N., R. 93 W. The elevation at the top of casing is 3823. Log data withheld. Oil was obtained in the Greybull sand.

Well No. G. 5. Bighorn Oil & Gas Company, owners. Well is located in the northeast corner of the southeast quarter of the northeast quarter of Section 17, T. 52 N., R. 93 W. The elevation at the top of this well, 3779. Log data was withheld, but it is known that oil was obtained in this well at a depth of approximately 1000 feet, in the Greybull sand.

Well No. G. 6. Bighorn Oil & Gas Company, owners. Well is located on an island in the Bighorn River, in the

southwest corner of the northwest quarter of Section 16, T. 52 N., R. 93 W. The elevation at the mouth of the well is 3780. Log data have been withheld, but it is reported that gas was obtained in the Greybull sand. The occurrence of gas in this well was not expected.

Well No. G. 7. Bighorn Oil & Gas Company, owners. Well is located in the northwest corner of the southwest quarter of Section 16, T. 52 N., R. 93 W., on an island in the Bighorn River. The elevation at the top of the casing is 3780. Log data withheld.

Well No. G. 8. Bighorn Oil & Gas Company, owners. The well is located in the northeast corner of the southwest quarter of the northwest quarter of Section 16, T. 52 N., R. 93 W. The elevation at the top of the casing is approximately 3950. Log data withheld. Gas was obtained from the Greybull sand.

Well No. G. 9. Bighorn Oil & Gas Company, owners. This well is located in the northeast corner of the northwest quarter of the southwest quarter of Section 16, T. 52 N., R. 93 W. The log of this well was withheld, but it is reported that gas was obtained in the Greybull sand at a depth of about 1065 feet.

Well No. G. 10. Bighorn Oil & Gas Company, owners. This well was located in the northeast corner of the southwest quarter of Section 16, T. 52 N., R. 93 W. The well record was withheld but gas is reported to have been obtained from the Greybull sand.

Well No. G. 11. Bighorn Oil & Gas Company, owners. The well is located in the northeast quarter of the southwest quarter of Section 16, T. 52 N., R. 93 W. Well record was not obtainable, but this well is said to produce gas from the Greybull sand.

Well No. G. 12. Bighorn Oil & Gas Company, owners. Located in the southwest corner of the southeast quarter of Section 16, T. 52 N., R. 93 W. Log data not obtainable, but the owners report gas from the Greybull sand.

Well No. G. 13. Bighorn Oil & Gas Company, owners.

Well is located in the northwest corner of the northeast quarter of Section 21, T. 52 N., R. 93 W. Log data not obtainable, but the owners report gas from the Greybull sand.

G. 14. There is no well corresponding to G. 14, as shown on the map.

Well No. G. 15. Owners unknown. Located in the southwest quarter of the northwest quarter of Section 22, T. 52 N., R. 93 W. This hole was drilled by Mr. H. T. Lamb, who has kindly furnished the following partial log:

Top of the "Muddy" sand	790 ft.
Top of the Cloverly	1116 ft.
Base of the Cloverly	1134 ft.
Bottom of the hole	1175 ft.

All sands reported dry.

Well No. G. 16. Owner unknown. Located in the northeast corner of the southwest quarter of Section 22, T. 52 N., R. 93 W. This well was drilled by Mr. H. T. Lamb, who has furnished the following data:

Top of the "Muddy" sand	870 ft.
"Greybull" sand	1197-1215 ft.
Bottom of the well	1220 ft.

All sands dry. The top of this well has an elevation, 3963. The drilling began at the top of the Peay sandstone.

Well No. G. 17. Bighorn Oil & Gas Company, owners. Well located in the northwest corner of the southeast quarter of Section 21, T. 52 N., R. 93 W. Partial log has been furnished by Mr. H. T. Lamb, as follows:

Top of the "Greybull" sand	1075 ft.	Water.
Bottom of the well	1150 ft.	Water.

This well is located at the top of the Peay anticline, and the presence of water in the Greybull sand is therefore rather surprising. Special conditions not accounted for by the anticlinal theory must exist at this point.

Well No. G. 18. Skinner well. Owner unknown. Located in the northeast quarter of the northwest quarter of Section 28, T. 52 N., R. 93 W. The elevation at the mouth of the well is 3798. This well was drilled during 1913 by Mr. H. T. Lamb, who has furnished the following partial log:

Gravel	22 ft.
Shale	613 ft.
Top of the "Muddy" sand	635 ft.
Top of the "Greybull" sand	952 ft.
Water in the "Greybull" sand	957 ft.
Bottom of the "Greybull" sand	972 ft.
Bottom of the hole (in red beds)	1108 ft.

At the present time water and gas are overflowing the top of this well in small quantities. The gas comes presumably from the Greybull sand.

Well No. G. 19. The Maloney well. Owner unknown. Located in the southwest quarter of the southwest quarter of Section 21, T. 52 N., R. 93 W. This well was drilled during 1913 by Mr. H. T. Lamb, who has furnished the following partial log:

Top of the "Muddy" sand	613 ft.
Some gas in the "Muddy" sand.	
Top of the "Greybull" sand	936 ft.
Water in the "Greybull" sand.	
Bottom of the "Greybull" sand	960 ft.

Well No. G. 20. Owner unknown. Located in the northwest corner of the southwest quarter of Section 28, T. 52 N., R. 93 W. Elevation at the mouth of the well, 3855. This well was being drilled during July and August, 1914. Results unknown.

Well No. G. 21. Bighorn Oil & Gas Company, owners. Well located in the southwest corner of the northwest quarter of Section 21, T. 52 N., R. 93 W. The elevation at the top of the casing is 3790. Log data not obtainable. This well is reported to have obtained oil from the Greybull sand.

Well No. G. 22. Bighorn Oil & Gas Company, owners. Located at the southeast corner of the northeast quarter of Section 19, T. 52 N., R. 93 W. Elevation at the mouth of the well, 3795. The log data not obtainable, but it is known that oil is obtained from the Greybull sand. This well is located on the north bank of the Greybull River, and was started at a point approximately in the center of the Basin shale.

Well No. G. 23. Bighorn Oil & Gas Company, owners. Well located on the north bank of the Greybull River. In the northeast quarter of the northeast quarter of Sec-

tion 20, T. 52 N., R. 93 W. Elevation at the mouth of this well is 3791. Log data were withheld, but it is reported that oil was obtained from the "Greybull" sand.

Well No. G. 24. Bighorn Oil & Gas Company, owners. Located at the northeast corner of the northeast quarter of Section 20, T. 52 N., R. 93 W. Elevation at the top of the casing 3786. Log data not furnished, but oil is reported to have been obtained in the "Greybull" sand.

Well No. G. 25. Bighorn Oil & Gas Company, owners. Located at the southeast corner of the southeast quarter of Section 17, T. 52 N., R. 93 W. Elevation at the top of the casing, 3784. The log of this well was withheld, but it is reported that oil was obtained from the Cloverly or "Greybull" sand.

Well No. G. 26. Bighorn Oil & Gas Company, owners. Located at the southeast corner of the northwest quarter of the southeast quarter of Section 17, T. 52 N., R. 93 W. The elevation at the top of the casing, 3825. The log of this well was withheld, but oil is reported from the "Greybull" sand.

Well No. G. 27. Bighorn Oil & Gas Company, owners. Located at the northeast corner of the southeast quarter of the southwest quarter of Section 17, T. 52 N., R. 93 W. The elevation at the top of the casing is 3828. This well was started at a point approximately at the top of the Torchlight sandstone. The log of the well was not obtainable, but it is reported that oil was obtained from the "Greybull" sand.

Well No. G. 28. Jewel oil well. Bighorn Oil & Gas Company, owners. Located at the southeast corner of the southeast quarter of Section 18, T. 52 N., R. 93 W. The elevation at the top of the casing is 3830. This well shows the following partial log data, as furnished by Mr. H. T. Lamb:

Shale, with abundant water	125 ft.
Top of the Peay sandstone (A)	770 ft.
Top of the "Muddy" sand	1475 ft.
Top of the "Greybull" sand	1795 ft.
Bottom of the well	1830 ft.

By pumping, this well yields a small amount of oil from the "Greybull" sand.

Well No. G. 29. Bighorn Oil & Gas Company, owners. Located in the center of the southeast quarter of the northwest quarter of Section 21, T. 52 N., R. 93 W. Log data withheld. Gas has been reported as obtained from the "Greybull" sand.

Well No. G. 29. Owner unknown. Located in the southeast corner of the northwest quarter of Section 15, T. 52 N., R. 93 W. Mr. H. T. Lamb has furnished the following partial log of this well:

Top of the "Muddy" sand	800 ft.	
"Greybull" (?)	1144-1160 ft	Water.
Stray sand	1200 ft.	
Red beds	1302 ft.	Water.

The elevation at the mouth of this well is 3930.

Well No. G. 30. Bighorn Oil & Gas Company, owners. Located in the northeast corner of the southwest quarter of the northwest quarter of Section 21, T. 52 N., R. 93 W. The log of this well was withheld. Gas is reported from the "Greybull" sand.

Well No. G. 31. Armstrong well. (Not shown on the map.) Located on Lot No. 4 in Section 16, T. 52 N., R. 93 W. This well is owned by the Bighorn Oil & Gas Company. The following data has been furnished by Manager H. T. Lamb:

Top of the "Greybull" sand	1075 ft.
Bottom of the "Greybull" sand	1095 ft.

Gas obtained from the "Greybull" sand. The pressure at this well is said to be between 120 and 400 lb., furnishing 2000 cu. ft. of gas per day.


STATE OF WYOMING
1933
GEOLOGICAL SURVEY

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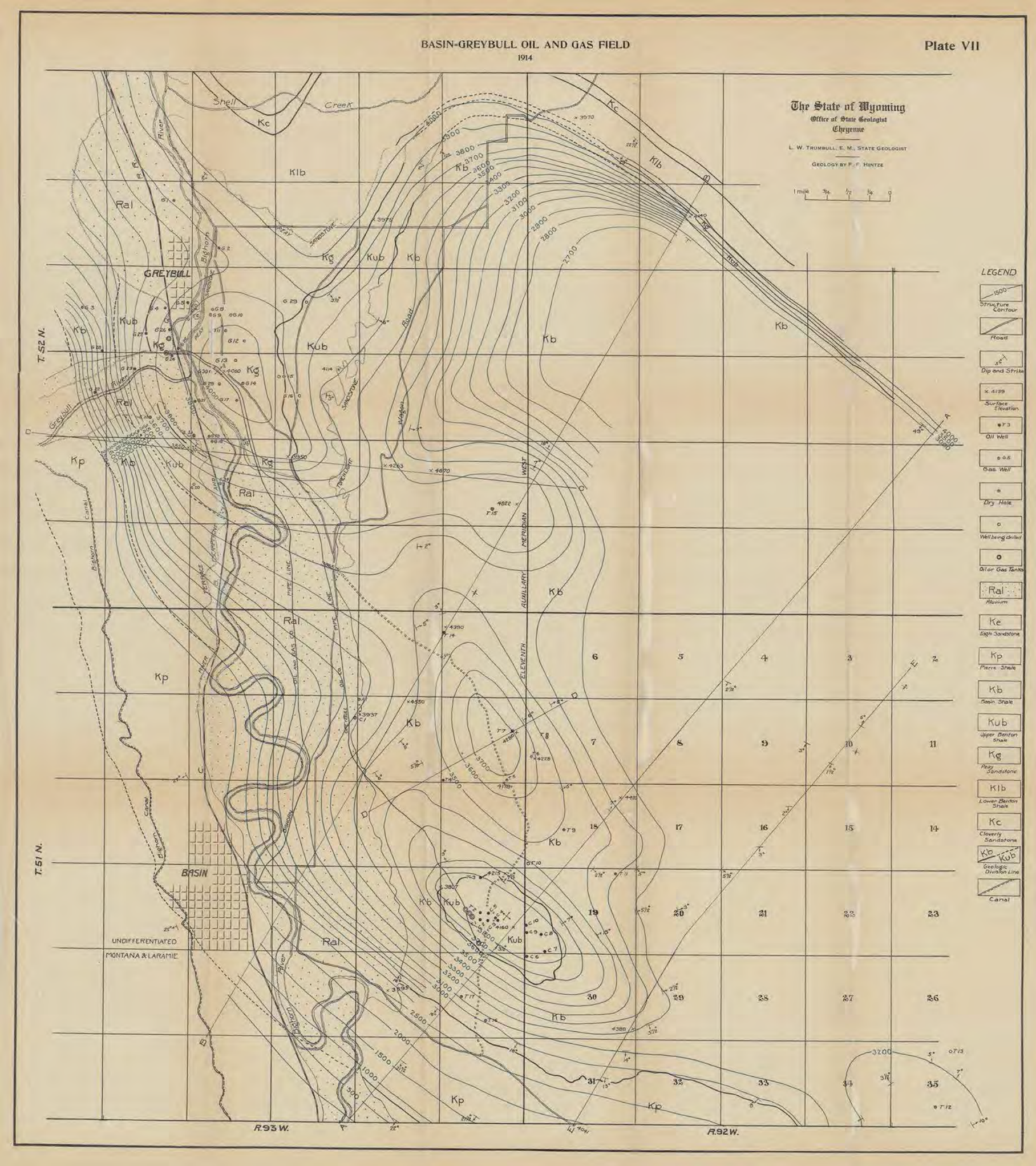
BASIN-GREYBULL OIL AND GAS FIELD

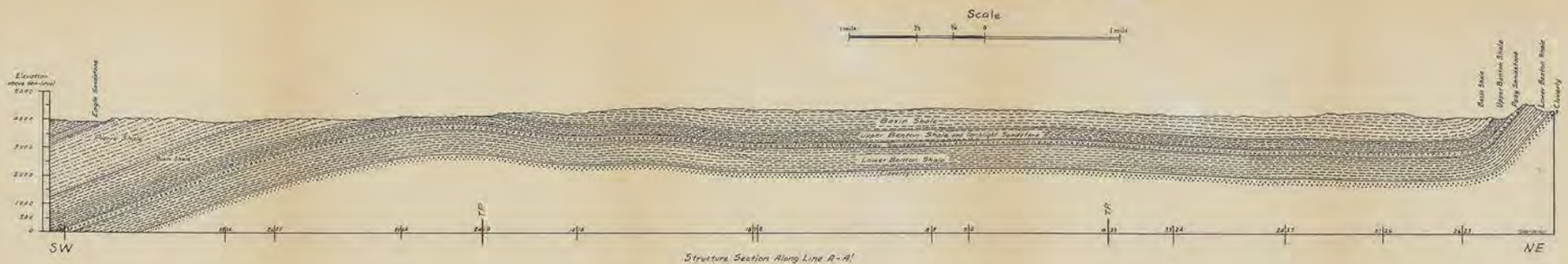
1914

Plate VII



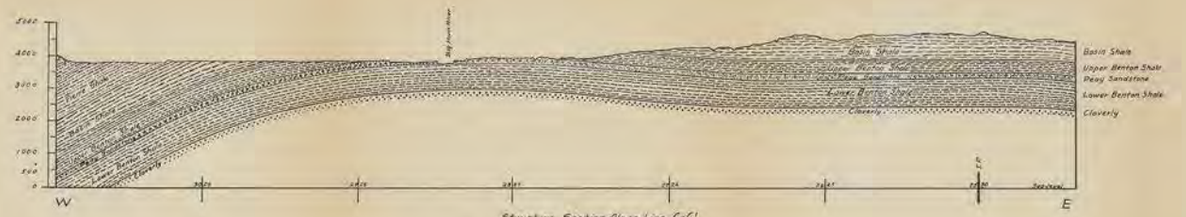
BASIN-GREYBULL OIL AND GAS FIELD

Plate VIII



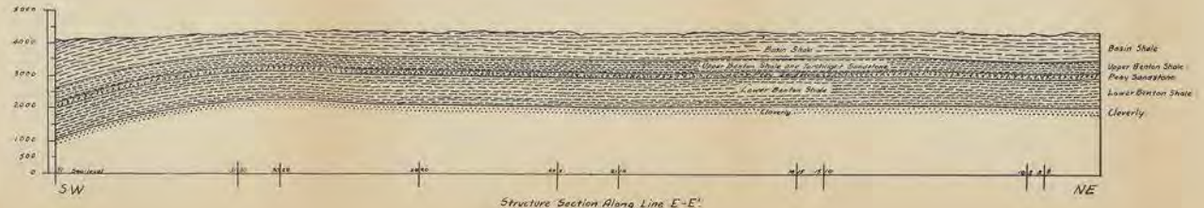
Structure Section Along Line A-A'

Structure Section Along Line B-B'

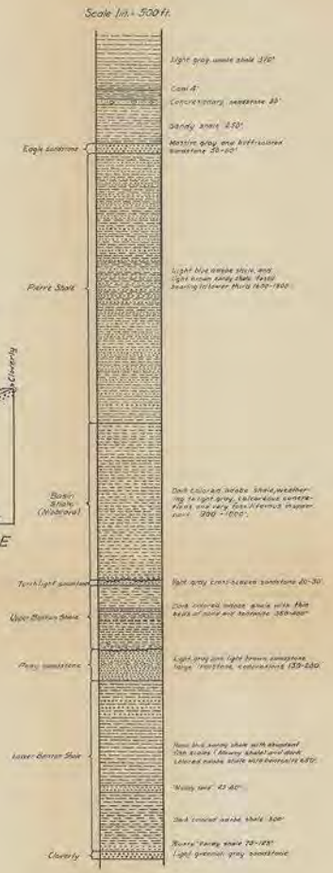


Structure Section Along Line C-C'

Structure Section Along Line D-D'



Structure Section Along Line E-E'



COLUMNAR SECTION,
SHOWING, SUCCESSION THICKNESS
AND CHARACTER OF FORMATIONS.

The State of Wyoming
Office of State Geologist
Cheyenne

1915

GEOLOGY BY F. F. HINTZE