THE DOUGLAS OIL AND GAS FIELD, CONVERSE COUNTY, WYOMING.

By V. H. Barnett.

LOCATION AND DEVELOPMENT OF THE FIELD.

The region discussed in this paper comprises about 180 square miles south of North Platte River and west of Douglas in Converse County, Wyo., and includes portions of Tps. 32 and 33 N., Rs. 72 to 74 W. of the sixth principal meridian. (See fig. 2.) The Chicago

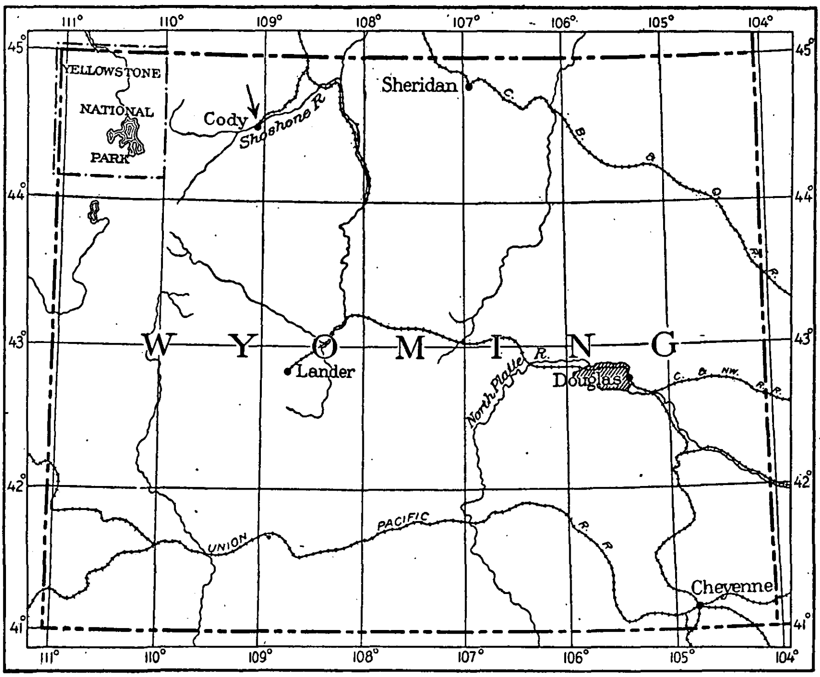

FIGURE 2.—Index map showing location of Douglas oil and gas field, Wyoming. Arrow indicates location of section shown on Plate V (p. 108).

& Northwestern Railway traverses the area in an east-west direction, and surveys have been made through the field for a branch line of the Chicago, Burlington & Quincy Railroad, which will connect the branch line to Orin with the line to Powder River.

The first discovery of oil in this field was probably made in 1894, when in the construction of an irrigation tunnel in the NW. ¼ sec. 16,

T. 32 N., R. 73 W., a sandstone more or less saturated with heavy oil was found in the top of the "Cloverly" formation. Since this discovery several companies have put down wells at different times until at present some 50 or 60 borings are scattered over the Brenning Basin. When drilling began the presence of gas in the basin was little suspected, but a number of the wells have proved to contain more gas than oil. In December, 1904, gas was struck at a depth of 435 feet in a well (No. 18, Pl. IV) in sec. 4, T. 32 N., R. 73 W., in which, according to a statement of J. B. Phillips in applying for title for mineral claim, a pressure of 50 pounds to the square inch was obtained when tested two days later. The Douglas Oil Fields Co. piped the gas to the adjoining claim and used it for several months under a boiler for drilling and for camp purposes. Gas from this well in 1912 was still used at the nearest house. Oil is reported to have been found in 32 wells, gas in 20 wells, and water in 24 wells in this basin. All the 66 wells indicated by numbers on the map (Pl. IV) have corresponding numbers in the list of wells on pages 73-74.

VEGETATION, FUEL, AND WATER SUPPLY.

Farming is carried on extensively in favorable localities, where alfalfa, timothy, and small grain are profitably raised by irrigation. The part of the area not under cultivation yields a good growth of grass which supplies perennial range for stock.

The rainfall is not sufficient to support a growth of timber, except scattered cottonwood and boxelder trees along the streams and a few scrubby pine and cedar on some of the rocky hills. However, marketable pine timber grows in isolated areas in the mountains to the south, especially along the precipitous walls of Boxelder Creek in T. 32 N., R. 75 W. This area was included in one of the wood reserves of the old Fort Fetterman Military Reservation.

The domestic fuel, for the most part, consists of pine and cedar wood, which is hauled from the mountains, and coal, which is mined in the northern part of the area near Inez or at Glenrock, just northwest of the field. Oil and gas have also been utilized to a slight extent as fuel. In 1912 a number of ranchmen in Brenning Basin were using gas for lighting and heating and in one place crude oil was used for heating.

The several streams which rise in the mountains and flow across the field to North Platte River yield a good supply of fresh water for domestic use. For a number of years water from La Prele, Boxelder, and Little Boxelder creeks has been utilized for irrigating small tracts along these streams, but within the last few years irrigation on a larger scale has been made practicable by the completion of the La Prele dam. This dam is so located that the water may be used to generate electricity before it is allowed to flow into the irrigation canals. With this end in view the Platte Valley Development Co. has constructed a power plant below the dam and proposes to transmit electricity to a pumping station on the North Platte, where water for irrigation is to be taken from that stream.

Several good springs of water seep from the gravel and sand beds of the White River formation, notably from the thick conglomerate covering the higher hills in T. 32 N., R. 72 W. A perennial spring with a flow of water several inches in diameter, coming from the sandstone or limestone of the Casper formation, rises at the foot of the mountain in sec. 2, T. 32 N., R. 74 W. Other springs of minor importance come from the granitic rocks or the Casper formation along the foot of the mountain ridge.

ACKNOWLEDGMENTS.

In presenting this report the writer wishes to express his thanks for courtesies extended during the progress of the field work by the people of Douglas and vicinity, and to Messrs. Consaul & Heltman, attorneys for the Wyoming Oil & Development Co., and Douglas Oil Fields (Ltd.). Especial credit is due to Mr. A. W. Phillips, who gave well logs and other information, and to Mr. L. C. Bishop, a local surveyor, who loaned a map of a part of the field.

The field work was done in September and October, 1912, by a party consisting of Frank A. Herald, R. Z. Pierce, Frank Elliott, Bernard Jackson, and the writer.

PURPOSE OF THE INVESTIGATION.

The primary object of the investigation of this field was to ascertain the mineral resources, especially oil, gas, and coal, for the purpose of classifying the land by legal subdivisions into mineral land and nonmineral land. A secondary object and one closely connected with the first was to determine, so far as possible, the geologic structure, the various formations involved, and the conditions which have resulted in the accumulation of oil and gas.

METHOD OF FIELD WORK.

The Douglas field was mapped on a scale of 2 inches to the mile by means of a plane table and telescopic alidade, the township being the unit represented by each field sheet. A complete system of triangulation was established covering the field, and the stations of this system served the purpose of horizontal and vertical control and as a means of tying the different plane-table sheets together. In beginning the primary control or triangulation a base line 11,200 feet in length was measured with a steel tape along a level road between two intervisible points. The line extended from the north quarter corner of sec. 8, T. 32 N., R. 73 W., eastward to a point a short distance west of the northeast corner of sec. 10 of the same township. The land net of T. 32 N., R. 73 W., having been drawn on the plane-table sheet before entering the field, the plane table[1] was set up at the west end (the north quarter corner of sec. 8) of the base and approximately oriented by compass. The telescopic alidade was then sighted on the station at the opposite end of the base, a line was drawn along the edge of the alidade, and the distance as determined by the steel tape scaled off. The exact position of the base line having thus been determined on the plane-table sheet, lines were drawn in the direction of a great number of prominent points, such as houses, trees, derricks, and buttes, and the vertical angles read. After sighting at as many points as were desired from this end of the base the other end was occupied and the table oriented by a back sight on the first station. A second line was then drawn in the direction of as many of the points first sighted as could be seen, thus locating these landmarks on the plane-table sheet. Many of the newly located points were in turn occupied and other points throughout the field were located that were invisible from either end of the original base line. This system was continued throughout the field by transferring points on the margin of one sheet to an adjoining sheet. Wherever a section corner was found it was located on the map with respect to triangulation stations. Altitudes were determined in a large part of the area by means of vertical angles, and in addition a line of levels was carried by the same method from Douglas, at an altitude of 4,800 feet, to each well. (See p. 73.) Stadia traverses were employed in conjunction with triangulation for mapping formation boundaries and locating wells. The map, Plate IV, was assembled after returning to the office by joining the individual plane-table sheets, using the points common to two or more of them.

LAND SURVEYS.

The positions of the Government land corners shown on the map were determined by triangulation and therefore are correct so far as the scale of the map would permit. No attempt was made to find all the section corners, but in the vicinity of the oil and gas wells a considerable number were found. The net shown on the map is based on section corners located in the field and from the alignment map of the Chicago & Northwestern Railway and the General Land Office plats. The net of R. 72½ was drawn from plats in the files of the General Land Office and from three corners shown on the map (Pl. IV), which were located by triangulation in the field and agree with the Land Office record. R. 72½ was surveyed in 1907, as well as

[1] A 15 by 15 inch plane table was used for mapping individual townships, but for carrying locations the larger 24 by 24 inch plane table was employed.

sec. 18, T. 32 N., R. 72 W., the net of which is copied from the Land Office data.

TOPOGRAPHY.

The Douglas oil field may be described in a general way as a rolling prairie dotted with a few prominent buttes and ridges that stand above the general level and inclosed on the south by a low range of mountains. Several small streams which emerge from the mountains through deep canyons cross the area in flat-bottomed valleys and flow into North Platte River. The main part of the oil field lies in the so-called Brenning Basin, a basin-like area in the northern part of T. 32 N., R. 73 W., which is surrounded on three sides by an upland of considerably greater altitude.

The elevation along North Platte River is about 4,800 feet above sea level, but the land rises gradually toward the south until at the foot of the mountains it is 5,400 feet above sea. Thence to the summit of the range, a horizontal distance of less than a mile, the surface rises about 600 feet.

GEOLOGY.

STRATIGRAPHY.

GENERAL SECTION.

The rocks of the Douglas oil field and vicinity include about 10,000 feet of Paleozoic and Mesozoic formations, ranging in age from Carboniferous to late Cretaceous, and extensive beds of Tertiary (Cenozoic) age, as shown by the following table:

Generalized section of rocks in the Douglas oil and gas field and vicinity, Wyoming.

System.	Series.	Group.	Formation and member.	Character.	Thickness.
Quaternary.				Alluvium, gravel, and sand.	*Feet.* 25±
			Unconformity		
Tertiary.	Oligocene.		White River formation.	Clay, conglomerate, and sandstone.	1,070
			Unconformity		
	Eocene.		Fort Union formation.	Friable sandstone and shale with beds of coal.	(?)
Cretaceous or Tertiary.	(?)		Lance formation.	Friable sandstone and shale with local bed of coal.	4,000+

Generalized section of rocks in the Douglas oil and gas field, Wyoming—Continued.

System.	Series.	Group.	Formation and member.		Character.	Thickness.
						Feet.
Cretaceous.	Upper Cretaceous.	Montana.	Pierre formation.	Probably includes Fox Hills sandstone.	Friable sandstone and shale with local beds of coal near top.	1660
				Parkman (?) sandstone member.	Massive buff sandstone.	150
					Friable sandstone and shale.	1,100
				Shannon (?) sandstone lentil.	Buff to brown sandstone.	300±
					Dark shale with sandstone and calcareous concretions.	1,900
		Colorado.	Niobrara shale.		Gray calcareous shale.	100
			Benton shale.		Dark shale.	300
				Wall Creek (?) sandstone lentil.	Gray and buff sandstone.	100
					Dark soft shale.	870
				Mowry shale member.	Dark-bluish hard shale; weathers light bluish gray to yellowish.	175
					Dark soft shale.	220
	Lower Cretaceous.		"Cloverly" formation.		Buff sandstone and dark shale with black shale near base.	115
Jurassic or Cretaceous.	(?)		Morrison formation.		Green, gray, buff, and maroon shales, and thin sandstone.	200+
Jurassic.	Upper Jurassic.		Sundance formation.		Greenish-gray limestone and sandstone. Largely concealed by White River formation.	300+
Triassic (?).			Chugwater formation.		Largely concealed by White River formation, but lower part where exposed consists of red sandy shale.	1500
Carboniferous.	Pennsylvanian.		Forelle (?) limestone.		Gray thin-bedded limestone.	29
			Satanka (?) shale.		Red shale with thin beds of limestone.	60
			Casper formation.		White, pink, and blue limestones, and gray, white, and buff sandstones.	1,100±
	Mississipian.				Coarse sandstone, interbedded in upper part with calcareous shale.	80
			——Unconformity——			
Archean or Algonkian.					Crystalline rocks cut by dikes.	

The map (Pl. IV) shows the limiting boundaries of each formation listed in the table, so far as they could be traced. These boundaries have been extended across the territory covered by the White River formation and represent the position which the formations would probably occupy if the overlapping White River formation was removed. In drawing boundaries across the White River formation the writer has used the data afforded by well records, which, however, if taken alone would be of very little use, but combined with other data are of considerable value. A fair estimate of the thickness of the several formations under the overlap is afforded by a measured section of the rocks exposed in T. 33 N., R. 74 W. In this township the Cretaceous formations strike east and west and pass under the White River formation east of Boxelder Creek. As shown on the map, there is an outcrop of the "Cloverly" formation in the extreme southeast corner of the area. This, with the other outcrops of the formation (indicated on the map), gives data for determining the general strike of the "Cloverly" across the entire field from east to west. Other formation boundaries, where concealed by the White River, are drawn approximately parallel to the "Cloverly." It should be borne in mind, however, that the location of the formation boundaries under the White River is more or less hypothetical and that the possible error may be half a mile.

CARBONIFEROUS SYSTEM.

CASPER FORMATION.

The term Casper formation was proposed by Darton[1] for limestone and sandstone constituting the greater part of the sedimentary rocks in the Casper and Laramie Mountains. Darton says that "these rocks represent the southeastward extension of the Amsden and Tensleep formations but are so changed in character and indefinite in statigraphic limits that correlation is not desirable."

The Casper formation in the Douglas field is a thick mass of limestone and sandstone interbedded locally with red calcareous or gypsiferous shale. It is the oldest sedimentary formation of the region and rests upon the uneven surface of the granite.

The lowest member of the Casper formation in this area consists of 80 to 100 feet of very hard coarse-grained sandstone interbedded in the upper part with calcareous shale. This sandstone resembles the Deadwood formation of the Black Hills and it has been so called by Jamison,[2] but in the present discussion it will be included in the Casper formation, as was done in Darton's original description. The following detailed section of the rocks was measured in Box-

[1] Darton, N. H., Geol. Soc. America Bull., vol. 19, pp. 418–430, 1908.

[2] Jamison, C. E., The Douglas oil field and the Muddy Creek oil field, Wyoming: Wyoming Geol. Survey Bull. 3, ser. B, 1912.

elder Canyon, where the exposures are good. Fossils determined by George H. Girty to be of Mississippian age were collected from the base of the top member and include five species given in the table of Casper fossils (station No. 70 in list, p. 57).

Section of lower part of Casper formation in Boxelder Canyon, sec. 6, T. 32 N., R. 74 W.

	Ft.	in.
Sandstone, pink, calcareous, with quartz pebbles and brachiopods	15	
Conglomerate of quartz pebbles the size of a pea	7	6
Shale, pink, calcareous	6	6
Limestone, thin bedded	1	6
Shale, greenish blue, calcareous, with beds of impure limestone 4 inches thick	13	
Sandstone, heavy bedded, very hard, locally contains white quartz pebbles, generally about as large as a pea but a few 1¼ inches in diameter	55	
Granite.		
	98	6

The Casper formation is the surface rock throughout a large part of the Laramie Mountains just south of the Douglas oil field, where its thick resistant beds are folded and faulted about the core of igneous rocks. It outcrops as a narrow strip along the south side of the Douglas oil field, where a thickness of over 1,100 feet was measured by the writer. This section is given below:

Section of Casper formation in sec. 23, T. 32 N., R. 73 W.

	Feet.
White River formation.	
Sandstone, upper 20 feet very hard, quartzitic and cherty	40
Limestone, hard, compact, impure	15
Sandstone, buff, cross-bedded	150
Sandstone, reddish, readily breaking into slabs in lower part; upper half calcareous	310
Dolomite, hard	10
Sandstone, yellowish	12
Dolomite, light buff, hard	211
Limestone, blue, hard, compact	16
Shale, red, calcareous, sandy	97
Sandstone, white and red, saccharoidal	81
Dolomite, pink and gray, impure, hard and cherty	150
Sandstone, conglomeratic, with some very small white quartz pebbles	81
Granite.	
	1,173

Fossils collected from the Casper formation are given in the accompanying list. Three of these species are referred by Mr. Girty to the Pennsylvanian; the rest belong to the Mississippian series. It might be added that the three species referred to the Pennsylvanian were found near the top of the Casper, and the others at lower horizons in the formation.

Fossils from Casper formation in the Douglas oil field.

[Determined by George H. Girty.]

	Station No.	Township N.	Range W.	Mississippian.	Pennsylvanian.
Camarotœchia aff. metallica	70	32	74	×	....
Camarotœchia sp.	67, 68	32	73	×	....
Chonetes illinoisensis	70	22	74	×	....
Composita subtilita	69	32	73	....	×
Derbya crassa?	69	32	73	....	×
Enteletes? sp.	69	32	73	....	×
Eumetria? sp.	68	32	73	×	....
Schuchertella chemungensis?	70	32	74	×	....
Spirifer centronatus	67 70	32 32	73 74	×	....
Spirifer sp.	68	32	73	×	....
Syringothyris sp.	70	32	74	×	....
Zaphrentis sp.	68	32	73	×	....

SATANKA (?) SHALE.

The name Satanka shale was given by Darton and Siebenthal[1] to the red sandy shale which lies between the Casper formation and the Forelle limestone in the Laramie region. The shale is a red calcareous and gypsiferous rock, closely resembling the shale of the Chugwater formation, but it is separated from the Chugwater in the Laramie Basin for the reason that Pennsylvanian fossils were obtained from the overlying Forelle limestone, and this would necessarily mean that the Satanka shale belongs to that series, whereas the Chugwater is probably Triassic. No fossils were collected by the writer in the Douglas oil field either from the Satanka (?) shale or from the Forelle (?) limestone, but the lithology and stratigraphic position of the shale and limestone agree with those of the Satanka shale and Forelle limestone of the Laramie region, as described by Darton and Siebenthal, and for this reason these terms are provisionally applied here rather than the terminology employed in the Black Hills.

The soft Satanka (?) shale lying between the more resistant Casper strata below and the Forelle (?) limestone above is usually eroded into shallow, narrow valleys. It is not differentiated from the Forelle (?) limestone on the accompanying map, however, because the scale would not permit. The Satanka (?) shale, on account of its softness, is in few places well exposed, but with the Forelle (?) limestone it outcrops in a very narrow strip in the southern part of T. 32 N., R. 72 W., and a similar strip in T. 32 N., Rs. 73 and 74 W. Darton and Siebenthal state that in the Laramie Basin the Satanka shale varies in thickness from a thin film to 240 feet. There are but one or two places in the Douglas oil field where the shale is wholly exposed, and here a thickness of only 50 feet was observed. The following

[1] Darton, N. H., and Siebenthal, C. E., Geology and mineral resources of the Laramie Basin, Wyo.: U. S. Geol. Survey Bull. 364, p. 22, 1909.

section, which includes the Satanka (?) shale, Forelle (?) limestone, and a part of the Chugwater formation, was measured on La Prele Creek:

Section of Satanka (?) shale, Forelle (?) limestone, and a part of the Chugwater formation near natural bridge in sec. 16, T. 32 N., R. 73 W.

	Ft.	in.
Chugwater formation:		
Shale, red, sandy	8	
Limestone, red, sandy, crushed	10	
Shale, red, sandy	15	
Sandstone, slabby in lower half, upper part locally saccharoidal	2	
Shale, red, calcareous, sandy	12	
Sandstone, calcareous	4	
Forelle (?) limestone:		
Limestone, with red shale bands 2 or 3 inches thick near base	10	
Limestone, bluish gray on fresh surface, slabby, thin bedded	19	
Satanka (?) shale:		
Shale, red, calcareous	45	
Limestone, gray		3
Shale, red		10
Limestone		4
Shale, red, calcareous	5	
Sandstone, red, massive, top of Casper formation.		
	131	5

FORELLE (?) LIMESTONE.

The name Forelle limestone, from a station on the railroad near Laramie, was applied by Darton and Siebenthal[1] to a limestone exposed along the west slope of the Laramie Mountains. From their description of the formation and its stratigraphic position there seems little doubt that the formation described by them as showing on the west slope of the Laramie Mountains is the same as the limestone found in this field on the north slope of the same range. The strata consist of thin-bedded compact bluish-gray limestones with a slight pinkish tint and an average thickness of about 25 feet. The individual beds are from half an inch to 2 or 3 inches thick and in places are so closely cemented that they present the appearance of a single heavy bed of limestone.

The exposures of the Forelle (?) limestone are not numerous, but wherever seen along the south side of Brenning Basin they present the same thin-bedded or laminated character and are weathered into low sharp ridges.

[1] Loc. cit.

TRIASSIC (?) SYSTEM.

CHUGWATER FORMATION.

The Chugwater formation, according to Darton,[1] "ranges in thickness from 900 to 1,200 feet and consists of sandy shales or soft massive sandstones, nearly all of bright-red color. Gypsum deposits occur in most places."

The Chugwater formation is almost wholly concealed in this field by the overlap of the White River formation. The only exposure noted is in sec. 16, T. 32 N., R. 73 W., where about 50 feet of the lower part is exposed (shown in the top of the section on p. 58). The strata consist of red sandy shale, limestone, and sandstone. It is probable, however, that some of the Chugwater strata are also exposed in sec. 1, T. 32 N., R. 74 W. The thickness of the formation is estimated at about 1,500 feet. This estimate is based on a calculation of the thickness of the beds concealed along La Prele Creek in sec. 16, T. 32 N., R. 73 W., and controlled by the dip of the "Cloverly" formation on the north and the outcrop of the Forelle (?) limestone on the south. As a section of the overlying Sundance and Morrison formations was measured near the southeast corner of the field, the remaining thickness after subtracting this measurement gives the probable thickness of the Chugwater formation.

JURASSIC SYSTEM.

SUNDANCE FORMATION.

The marine Sundance formation (of Upper Jurassic age) and the overlying fresh-water Morrison formation (of Jurassic or Cretaceous age) are poorly exposed in this area on account of the overlap of the White River formation, but in the east bluff of North Platte River, about 6 miles south of Douglas, the full thickness is exposed and about 180 feet of Morrison formation and 250 feet of Sundance were measured. The two formations are similar lithologically, each consisting predominantly of shale interbedded with sandstone and limestone, but the Sundance is marine and contains more limestone than the fresh-water Morrison formation.

Section of Morrison and Sundance formations in east bluff of North Platte River, in sec. 9, T. 31 N., R. 71 W.

	Feet.
Morrison formation:	
Shale, blue and red, with a 6-foot carbonaceous shale near top.	180
Limestone, compact, fossiliferous	3

[1] Darton, N. H., Paleozoic and Mesozoic of central Wyoming: Geol. Soc. America Bull., vol. 19, p. 432, 1908.

Sundance formation:	Feet.
Shale, blue and pink, calcareous and sandy, fossiliferous in lower part	60
Sandstone	10
Shale, bluish gray, sandy, with few bands of sandstone	60
Sandstone	12
Shale, bluish gray, sandy	30
Sandstone, gray, heavy bedded	75
	430

Fossils were collected at two horizons in the foregoing section, about 50 feet apart. In the collection from the upper horizon T. W. Stanton determined a single species, *Planorbis veternum* M. and H., which he refers to the Morrison. He also determined from the collection from the lower horizon two species, Nucula sp. and *Tancredia warrenana* M. and H., which are referred to the Sundance formation. The latter collection is from the top member of the Sundance formation, whereas the other is from the 3-foot bed of limestone at the base of the Morrison formation. The formation boundary, therefore, between the Morrison and Sundance formations is determined in the section within 50 feet.

Of the four small areas of outcrop of the Sundance formation shown on the map (Pl. IV) two are verified by fossils, one in sec. 34, T. 33 N., R. 74 W., and the other in sec. 1, T. 32 N., R. 74 W. (See table of fossils below.) The other two areas, one in T. 32 N., R. 73 W., and the other in sec. 28, T. 33 N., R. 74 W., may be partly or wholly Morrison.

The fossils collected from the Sundance formation are given in the following list:

Fossils from the Sundance formation.

[Determined by T. W. Stanton.]

	Station No.	Township N.	Range W.
Belemnites densus M. and H	91	31	71
	72	33	74
Camptonectes sp	72	33	74
Eumicrotis curta Hall	71	32	74
	72	33	74
Gryphæa calceola var. nebrascensis M. and H	72	33	74
Nucula sp	91	31	71
Ostrea strigilecula White	72	33	74
	71	32	74
Tancredia? inornata (M. and H.)	91	31	71
Tancredia sp	72	33	74
Tancredia warrenana M. and H	91	31	71
Trigonia conradi M. and H	71	32	74

JURASSIC OR CRETACEOUS SYSTEM.

MORRISON FORMATION.

The Morrison formation, which is discussed in connection with the Sundance formation, is mapped with the overlying "Cloverly" formation, as it could not be differentiated in the field. The "Cloverly"-Morrison contact is so poorly exposed throughout the field that little evidence was obtained regarding the true relations of the two formations. Future field work in surrounding areas may throw some light on this subject. The scale of the map is so small that it would not permit much more detail than is already included on it, even if the data were at hand.

CRETACEOUS SYSTEM.

"CLOVERLY" FORMATION.

The "Cloverly" formation is partly exposed along Boxelder Creek in secs. 27, 28, 29, and 30, T. 33 N., R. 74 W.; secs. 6, 7, 17, and 16, T. 32 N., R. 73 W.; sec. 36, T. 32 N., R. 71 W. of the sixth principal meridian, and at several other localities as shown on Plate IV. The excavation for an irrigation ditch has removed the cover in one place (sec. 27, T. 33 N., R. 74 W.), where the full thickness of the formation appears to be exposed. This section is as follows:

Section of "Cloverly" formation in SW. ¼ sec. 27, T. 33 N., R. 74 W.

	Ft.	in.
Sandstone, gray to buff	25	
Shale, dark, light, and sandy in upper half	25	
Sandstone, firm, hard	3	
Shale, blue, sandy, and carbonaceous	1	2
Sandstone, hard, coarse	1	
Sandstone, gray to buff, saccharoidal (not well exposed)	50±	
	105	2±

The sandstones of the "Cloverly" form a low ridge where they outcrop. They are brown, buff, or gray in color and locally conglomeratic and ripple-marked. As described by Darton and Siebenthal[1] the "Cloverly" formation of the Laramie Basin consists of sandstone and clay, representing the Dakota sandstone, Fuson formation, and Lakota sandstone, and lies unconformably upon the Morrison formation. As shown in the foregoing section, in the Douglas field the formation consists of two thick sandstones separated by a shaly member. At the "Cloverly" type locality, however, it is understood, no Dakota sandstone is present, and the rocks are wholly of Lower Cretaceous age. The application of the name, therefore, in other regions to include strata of Upper Cretaceous age is not regarded as good usage, and for that reason the name is now quoted.

[1] Loc. cit.

COLORADO GROUP.

BENTON SHALE.

The Benton shale consists of about 1,600 feet of dark and light shale with a thick sandstone member near the top. It lies directly upon the "Cloverly" formation and is followed above by about 100 feet of hard chalky shale of the Niobrara. The Benton shale comprises at the base about 220 feet of dark soft shale overlain by about 175 feet of dark-bluish hard shale, the Mowry shale member, which weathers light bluish gray to yellowish and produces low ridges. Above the Mowry member is some 870 feet more of dark soft shale which is overlain by 100 feet of gray to yellowish-brown sandstone containing locally abundant Benton fossils. Above the sandstone member and below the Niobrara shale there is about 300 feet of dark shale similar to the dark shale in the lower part of the formation.

Section of the Benton shale measured in sec. 29, T. 33 N., R. 74 W.

	Feet.
Shale, dark	300
Sandstone, forming ridge, fossiliferous	100
Shale	867
Shale, dark, weathering light bluish gray; yellowish gray in upper half, and locally forming pine-clad ridges (Mowry shale member)	175
Clay (bentonite?), gray and yellow mottled, gummy, interbedded in darker clay (one bed of the light clay 8 inches thick)	3
Shale, dark	215
	1,660

A collection of invertebrate fossils from the sandstone member of the Benton yielded nine species, which T. W. Stanton assigned to the Benton shale. These fossils are included in the list on pages 64–65, where they are designated by station No. 74. The fossiliferous sandstone member of the Benton shale in the foregoing section corresponds with the Wall Creek sandstone lentil of the section in the Salt Creek field, as described by Wegemann.[1] The Mowry shale member of the Benton, about 175 feet thick, is shown in the section, but its limits are not defined on the map, Plate IV, because the scale will not permit. The base of the Mowry in sec. 29, T. 33 N., R. 74 W., is marked by some thin beds of bentonite, a compact clay which has the property of absorbing great quantities of water. The Mowry contains numerous fish scales, a characteristic feature of the member, and locally produces low rounded pine-clad ridges, another feature characteristic of the Mowry member in this vicinity.

[1] Wegemann, C. H., The Salt Creek oil field, Natrona County, Wyo.: U. S. Geol. Survey Bull. 452, 1911, pp. 37–83.

NIOBRARA SHALE.

The Benton shale is overlain in sec. 25, T. 33 N., R. 75 W., by about 100 feet of hard chalky Niobrara shale, which contains a few *Ostrea congesta* (Conrad) and some fragments of an Inoceramus characteristic of the Niobrara. The outcrop of the shale was traversed for a distance of a little over a mile, as indicated on the map (Pl. IV) by a solid line at the top of the Benton shale, in T. 33 N., R. 75 W. East and west of this outcrop the position of the Niobrara is inferred, as indicated on the map by the broken line. It is continued eastward across the White River formation (indicated by dotted line on the map) approximately parallel to the line marking the top of the "Cloverly" formation, which projects through the White River in T. 32 N., R. 73 W., and outcrops in the bluff of North Platte River in the southeast corner of the field.

MONTANA GROUP.

PIERRE FORMATION AND FOX HILLS (?) SANDSTONE.

The Niobrara shale is succeeded by about 5,000 feet of interbedded shale and sandstone, which is largely marine. There is, however, in the upper part a few coal beds above which marine fossils were collected. Besides *Halymenites major* Lesquereux, the collection includes about 10 species of invertebrates, which according to Mr. Stanton probably belong to the Fox Hills. The species include those in the list (pp. 64–65) bearing locality Nos. 85 and 86. In the area discussed in this report the Montana group is exposed only in the western part of the field, mainly in T. 33 N., Rs. 74 and 75 W., but one little exposure was noted in sec. 19, T. 33 N., R. 73 W., as indicated on the map. The following section was measured in T. 33 N., R. 74 W., and compares favorably (except in the upper part) with the section of the Montana group in the Salt Creek oil field described by Wegemann.[1]

Section of Montana group in T. 33 N., R. 74 W.

	Ft.	in.
Sandstone, brown, friable, with *Halymenites major* and other marine forms and with a thin bed of oysters near middle.	50	
Shale, brown, carbonaceous	4	11
Coal	2	2
Shale, brown, carbonaceous	1	5
Coal	1	9
Shale, brown, carbonaceous	1	9
Sandstone, friable	1	6
Coal, bony		8

[1] Loc. cit.

	Ft.	in.
Clay	2	
Shale, brown, carbonaceous		10
Coal	1	9
Sandstone, friable, interbedded with shale, carbonaceous and sandy	1,600	
Sandstone, buff, massive bedded	150	
Sandstone and shale	1,100	
Sandstone, buff and brown	300	
Shale, dark, with calcareous concretions	1,900	
	5,118	9

In the foregoing section the following comparisons may be made with the section of the Montana group in the Salt Creek oil field. The lower 1,900 feet of dark shale with inclusions of sandstone and calcareous concretions is typical of the Pierre. Overlying this shale is a thick sandstone (300± feet) which seems to occupy the same stratigraphic position as the Shannon sandstone lentil of the Salt Creek field. At 1,100 feet above this is another sandstone about 150 feet thick occupying the stratigraphic position of the Parkman sandstone member. The Fox Hills sandstone is probably represented in the upper 1,600 feet of the section, but it can not be differentiated from the lower beds of the Montana group until more detailed field work is done. Further detailed work may prove also that the 150-foot sandstone here referred to the Parkman is a much higher sandstone and the 300± feet of sandstone referred to the Shannon sandstone lentil is the Parkman member, the Shannon sandstone lentil being absent. The following list of fossils includes all invertebrates from the Colorado and Montana groups collected in the field.

Fossils from Colorado and Montana groups.

[Determined by T. W. Stanton.]

	Station No.	Township N.	Range W.	Benton shale.	Montana group.	Montana group probably Fox Hills.
Actæon sp	78,81	33	75		×	
Anchura? sp	80	33	74		×	
Anomia sp	81,83	33	75		×	
Avicula linguiformis E. and S.	80	33	74		×	
	78,81,83	33	75			
Avicula nebrascana E. and S.	88	33	73			
	80	33	74			
	81,83	33	75		×	×
Baculites ovatus Say	77,80	33	74		×	
	78,81	33	75			
Baculites compressus Say	84	33	75			×
Baculites sp	76,83	33	75		×	
Callista sp	85,86	33	74			×
Corbulamella gregaria M. and H.	77	33	74		×	
Cardium n. sp	74	33	74	×		
Cardium speciosum M. and H.	78,84	33	75			
	86	33	74		×	×
Chætetes? dimissus White	83	33	75		×	
Cyprina? sp	83	33	75		×	
Dentalium sp	86	33	74			×

Fossils from Colorado and Montana groups—Continued.

	Station No.	Township N.	Range W.	Benton shale.	Montana group.	Montana group; probably Fox Hills.
Donax? sp. related to D.(?) oblonga Stanton	74	33	74	×		
Donax? sp	74	33	74	×		
Fasciolaria? sp	80	33	74		×	
Haminea? sp	86	33	74			×
Inoceramus barabini Morton	77	33	74		×	
	82	33	75			
Inoceramus fragilis H. and M. variety	74	33	74	×		
Inoceramus oblongus Meek	78	33	75		×	
Inoceramus sagensis Owen ?	78, 81	33	75			
	80	33	74		×	×
Inoceramus sp	83	33	75		×	
Leda sp	78	33	75		×	
Lucina sp	78	33	75		×	
Lunatia sp	74, 86	33	74	×		×
Mactra gracilis M. and H.	79	33	74		×	
Mactra huerfanensis Stanton	74	33	74	×		
Mactra sp	88	33	73			
	84	33	75			×
Mactra warrenana M. and H. ?	78, 81	33	75			
	80, 86	33	74		×	×
Micrabacia americana M. and H.	83	33	75		×	
Modiola sp	83	33	75		×	
Modiola galpiniana E. and S.	78, 81	33	75		×	
Nucula cancellata M. and H.	86	33	74			×
Nucula sp	84	33	75			×
Ostrea pellucida M. and H.	85	33	74			×
Ostrea soleniscus Meek	74	33	74	×		
Ostrea sp	80, 85	33	74			×
Protocardia subquadrata E. and S.	78, 81, 83, 84	33	75		×	×
Protocardia? sp	88	33	73			×
Pyrifusus sp	83	33	75		×	
Scaphites sp	88	33	73			
	80	33	74			
	83	33	75		×	×
Scalaria? sp	74	33	74	×		
Shark's tooth	76	33	75		×	
Syncyclonema rigida H. and M.	78	33	75		×	
Syncyclonema sp	83	33	75		×	
Tellina scitula M. and H.	86	33	74			×
Tellina sp	74, 80	33	74	×	×	
Thetis circularis M. and H.?	84	33	75			×
Turris minor M. and H.	81, 78	33	75		×	
Vanikoro ambigua M. and H.	80	33	74		×	

Fossils from stations 83 and 84 were identified by F. H. Knowlton as *Halymenites major* Lesq. and were assigned to the Fox Hills.

CRETACEOUS OR TERTIARY SYSTEM.

LANCE AND FORT UNION (?) FORMATIONS.

The Montana group is overlain within the limits of the area represented on Plate IV by about 4,000 feet of strata which include the Lance formation and possibly some of the Fort Union formation, but no attempt is made by the writer to differentiate the two formations, as the field work was confined mainly to older rocks. The scope of this paper does not permit a discussion of these formations in detail, but as two lots of fossil plants were collected, the fossils are included in the list below. All these species are referred by Mr. Knowlton to the Fort Union. Station 89 is near the top of the Inez group of coal beds, about 3,000 feet stratigraphically above the top of the Montana. Station 90 is at a little higher horizon.

Fossil plants from the Douglas oil and gas field.

[Determined by F. H. Knowlton.]

	Station No.	Township N.	Range W.
Aralia notata Lesq	89	33	73
Aralia, perhaps new	89	33	73
Ficus artocarpoides? Lesq	90	33	72
Ginkgo sp	90	33	72
Platanus, probably P. haydenii Newb	89	33	73
Platanus raynoldsii Newb	90	33	72
	89	33	73
Quercus? sp	89	33	73
Sapindus sp	89	33	73

TERTIARY SYSTEM.

WHITE RIVER FORMATION (OLIGOCENE).

As stated in a previous paragraph and shown on the map, a large part of the Douglas oil field is covered with a thick mantle of the White River formation, which rests unconformably on all the lower formations. It is composed largely of clay, with fine sand, limestone, and conglomerate occurring at various places in the formation. The total thickness of the formation exposed from the top of Table Mountain to the bed of La Prele Creek, including the 90-foot cap of conglomerate, is 580 feet. The exposures are poor, but so far as can be seen the 490 feet below the conglomerate is composed largely of clay, mostly of drab and gray shades, but some of pink or green. The conglomerate is made up largely of quartz or quartzite pebbles, with here and there a bowlder of granite, the whole cemented together with calcium carbonate. The pebbles average about half an inch in size, though many are much larger. One granite bowlder was noted having a diameter of 18 or 20 inches. The most prominent bed of conglomerate noted is on the east side of Brenning Basin and is 90 feet thick, capping Table Mountain and extending over a large part of T. 32 N., R. 72 W.

QUATERNARY SYSTEM.

Alluvium along the streams and some local deposits of unconsolidated gravel and sand constitute the only beds of Quaternary age in the Douglas field. An attempt was made to map the alluvium along North Platte River and Boxelder and La Prele creeks, as shown on the map (Pl. IV), but the gravel and sand were not mapped. These materials were laid down unconformably upon the White River formation, from which it is in places difficult to distinguish them. The thickest bed of Quaternary material observed in the field is in the east bank of Little Boxelder Creek in the NE. ¼ sec. 25, T. 33 N., R. 74 W., where there is a cliff 40 feet high, the upper half of which is gravel and sand of Quaternary age, and the lower half the White River formation.

IGNEOUS ROCKS.

Underlying the Casper formation just south of the Douglas oil field and forming the core of the Laramie Mountains is red granite, which is cut by basic dikes of various kinds. Only one little area of the granite is indicated on the map, but it forms the surface rock of a large part of T. 32 N., Rs. 74 and 75 W., just south of the area treated in this report. The granite exposed in secs. 23, 26, and 27, T. 32 N., R. 73 W., is cut by several parallel dikes, as indicated on the map. The dike rock is a hornblende gneiss, as determined in the laboratory of the United States Geological Survey by J. Fred Hunter, from microscopic slides. The dikes have been prospected for copper by local mining companies, one prospect having been extended into the largest of the dikes to a depth of about 75 feet. A little copper in the form of chalcopyrite was found, but it is hardly probable that it will ever be found in paying quantities.

STRUCTURE.

The overlap of the White River (Tertiary) formation renders the interpretation of the structure of the older beds very difficult, yet it is apparently monoclinal, with a general dip toward the north. This interpretation is based on the observed dips of the older beds north, west, and south of the overlap. At all these places the dip is uniformly toward the north, northeast, or northwest, with the exception of a narrow belt in T. 33 N., Rs. 74 and 75 W., where the beds are slightly overturned to the north. If the great fault described by Darton,[1] as striking eastward in the vicinity of Casper Mountain (20 or 30 miles west of the Douglas oil field), extends under the mantle of the White River formation, it probably has no great throw, as the structure seems to resemble a fold more than a fault. That this flexure was produced by compressive forces is evident, however, from the fact that there are numerous small thrust faults and some overturned strata at a number of places in the field. The displacement in most of the small faults is only a few inches. Such an overthrust was observed in sec. 25, T. 33 N., R. 75 W., where a sandstone in the Benton shale, dipping at a high angle, has been broken by a series of parallel faults, as shown in figure 3. There are also overturned strata in secs. 31, 32, 33, and 34, T. 33 N., R. 75 W.,

[1] Darton, N. H., Preliminary report on the geology and underground water resources of the central Great Plains: U. S. Geol. Survey, Prof. Paper 32, pp. 53-55, 1905.

and secs. 28 and 34, T. 33 N., R. 74 W. The fault in T. 32 N., R. 73 W., is distinct in the White River formation and is indicated on the map by a solid line. No data are at hand bearing upon the amount of throw of the fault, but it is believed to be small.

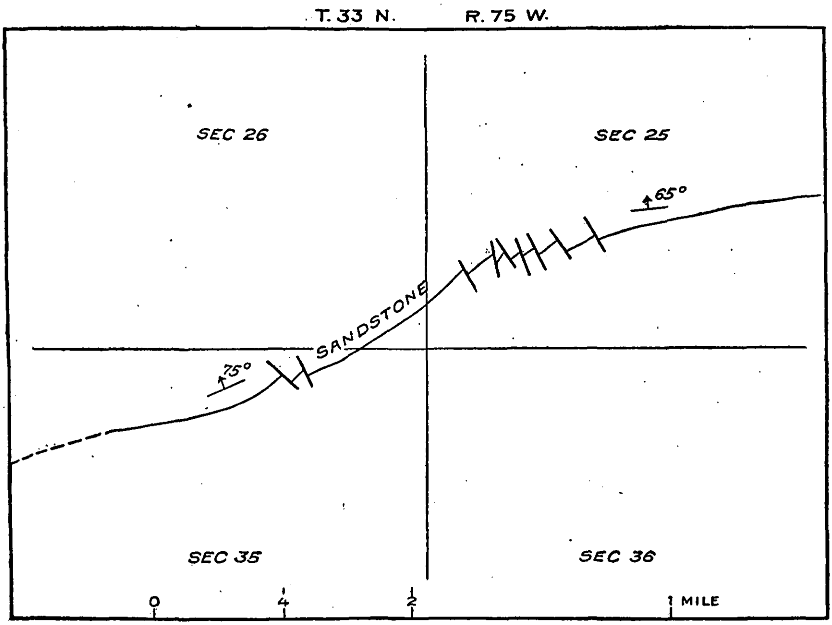

FIGURE 3.—Faults cutting sandstone in Benton shale, T. 33 N., R. 75 W., Wyoming.

OIL AND GAS.

OCCURRENCE.

There are several localities in the Douglas field where oil finds its way to the surface in the form of seeps or springs. About 1894, while a tunnel was being dug for an irrigation ditch in the NW. ¼ sec. 16, T. 32 N., R. 73 W., a sandstone in the top of the "Cloverly" formation was penetrated and found to be saturated with oil. At another place in sec. 6, T. 32 N., R. 74 W., in the bed of Boxelder Creek, oil seeps from the top of the Casper formation, appearing on the surface of the water. Still another oil seep is reported by Jamison[1] in a small ravine near the northwest corner of T. 32 N., R. 73 W. Oil is obtained from wells in secs. 8 and 9, T. 32 N., R. 73 W., and a small quantity from a well in sec. 31, T. 33 N., R. 74 W. In the last-mentioned well the oil seems to come from the same horizon as the oil that appears on the water in Boxelder Creek about a mile south of the well. Oil in the wells in secs. 8 and 9, T. 32 N., R. 73 W., seems to come either from the top of the "Cloverly" formation or

[1] Jamison, C. E., Wyoming Geol. Survey Bull. 3, ser. B, 1912.

from the lower part of the Benton. The wells in sec. 8, however, yield a much lighter oil than those in sec. 9. This suggests different horizons or at least different conditions of accumulation. It is probable that in sec. 8 the oil is held in a reservoir formed either by a small anticline, suggested by the curve in the outcrop of the "Cloverly" and the Chugwater formations, or by the White River formation, which overlies the older rocks and on account of its water-saturated condition is impervious to oil. In sec. 9 the wells are near the seeps and also near a fault, so that the lighter elements of the oil may have escaped, leaving a heavy oil behind.

It is difficult to determine with any degree of certainty the geologic structure under the heavy mantle of the White River formation. Jamison [1] has assumed an anticline striking in an east-west direction through the northern part of T. 32 N., R. 73 W., but the writer is inclined to the view that the beds dip rather uniformly toward the north and that the accumulation of oil and gas is due to the thick impervious mantle of clay of the White River formation. The base of the White River seems to contain conglomerate and other porous material in which the oil and gas might accumulate after migrating from the underlying older rocks. Such a relationship exists in the Coalinga district, California, described by Arnold and Anderson [2] as follows:

Within the tested territory of the Coalinga district it has been found that the areas of Miocene sediments (either Vaqueros, Santa Margarita (?), or Jacalitos) immediately underlain by the shales of the Tejon are oil bearing; that the productiveness of these beds varies roughly inversely with their distance from the shales of the Tejon; that the productiveness is greatest where the Tejon occupies a position of angular unconformity with the Miocene sands or is more or less disturbed, as near the axis of an anticline such as the Coalinga anticline.

The White River formation in the Douglas field rests unconformably on the upturned edges of the older rocks, which include nearly all the beds of the Colorado and Montana groups, both of which are known to yield oil in the Salt Creek field and near-by areas. It is believed by the writer that the oil in migrating upward along bedding planes and through porous sandstone finds a barrier when it reaches the White River formation, so that oil and gas accumulate near this line, penetrating the White River only where they encounter lenses of porous material or fault planes. There are at least two parallel faults cutting the White River formation in T. 32 N., R. 73 W. (see Pl. IV), and others are believed to exist. In sec. 6, T. 32 N., R. 72 W., heavy oil is reported in a water well at a depth of 175 feet. The White River formation is almost certainly over 175 feet thick at this

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[1] Loc. cit.

[2] Arnold, Ralph, and Anderson, Robert, Geology and oil resources of the Coalinga district, California: U. S. Geol. Survey Bull. 398, p. 186, 1910.

place, so that probably the oil is in the White River, having migrated from older underlying beds.

Oil is found in the Salt Creek field, according to Wegemann,[1] as high in the section as the Shannon sandstone, a lentil in the Pierre formation. If the boundaries of that formation where it extends under the White River are as indicated on the map, then the wells in the northern part of T. 32 N., R. 73 W., if extended entirely through the White River formation, would penetrate shale of the Pierre formation below the horizon of the Shannon sandstone lentil. The writer holds that less than half of the wells in the Brenning Basin, except those near the outcrop of the "Cloverly" formation, have gone deep enough to enter the older formations. If this is granted, another hypothesis must be postulated, namely, that the White River formation occupies an old valley, the bottom of which is near the same elevation as the present bed of North Platte River above Douglas. To illustrate, the elevation of the bed of North Platte River at Douglas is about 4,750 feet. The altitude of the surface at well No. 2 in sec. 1, T. 32 N., R. 73 W., is 5,140 feet, and the depth to the bottom of the White River formation in this well (according to the writer's interpretation of the well log) is at least 412 feet, making the base of the White River formation 4,728 feet above the sea, or 22 feet lower than the bed of the North Platte at Douglas. From other calculations, the elevation of the base of the White River varies in different wells from about 4,600 to 5,244 feet; therefore, to account for this variation, it is held that prior to the deposition of the White River there was a valley extending eastward from the Brenning Basin and passing just south of Douglas.

CHARACTER OF THE OIL.

There are two grades of oil in the Douglas field. One of these is a heavy oil, having a specific gravity ranging from 0.9309 to 0.9743, and the other is comparatively light and has a specific gravity of 0.8439. The light oil is of good quality, as shown by the analysis below. The well from which this oil comes (No. 30, Pl. IV) is reported to have yielded about 40 barrels a day for a long time, the oil being used in connection with the construction of the La Prele dam. The heavy oil is said to be a good lubricating oil in the crude state, having been used on the machinery of drilling outfits.

The following analyses of oil from the Douglas field were made in the laboratory of the United States Geological Survey under the direction of David T. Day:

Sample No. 1, from well No. 30, is evidently the best oil in the field. This sample was unoxidized, having been pumped direct from

[1] Wegemann, C. H., The Salt Creek oil field, Natrona County, Wyo.: U. S. Geol. Survey Bull. 452, pp. 37-83, 1911.

the well and at once soldered in a can. Mr. Day says that it "would be classed as regular Pennsylvania crude and evidently consists entirely of paraffin hydrocarbons. It gives an amount of gasoline and kerosene sufficient to constitute a good refining oil, and the residue would be satisfactory for cylinder oils."

Sample No. 2, from well No. 49, was procured from a tank where it had stood partly exposed to the weather for two or three months.

Sample No. 3, from well No. 66, was procured from oil floating on the water, which fills the casing nearly to the surface of the ground. This oil is so stiff that the sample was wound about a stick in order to lift it from the casing.

Analyses of oils from Douglas oil field, Wyoming.

[Made in the laboratory of the United States Geological Survey, David T. Day in charge.]

Wells.		Depth (feet).	Physical properties.			Distillation.							Paraffin (per cent).	Asphalt (per cent).	Sulphur (per cent).	Water.
			Gravity.		Color.	Begins to boil at (° C.)—	To 150° C.		150–300° C.		Residuum.					
Sample No.	Well No.		Specific.	Baumé (°).			Per cent.	Specific gravity.	Per cent.	Specific gravity.	Per cent.	Specific gravity.				
1	30	328	0.8439	35.9	Olive-green	80	8.0	0.7205	38.5	0.7928	53.5	0.9340	2.0	None.	0.2	None.
2	49	440	0.9309	20.4	Dark green	225	...	...	6.0	0.8605	...	...	...	None.	.3	Considerable.
3	66	600	0.9743	13.7	Dark brown, greenish cast.	225	...	...	2.0	...	...	...	None.	None.	.5	About 4 per cent.

CHARACTER OF THE GAS.

The following analysis of gas from the Douglas field was made by Frederick Salathe, of Casper, Wyo., in 1904:

Analysis of sample of natural gas from the Douglas oil and gas field, Wyoming.[1]

[Analyzed by F. Salathe, formerly in charge of the oil refinery at Casper, Wyo.]

Specific gravity	0.5890
Hydrogen .... per cent	3.89
Marsh gas (methane) .... do	87.75
Ethane, propane, butane .... do	7.23
Illuminating hydrocarbons .... do	.92
Carbon dioxide .... do	.21
Carbon monoxide	Trace.
Oxygen	Trace.
Nitrogen	Trace.
	100.00

The above analysis was made with the improved Hempel-Winkler gas analysis apparatus.

[1] Published by permission of Consaul & Heltman, attorneys in 1911 for the Wyoming Oil & Development Co. and Douglas Oil Field (Ltd.).

The calorific value of this natural gas as compared with coal at $5 per ton (Rock Springs, Wyo., coal) is as follows: 9.2 cubic feet of natural gas is equal to 1 pound of coal or 18,400 cubic feet of natural gas is equal to 1 ton (2,000 pounds) coal, which will give this natural gas a value of 27.2 cents per 1,000 cubic feet.

ORIGIN OF THE OIL.

No definite data bearing on the origin of the oil in the Douglas field are available. At present oil appears to be found at the top of the Casper formation, in the "Cloverly" formation, in the lower part of the Benton shale, and in the White River formation. Whether the oil originates from a single source or from several the writer is unable to state, but be that as it may, it seems certain that the oil now occurs in porous rocks into which it has migrated. The conditions in this field are good for the segregation of oil and gas into local small bodies by the combination of hydraulic pressure and capillarity, a mode of accumulation discussed by Munn.[1] The theory of this mode of accumulation is founded on the fact that rocks of different densities permit the passage of water through them freely if the capillaries are large and less freely if they are small. Water entering an oil-bearing shale from every side will force the oil into a segregated mass or pool. It will also find certain zones through which friction is less so that into these zones the oil and water will penetrate faster than into others. The zones of rapid capillary movement will admit the water so much faster than those in which the rock is denser that after a time certain bodies of the rock may become inclosed by rock saturated with water, the oil having been driven into the unsaturated mass. In the Douglas field conditions are favorable for this sort of segregation of oil and gas. The older rocks dip at high angles away from the mountains (toward the north) and their upturned edges, where not concealed by the White River overlap, form excellent intakes for meteoric water, but the White River formation overlaps and conceals these older beds north of the intake area. The White River formation also affords an excellent reservoir for water and generally almost all its members are saturated. The water which enters the older beds works upward underneath the White River formation, forcing the oil and gas ahead of it; when the oil encounters a dry sandy lens in the White River it doubtless fills the lens and remains there on account of the water-saturated rock above. The oil in the bed of Boxelder Creek exudes from the bedding planes and although the rock itself is a porous sandstone, the oil does not seem to have saturated the rock. At the time the oil migrated to this place the sandstone must have been saturated with water, thus compelling the oil to confine itself to the bedding planes and other larger cracks.

[1] Munn, M. J., The anticlinal and hydraulic theories of oil and gas accumulation: Econ. Geology, vol. 4, pp. 509-529, 1909.

WELLS IN THE DOUGLAS OIL FIELD.

The data contained in the following table are taken largely from Jamison's report [1] on the Douglas oil field, but the altitudes of wells and some items under "Remarks" are derived from data collected by the writer. The locations of all wells [2] marked by an asterisk (*) are taken from Jamison's map, these wells not having been visited by the writer.

Wells in Douglas oil field, Wyoming.

No.	Section.[a]	Owner.	When drilled.	Depth.	Altitude of surface.	Remarks.
				Feet.	*Feet.*	
1	1	Wyoming Oil & Development Co.			5,140	Dry.
2	1	do		1,575	5,140	Casing collapsed and well abandoned.
3	2	do	1906	200		Well unfinished.
4	2	La Prele Oil Co		542	5,260	Gas.
5	2	do				Abandoned.
6	3	do			5,230	Gas.
7	3	do			5,230	Do.
8	3	do			5,210	Abandoned gas well.
9	3					Abandoned.
10	3	Douglas Oil Fields (Ltd.)	1905	436	5,210	Abandoned gas well.
11	3					Abandoned.
12	3	Douglas Oil Fields (Ltd.).	1904	526		Gas reported.
*13	3	do	1904	563	5,240	Abandoned; water.
14	3	do	1904	526	5,200	Small amount of oil and gas.
15	4	do	1905	507	5,210	Small amount of oil.
16	4	do	1905	1,705	5,210	Small amount of oil and gas.
17	4	do	1902	485	5,200	Gas at 457 feet; abandoned.
18	4	do	1904	435	5,175	Producing gas well.
19	4	do	1907	578		Crooked hole.
20	6	do	1905	624		Small amount of oil reported.
21	6	do	1905	161	5,380	Do.
22	6	do	1905	693	5,370	Do.
23	6	do	1905	159	5,390	Do.
24	7	do	1905	110	5,440	Well unfinished; abandoned.
25	8	Wyoming Oil & Development Co.	1905	655	5,360	Small amount of oil; abandoned.
26	8	do	1905	302	5,400	Small amount of oil; flowing water well.
27	8	do	1904	215	5,350	Abandoned oil well.
28	8	do	1905	325	5,360	Do.
29	8	do	1905	365		Small amount of oil.
30	8	do	1906	328	5,340	Producing oil by pumping.
31	8	do	1905	632	5,330	Small amount of oil; abandoned.
32	8	do		393	5,320	Do.
33	8	do	1905	602	5,280(?)	Do.
34	8	do		930	5,290(?)	Abandoned.
35	8	do		725	5,300(?)	Light oil to top of casing.
*36	8	do		510		Small amount of oil; abandoned.
*37	8	do	1907	390		Do.
38	8	do	1907	236	5,320	Do.
39	8	do	1906	670	5,320(?)	Do.
40	8	do	1907	374	5,320	Do.
41	8	do	1906	401	5,320	Producing light oil by pumping.
42	8	do	1906	428	5,320	Abandoned oil well.
44	9	Douglas Oil Fields (Ltd.).	1902	342	5,300	Abandoned.
45	9	Wyoming Oil & Development Co.	1907	780	5,340	Abandoned; dry.
46	9	do		742	5,330	Small amount of oil and gas; abandoned.
47	9	do	1907	320	5,300	Abandoned oil well.
48	9	do	1906	425	5,290	Oil well with pump jack attached.

[a] In T. 32 N., R. 73 W., unless otherwise stated.

[1] Loc. cit.

[2] The writer found some difficulty in attempting to identify some of the wells mentioned by Jamison, as his descriptions do not invariably agree with the locations of the wells on his map.

Wells in Douglas oil field, Wyoming—Continued.

No.	Section.[a]	Owner.	When drilled.	Depth.	Altitude of surface.	Remarks.
				Feet.	*Feet.*	
49	9	Douglas Oil Fields (Ltd.).	1908	440	5,300	Oil well with pump jack attached.
50	9	do	1908	475	5,290	Small amount of oil reported.
*51	9	Wyoming Oil & Development Co.	1907	767		Small amount of oil.
52	9	do	1907	765	5,250	Small amount of gas.
*53	9	do	1907	970		Small amount of oil and gas.
54	9	do		406	5,250	Producing gas well.
55	9	Douglas Oil Fields (Ltd.).	1902	466	5,200	Small gas well.
*56	9	do	1904	388		Drilling stopped by order of court.
57	9	do	1903	470	5,210	Small gas well.
*58	9	do	1905	600		Water well.
59	11	Wyoming Oil & Development Co.	1907	515	5,220	Small gas well.
60	11	Douglas Oil Fields (Ltd.).	1904	498	5,230	Producing gas well.
61	12	do	1908	493	5,220	Small gas well.
62	12	do	1906	520	5,260	Crooked hole.
63	Lot in T. 32 N., R. 72½ W.	Wyoming Oil & Development Co.		665	5,316	Small gas well.
64	Sec. 35, T. 33 N., R. 74 W.					Abandoned; no data.
65	Sec. 29, T. 33 N., R. 74 W.	Wyoming Oil, Gas & Power Co.	(b)		5,150	
66	Sec. 31, T. 33 N., R. 74 W.	do	1912	600	5,350	A little heavy oil collects on the water, which rises to top of casing.

[a] In T. 32 N., R. 73 W., unless otherwise stated. [b] Unfinished.

DETAILS OF WELLS AND WELL LOGS.

INTERPRETATION OF THE LOGS.

In the well logs that follow there are five columns. In the first is given the name of the geologic formation as interpreted by the writer; in the second the driller's description of the rock; in the third information as to whether gas, oil, or water was found; in the fourth the thickness of beds; and in the fifth the depth from the surface of the ground to the base of each bed.

It should be borne in mind that the interpretation of well logs is difficult at best, but when the logs are complicated, as many of these are by starting in the White River formation and then passing into some other formation unconformably underlying it, the difficulty is greatly increased. Another source of possible error is the lithologic similarity between the Benton and Pierre formations. When these are encountered under the White River, the geologist can determine which is which only by the assumption that the strike of the older rocks continues under the mantle of White River in the same direction as it is where these rocks have been removed.

The logs of wells Nos. 2, 4, 16, 17, 18, 30, 35, 41, 44, 48, 49, 50, 55, 59, 60, and 63 were obtained from A. W. Phillips, of Douglas, Wyo., and the remainder are taken from the report of C. E. Jamison (State geologist of Wyoming) on the Douglas oil field, published in 1912.

WELL NO. 2.

Well No. 2 is located on the south bank of La Prele Creek in sec. 1, T. 32 N., R. 73 W. It is 1,575 feet deep, the first 500 feet of which seem to be in the White River formation, and the remaining 1,000 feet are quite certainly in the lower shale of the Pierre formation. The well is abandoned but is marked by the casing projecting a few feet above the surface of the ground. The log follows:

Log of well No. 2, sec. 1, T. 32 N., R. 73 W.

[Altitude of surface, 5,140 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Shale	Water at 40 feet	412	412
	Sand	"Showing" of gas and oil at 412 feet, water at 525 feet.	128	540
	(?)			
Pierre formation.	Black shale	"Showing" of oil at 1,575 feet	1,035	1,575

WELL NO. 4.

Well No. 4 is in the SW. ¼ sec. 2, T. 32 N., R. 73 W., and is cased and capped. A good flow of gas is reported from a sand at 542 feet below the surface, which was used for a time at a driller's camp about half a mile away.

Log of well No. 4, SW. ¼ sec. 2; T. 32 N., R. 73 W.

[Altitude of surface, 5,260 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Pale-blue, gray, and greenish shales		468	468
	Red shale		37	505
	Sand		3	508
	Red shale		5	513
	Sand		5	518
	Red shale	Gas at 515 feet	17	535
	Sand	Strong flow of gas at 538 feet	7	542

WELL NO. 14.

Well No. 14 is about 700 feet northeast of well No. 16. It is cased and capped, but apparently only a small amount of oil or gas was obtained in it. The lower 10 feet of the well undoubtedly is in the Pierre formation, the White River formation being 516 feet thick.

Log of well No. 14, SW. ¼ SW. ¼ sec. 3, T. 32 N., R. 73 W.

[Altitude of surface, 5,200 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	White, gray, and bluish shales		440	440
	Red shale		11	451
	Coarse sand	Gas	6	457
	Red shale		19	476
	Green and white sand	Gas and oil	40	516
Pierre formation.	Black shale		10	526

WELL NO. 16.

Well No. 16 is one of two deep wells in the Brenning Basin. The writer believes that it penetrates the Pierre formation to a depth of 1,000 feet. In the sand at the base of the White River formation small amounts of gas and oil are reported, but none below that level.

Log of well No. 16, SE. ¼ SE. ¼ sec. 4, T. 32 N., R. 73 W.

[Altitude of surface, 5,210 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.		Surface water	57	57
	White, grayish shale formation		363	420
	Red rock		53	473
	Coarse and loose sand		11	484
	Coarse sand	Gas	3	487
	(?)	First "showing" of oil	1	488
	(?)	Good "showing" of oil	10	498
	Coarse sand	Oil	3	501
	Finer sand	do	3	504
	Harder and finer sand	do	20	524
Pierre formation.	Black shale, with small streaks of sand.	Water at 815, 1,420, and 1,448 feet.	896	1,420
	Streaks of sand and black shale		285	1,705

WELL NO. 17.

Well No. 17 is about 800 feet west of No. 16. It is cased and is plugged with wood. It probably does not extend more than a few feet, if at all, below the White River formation, as it is less than 500 feet deep. In well No. 16 the base of the White River was probably reached at 524 feet.

Log of well No. 17, SW. ¼ SE. ¼ sec. 4, T. 32 N., R. 73 W.

[Altitude of surface, 5,200 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.		Water at 12 and 38 feet.	38	38
	Blue and gray formations		334	372
	Gray sand	Fair flow of water.	4	376
	Blue and gray shale		34	410
	Pink shale		37	447
	Blue rotten shale		7	454
	Gray soft sand		1	455
	Do	"Showing" of gas.	2	457
	Coarse and pebbly sand		3	460
	Hard white sand		14	474
	(?)	Oil with water	3	477
	Harder gray sand		8	485

WELL NO. 18.

Gas from well No. 18 is used in the nearest house, about 2,000 feet away, for fuel and light. The source of the gas, as in the other wells, appears to be the sandstones or bands of conglomerate in the White River formation.

Log of well No. 18, NW. ¼ SE. ¼ sec. 4, T. 32 N., R. 73 W.

[Altitude of surface, 5,175 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Surface formation	Water at 25 feet	345	345
	Soft green shale		45	390
	Pink shale		37	427
	Soft blue-gray shale	"Showing" of gas	1	428
	Soft gray sand		2	430
	Soft pink shale		3	433
	Hard mixed sand	Large flow of gas and some oil.	2	435

WELL NO. 19.

Well No. 19 almost certainly reaches the Pierre formation at a depth of 525 feet. Above this depth the formation is believed to be White River. The well was not visited by the writer.

Log of well No. 19, SE. ¼ NW. ¼ sec. 4, T. 32 N., R. 73 W.

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Surface loam and shale	At 105 feet sand streak and water.	105	105
	Gray and bluish shales		295	400
	Red shale		70	470
	Sand		20	490
	Green-brown shale		5	495
	Brown sand		5	500
	Coarse gravel and sand		25	525
Pierre formation.	Black shale		12	537
	Gray shale		41	578

WELL NO. 22.

It is probable that well No. 22 penetrates the "Cloverly" formation, as the 182 feet of sandstone mentioned in the record resembles that formation. The rocks dip 41°–55° E., so that 182 feet vertical depth would penetrate only about 60 feet of strata.

Log of well No. 22, NW. ¼ SW. ¼ sec. 6, T. 32 N., R. 73 W.

[Altitude of surface, 5,370 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Coarse gravel		11	11
	Gravel and clay		8	19
	Sandy clay		35	54
	Red and light-blue sandy clay		42	96
	Gray sandy clay		9	105
	Red and gray sandstone		14	119
	Reddish clay		12	131
Benton shale.	Hard black shale		49	180
	Black sandy shale with streaks		31	211
	Blue shale with streaks of sand		27	238
	Black sandy shale	Oil "showing"	8	246
	Sand rock		4	250
	Black shale	Oil "showing"	92	342
"Cloverly" and Morrison formations.	Sand rock	Oil "showing"	182	524
	Dark-blue shale		10	534
	Blue shale with streaks of sand		18	552
	Blue sandy shale		8	560
	Blue shale with streaks of sand rock		5	565
	Black shale		3	568
	Soft sand		3	571
	Brown shale		85	656
	Black sandy shale		37	693

WELL NO. 26.

It seems certain that in well No. 26 the "Cloverly" formation was reached at a depth of 282 feet, although Jamison [1] states that in part his Dakota was entered at 48 feet. To depth of 282 feet there is too much shale to justify referring the beds to the "Cloverly" formation. The two oil sands mentioned in the log are probably sandstone lentils in the lower part of the Benton. The well yields a small stream of flowing water which is used for stock.

[1] Jamison, C. E., The Douglas oil field and the Muddy Creek oil field, Wyoming: Wyoming Geol. Survey Bull. 3, ser. B, p. 27, 1912.

Log of well No. 26, SW. ¼ sec. 8, T. 32 N., R. 73 W.

[Altitude of surface, 5,400 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Wash and brown gumbo		48	48
Benton shale.	Oil sand	Dark lubricating oil	2	50
	Brown shale		20	70
	Oil sand		7	77
	Shale	Water at 80 feet	20	97
	Black gumbo		31	128
	Brown shale		110	238
	Black gumbo		7	245
	Coarse rock	Water at 254 feet	10	255
	Lead-colored gumbo		7	262
	Wash		10	272
	White gumbo		6	278
	Dark shale		4	282
"Cloverly" formation.	Wind cap rock	Water at 294 feet	2	284
	White water sand		18	302

WELL NO. 28.

As stated by Jamison, well No. 28 does not penetrate the "Cloverly" formation (in part his Dakota). This formation is probably from 400 to 600 feet below the bottom of the well. The 1-foot sandstone band at the bottom of the well is probably a sandstone lentil in the Benton shale.

Log of well No. 28, SW. ¼ SE. ¼ sec. 8, T. 32 N., R. 73 W.

[Altitude of surface, 5,360 feet.]

Probable formation.	Driller's description of the rock.	Thickness.	Depth
		Feet.	*Feet.*
White River formation and Benton shale.	Gravel and sand	65	65
	Green shale	62	127
	Gray shale	38	165
	Green oil sand	10	175
	Light-gray shale with a pink tint	40	215
	Brown clay	40	255
	Black shale	40	295
	Black sand	5	300
	Gray shale and sand	5	305
	Dark-gray shale and sand	6	311
	Dark clay	13	324
	Dakota sand	1	325

WELL NO. 29.

Well No. 29 was not visited by the writer, hence its location is taken from the map accompanying Jamison's report. The well is near the outcrop of the "Cloverly" formation and probably penetrates that formation to a depth of 60 feet.

Log of well No. 29, SE. ¼ sec. 8, T. 32 N., R. 73 W.

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation and Benton shale.	Wash		25	25
	Gray shale	Water at 55 feet	30	55
	Blue and gray shale	Good oil "showing"	53	108
	Brown sugary oil sand	Gas and oil; gas burned over the hole.	2	110
	Yellow shale	Good oil "showing" with some gas.	30	140
	Greenish sand		5	145
	Gray shale		15	160
	Brown gumbo		5	165
	Brown shale	"Showing" of oil and some gas.	135	300
	Purple and lilac gumbo		5	305
"Cloverly" formation.	Sandstone		60	365

WELL NO. 30.

Well No. 30 has a pump attached, which in the fall of 1912 was rigged up with a long gas-pipe handle for pumping by hand. By this means a near-by ranch procured oil for use in a heating stove which had been arranged for burning this kind of fuel. Mr. A. W. Phillips states that the oil from this well was pumped steadily by steam power for a long time for use as fuel by the contractors who built the La Prele dam, and that it produced over 40 barrels a day. This well yields a light oil having a paraffin base; its composition is given in the table (p. 25, No. 30).

Log of well No. 30, SW. ¼ SE. ¼ sec. 8, T. 32 N., R. 73 W.

[Altitude of surface, 5,340 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Clay		50	50
	Blue rock	Water	30	80
	Clay		105	185
	Green shale		70	255
Benton shale.	Black shale		45	300
	Black shale and paraffin	Oil at 325 feet	28	328

WELL NO. 33.

Well No. 33 does not penetrate the "Cloverly" formation. If the dip observed along the outcrop is continuous to the point where the well is located, the "Cloverly" would be about 1,000 feet below the surface, or about 400 feet below the bottom of the well. This statement is based on the assumption that the fault in sec. 9 does not extend as far west as this well. If, however, the fault is present in sec. 8 and the downthrow is on the north, as it appears to be farther east, then the "Cloverly" is deeper than is stated above.

Log of well No. 33, NW. ¼ SE. ¼ sec. 8, T. 32 N., R. 73 W.

[Altitude of surface, 5,280 (?) feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
White River formation and Benton shale.			*Feet.*	*Feet.*
	Gravel wash and gray shale		74	74
	Brown shale	Water at 74 feet	50	124
	Gray shale		60	184
	Brown and gray shale		36	220
	Blue and brown shale	Water at 220 feet	50	270
	Brown dope; very slow drilling		26	296
	Gray rock, shell mixed with yellow shale, and a little sand; turned into a brown dope which stands up well.		50	346
	Benton shale; caves badly		10	356
	Paraffin		7	363
	Benton shale		42	405
	Gray shale	Very good oil "showing"	10	415
	Gray shale, black dope, and a little Benton shale.	Oil	8	423
	Benton shale		177	600
	Artesian water sand		1	601
	A pinch of Dakota oil sand	Water at 601 feet	1	602

WELL NO. 34.

Well No. 34, which has been left with the casing open, stands full of water. Apparently there is a small flow of water from the well. It is probable that bentonite or some similar clay is meant by the driller's term "paraffin" in the well log.

Log of well No. 34.

[Altitude of surface, 5,290 (?) feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
White River formation.			*Feet.*	*Feet.*
	Light clay		10	10
	Granite		5	15
	Light shale		45	60
	(?)		60	120
	Light clay	Water at 60 feet	33	153
	Clay and blue shale		142	295
	Red rock		15	310
	Yellow rock		35	345
Benton shale.	Black shale	Water at 665 feet	330	675
	Black sand	Water at 675 feet	27	702
	Black shale and paraffin		3	705
	Black shale		9	714
	Black sand		6	720
	Black shale and paraffin		11	731
	Gray shale and paraffin		141	872
	Soft gray sand		19	891
	Black and gray shale		9	900
	Gray shale		10	910
	Black shale and iron		15	925
	Paraffin	Water at 930 feet	5	930

WELL NO. 35.

Light oil fills the casing in well No. 35 to the level of the surface of the ground. The well also yields some water which flows up around the inner casing.

Log of well No. 35, NE. ¼ SE. ¼ sec. 8, T. 32 N., R. 73 W.[a]

[Altitude of surface, 5,300 (?) feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Water formation		10	10
	Brown lime formation	Water at 36 feet	70	80
	Gray shale		40	120
	Blue shale		70	190
	Blue gumbo		22	212
	Brown and green gumbo	Water at 217 feet	50	262
	Crystal formation		13	275
	Blue gumbo		10	285
	Pink and brown formation		25	310
	Mixed shales		22	332
	Shale		188	520
Benton shale.	Water sand	Water flowed over top of hole.	8	528
	Hard shell rock	Strong flow of gas	1	529
	Black sand		13	542
	Shale	Water at 550 feet	104	646
	Paraffin		5	651
	(?)	Water cased off at 667 feet; struck oil at 718 feet.	74	725

[a] This well log is identical with Jamison's No. 13, so far as it goes, but his log shows a maximum depth of 810 feet, whereas the log given above, which was procured from A. W. Phillips, states that the depth of this well is 725 feet.

WELL NO. 41.

Well No. 41 is about 1,000 feet south of No. 35 and contains oil of a similar character. It has tubing and jack attached for pumping. The oil comes from a sandstone in the bottom of the well, apparently in the Benton shale.

Log of well No. 41, SE. ¼ sec. 8, T. 32 N., R. 73 W.

[Altitude of surface, 5,320 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Surface formation		10	10
	Gray shale	Water at 85 feet	80	90
	Gumbo		50	140
	Gray shale	Water at 145 feet	10	150
	Brown gumbo		15	165
	Blue shale		10	175
	Gray shale		15	190
	Light shale		50	240
	Sand		5	245
	Gumbo		21	266
	Yellow shale		29	295
Benton shale.	Black shale	Gas at 312 feet	104	399
	(?)	Oil at 399 feet	2	401

WELL NO. 44.

Well No. 44 was drilled near the outcrop of the oil-saturated sandstone which was uncovered in digging the tunnel for an irrigation ditch, but only a small amount of oil was found. The casing was pulled and the well abandoned.

Log of well No. 44, SW. ¼ sec. 9, T. 32 N., R. 73 W.

[Altitude of surface, 5,300 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Surface formation		118	118
	Red shale		22	140
	Light shale		20	160
Benton shale.	Black shale		40	200
	Light shale		20	220
"Cloverly" formation.	Sand	Good "showing" of oil	2½	222½
	do	Oil	7½	230
	White, fine sand		5	235
	do	Water	6	241
	Coarse, gray sand		4	245
	Soft, light gray sand		7	252
	Light and red shale		5	257
	Darker shale		10	267
	Black shale		18	285
	Sand, with coarse pebbles		4	289
	Fine white sand		26	315
	White sand, coarse, soft		15	330
	Shale, black		12	342

WELL NO. 47.

Well No. 47, like most of the other wells in sec. 9, was drilled near the outcrop of the oil-saturated sandstone and found only a small amount of oil. The casing was pulled and the well abandoned.

Log of well No. 47, SE. ¼ sec. 9, T. 32 N., R. 73 W.

[Altitude of surface, 5,300 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Made land and sedimentary formation.		118	118
	Red rock		22	140
	Light shale		20	160
	Black shale		40	200
	Light shale		20	220
	Sand	"Showing" of oil	10	230
	Fine white sand	do	11	241
	Gray soft sand	Water	4	245
	Light-gray soft sand		7	252
	Light and red shales		5	257
	Darker shale		10	267
	Black shale		18	285
	Sand, with coarse pebbles		4	289
	Fine white sand	Water	16	305
	Coarse white sand		15	320

WELL NO. 48.

Well No. 48 has tubing and pumping jack attached. Heavy oil like that from well No. 49 has been pumped from it. This well is about 200 feet south of No. 49 and its log is almost identical.

Log of well No. 48, SW. ¼ sec. 9, T. 32 N., R. 73 W.

[Altitude of surface, 5,290 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Light clay		65	65
	(?)	Water	10	75
	Green shales		248	323
	Mixed sand and gumbo		17	340
Benton shale.	Black shale		25	365
	(?)	Oil "showing"	5	370
	Black shale and paraffin		50	420
	Oil sand	Heavy oil	5	425

WELL NO. 49.

Well No. 49 has a pump with a gasoline engine attached. The oil is heavy and is the one from which sample No. 2 was collected. (See analysis, p. 71.) When drilling stopped the oil rose within 20 feet of the surface.

Log of well No. 49, SW. ¼ sec. 9, T. 32 N., R. 73 W.

[Altitude of surface, 5,300 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Clay	Water at 60 feet	60	60
	Green shale		267	327
	Red rock and green shale		8	335
	Yellow rock		5	340
	Gas sand		5	345
Benton shale.	Yellow rock		5	350
	Black shale		45	395
	Black shale and paraffin		40	435
	Oil sand	Good supply of heavy oil	5	440

WELL NO. 50.

Well No. 50, like Nos. 49, 48, 44, and 47, is near the outcrop of the oil-saturated sandstone. The well is cased and capped.

Log of well No. 50, NW. ¼ SE. ¼ sec. 9, T. 32 N., R. 73 W.

[Altitude of surface, 5,290 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Clay	Water	55	55
	Green shale and clay		263	318
	Red rock		8	326
	Gas sand		8	334
	Yellow rock and light shale		29	363
Benton shale.	Black shale		42	405
	Black shale and paraffin		45	450
	Oil sand		5	455
	Gray shale		13	468
	Black shale		7	475

WELL NO. 54.

Well No. 54 produces gas that has been piped to the nearest ranch. It is asserted by the ranchmen that there is sufficient to supply the ranch if the well were kept cleaned out, but at the time of the writer's visit the flow had nearly stopped.

Log of well No. 54, SW. ¼ NE. ¼ sec. 9, T. 32 N., R. 73 W.

[Altitude of surface, 5,250 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Dark-gray shale		55	55
	Light-green shale	Water at 55 feet	75	130
	Blue shale		30	160
	Light-brown shale		30	190
	Light-blue shale		60	250
	Brown and slate-colored shale		87	337
	Light-brown shale		33	370
	Slate-colored shale		35	405
	Gas sand	Gas	1	406

WELL NO. 55.

Well No. 55 is said to contain sufficient gas for ranch use, but it is not being utilized at the present time. The well was drilled in 1902, and since that time it has remained cased and capped.

Log of well No. 55, NW. ¼ NE. ¼ sec. 9, T. 32 N., R. 73 W.

[Altitude of surface, 5,200 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Blue, green, and light-colored shale	Water at 8, 48, and 375 feet	375	375
	Sandy	Water and gas	5	380
	Green and light-blue shale		32	412
	Red shale		39	451
	Green shale		3	454
	Sand, with green shale mixed	Gas	1	455
	Soft gray sand		2	457
	Shale and sand mixed		3	460
	Fine white sand		3	463
	Sand	Strong flow of gas	3	466

WELL NO. 57.

Well No. 57, according to Jamison's report, had so strong a gas pressure when the drill reached the depth of 468 feet that it threw sand and pebbles 70 feet into the air. The well is now cased and capped, but the gas is not being used.

Log of well No. 57, NE. ¼ NE. ¼ sec. 9, T. 32 N., R. 73 W.

[Altitude of surface, 5,210 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Shale	Water at 12 and 22 feet	308	308
	Coarse white sand		2	310
	Shale		98	408
	Pale pink shale		24	432
	Red shale; hole caved		26	458
	Green shale and gray sand		10	468
	(?)	Gas	2	470

WELL NO. 59.

Well No. 59 is one of three gas wells just northwest of Table Mountain. It is 515 feet deep and is probably entirely in the White River formation.

Log of well No. 59, NE. ¼ sec. 11, T. 32 N., R. 73 W.

[Altitude of surface, 5,220 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Brown soapstone		20	20
	Blue soapstone		38	58
	Gray shale		20	78
	Green shale		10	88
	Gray shale		22	110
	Sandy green shale	Water	10	120
	Blue shale		28	148
	Gray, mixed with blue shale		33	181
	Gray shale		67	248
	Brown, mixed with blue shale		25	273
	Gray shale		5	278
	Brown shale		61	339
	Gray shale		76	415
	Blue shale		32	447
	Red shale		35	482
	Gas sand	Water and oil	6	488
	Gray shale and paraffin mixed		4	492
	Red shale		20	512
	Gas sand	Gas	3	515

WELL NO. 60.

Well No. 60, like Nos. 59 and 61, is on the west flank of Table Mountain and is a producing gas well. Gas is piped,[1] as indicated on the map, to two ranches in the Brenning Basin, where it is used for domestic purposes. The gas pressure is reported by Jamison to be 145 pounds to the square inch.

[1] In 1913, after this paper was written, the pipe was taken up.

Log of well No. 60, NE. ¼ sec. 11, T. 32 N., R. 73 W.

[Altitude of surface, 5,230 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Shale formations; stray sand	Gas at 480 feet	480	480
	Red rock	Strong flow of gas	11	491
	Sand		7	498

WELL NO. 61.

The casing of well No. 61 is still in the well and is capped. Gas is reported.

Log of well No. 61, NW. ¼ NW. ¼ sec. 12, T. 32 N., R. 73 W.

[Altitude of surface, 5,220 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Surface dirt		50	50
	Blue shale		4	54
	Gray and brown shale		6	60
	Blue sand	Water at 60 feet	60	120
	Brown sandy shale		25	145
	Clay		15	160
	Green shale		40	200
	Light-gray shale		10	210
	Sand		3	213
	Light shale		58	271
	Red rock mixed with green shale		87	358
	Green shale		15	373
	Green and red shale		15	388
	Green shale		67	455
	Red rock		20	475
	Gray shale		5	480
	Red rock		8	488
	Gray rock		3	491
	Gas sand	Gas	2	493

WELL NO. 63.

Well No. 63 is on the northeast side of Table Mountain, in R. 72½, very near the west quarter corner of sec. 7, T. 32 N., R. 72 W., and is cased and capped. The well record indicates that water, oil, and gas were found, but apparently only a small amount of oil. Gas is reported to have been obtained from the bottom of the well.

Log of well No. 63, lot in sec. 12, T. 32 N., R. 72½ W.

[Altitude of surface, 5,316 feet.]

Probable formation.	Driller's description of the rock.	Content.	Thickness.	Depth.
			Feet.	*Feet.*
White River formation.	Greenish shale		97	97
	Brown shale and gumbo		78	175
	Bluish shale, with streaks of sand	Gas	100	275
	Chalky formation		10	285
	Shale formation	Oil and water	15	300
	Shale formations	Gas	365	665

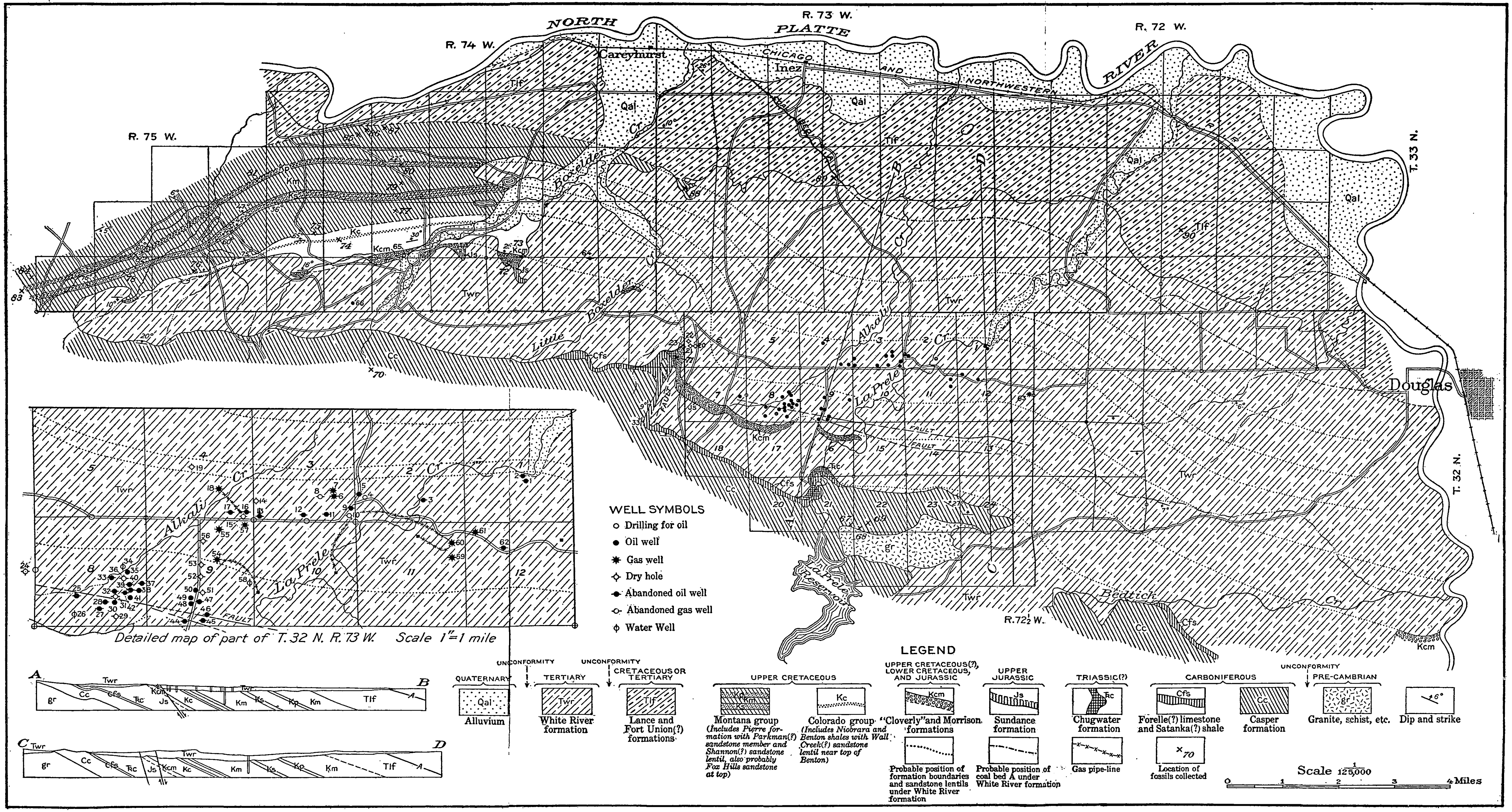
PRODUCTION.

The present production of oil in the Douglas field is small, but if the demand were sufficient the field could probably produce from the wells now open a hundred barrels a day for a short time. The gas supply is small, only three ranches using it in 1912. It seems probable, however, that the output could be increased so as to supply other ranches with light and heat, but the amount available would never be large unless new wells with greater flows of gas were found.

FUTURE DEVELOPMENT.

Although no one can say definitely that oil will or will not be found in a given area in advance of drilling, yet the writer is inclined to the opinion that future drilling in this field will find no great quantity of oil. It is said that drilling in 1913 is contemplated in the region north of Douglas. Here the highest known oil sand in this part of the State—the Shannon sandstone lentil—if present, should be reached at a depth of 4,000 to 5,000 feet. Drilling is also contemplated in the Labonte district, south of Douglas, but the writer is unfamiliar with this region.

The dips of the rocks near Glenrock suggest a favorable structure for the accumulation of oil, but this area has not been sufficiently studied to justify more than a mere mention at this time. The rocks at Glenrock dip toward the north, about 2½ miles southeast they dip toward the east, and about 3½ miles south of Glenrock they dip nearly south. These attitudes suggest a pitching anticline with an east-west axis about 1½ miles south of the town of Glenrock, but to reach the Shannon sandstone lentil here, if present, a thickness of about 2,700 feet of strata would have to be penetrated.



MAP OF THE DOUGLAS OIL AND GAS FIELD, CONVERSE COUNTY, WYO.

By V. H. Barnett.

THE SHOSHONE RIVER SECTION, WYOMING.

By D. F. Hewett.

INTRODUCTION.

Shoshone River rises among the ridges of the Absaroka Range in northwestern Wyoming and, except for a local diversion around McCulloch Peak, flows in a course approximately N. 60° E. to a point near the Montana line, where it empties into Bighorn River. (See fig. 2, p. 49.) Its course is approximately normal to the axis of the Bighorn Basin. On the west side of the basin the front of the Absaroka Mountains coincides approximately with the eastern limit of lava flows which overlie the pre-Eocene sedimentary rocks, but in the border belts on the east and west the river cuts through broad anticlinal folds, along the flanks of which the stratigraphic section is exposed in great detail. Thus on the west, along the east limb of the Rattlesnake-Cedar Mountain anticline, a complete section from the base of the Cambrian to the Eocene is visible, and though on the east, where Shoshone River cuts through the north end of Little Sheep Mountain, only the Cretaceous and Eocene formations are shown along the river, the complete Mesozoic section is brought to the surface near the center of the mountain.

With the view of using it as a guide in the study and mapping of a large area south of the river in which the geologic structure is favorable for the accumulation of oil and gas, the Mesozoic section along the river east of the Rattlesnake Mountain fold has been accurately measured and examined in greater detail than is customary in areal geologic work. Though the entire section from Cambrian to Eocene is exposed, the present examination has been confined to the Mesozoic and overlying Tertiary formations, for the reason that they probably contain all the sands which may carry oil and gas in the region under consideration. Furthermore, oil and gas have been found in two wells located on the axis of the narrow anticline shown on Plate V, and the sands from which they are derived outcrop prominently along the upper portion of the river.

The detailed examination of so continuous a stratigraphic section involving a great thickness of sedimentary rocks is not only rarely possible, but aside from the accuracy of measurement which it permits, it has the advantage of facilitating the more accurate delimitation of the formations. The section also shows in detail the sedimentary succession on the west side of the Bighorn Basin. The Mesozoic and Tertiary formations, exclusive of beds of Wasatch age, are approximately 15,000 feet thick along Shoshone River.

METHOD OF WORK.

In order to measure and study in detail the formations along the Shoshone Canyon, two operations were involved—first, the location, by means of a plane-table survey on a scale of 2,000 feet to an inch, of numerous points on prominent as well as critical lithologic members, between which the stratigraphic thickness does not exceed 1,000 feet; second, the detailed measurement by tape or by clinometer and pacing, as the exposures permitted, of the various lithologic units, the points previously established being used as a basis of control. It is obvious that detail is more desirable in those portions of the section which contain thin, clearly separable formations of distinct lithologic character than where the formations are thick and merge gradually with bounding formations of different character. Thus greater detail has been sought in the lower marine sandstones and shales than in the higher beds of fluviatile origin. Lack of time also prevented the same amount of study of the higher beds that was given to those of the lower part of the section.

FOSSILS.

On several occasions the section along the Shoshone has been examined in more or less detail by members of the Geological Survey,[1] and numerous collections of fossils have been made with the view of correlating the formations with those that are well known in south-central Montana and eastern Wyoming. In 1907 Fisher and Woodruff [2] measured the Mesozoic part of the section, and with Stanton, Knowlton, and Willard collected plants and invertebrate fossils from a number of horizons. It has been possible to identify most of these horizons, and with the permission of those who made the collections their lists of fossils are here presented with those made by the writer. Acknowledgment is also due to Mr. E. G. Woodruff for suggestions in the field and for reference to unpublished notes in the office.

[1] Woodruff, E. G., Coal fields of the southwest side of the Bighorn Basin, Wyo.: U. S. Geol. Survey Bull. 341, p. 202, 1909.
[2] Unpublished notes.

GEOLOGY.

STRATIGRAPHY.

OUTLINE.

The following table shows the character and relations of the formations from the Sundance (Upper Jurassic) to the Wasatch (Eocene):

Summary of Jurassic, Cretaceous, and Tertiary formations along Shoshone River.

System.	Series.	Formation.	Character.	Thickness (feet).
Tertiary.	Eocene.	Wasatch.	Buff and white sandstones, locally conglomeratic and feldspathic, alternating with greenish and red shales and clays.	(?)
		—Unconformity—		
		Fort Union.	White and buff massive sandstones with conglomerate zone at base. Upper portion more shaly. Contains flora and fresh-water fauna.	5,592
		Unconformity (?)		
Cretaceous or Tertiary.	?	Ilo.	Buff and yellow sandstones with minor sandy shale and clay. No coal beds; saurian bones and fresh-water invertebrate fossils.	1,790
Cretaceous.	Upper Cretaceous.	Meeteetse.	Argillaceous sandstone and sandy shale with numerous beds of brown carbonaceous shale and lenticular coal near top. Montana flora.	1,110
		Gebo.	Massive sandstone, buff near base and white near top, separated by thin beds of shale. One or more coal beds near base. A few plants and invertebrates of Montana types.	1,120
		Colorado.	Upper member: Dark-green to black shale, sandy near top; numerous marine fossils.	2,150
			Middle member: Buff sandstone locally conglomeratic, alternating with sandy shale and thin carbonaceous shale. One coal bed near top and several beds of bentonite.	494
			Lower member: Gray to black shale with several sandstones and numerous beds of bentonite throughout. Few marine fossils and fish scales.	1,026
	Lower Cretaceous.	"Cloverly."	Two sandstones separated by shale.	110
Jurassic or Cretaceous.	?	Morrison.	Maroon, gray, and brown shales with several sandstones. Saurian bones.	580
Jurassic.	Upper Jurassic.	Sundance.	Glauconitic green and gray shales, calcareous sandstone, and gypsum beds. Numerous marine and brackish-water fossils.	530

Total thickness, 14,502+ feet.

Plate V presents a plan of the survey of Shoshone River covering a strip 9 miles long and a vertical cross section showing an interpretation of the structure along a line approximately coinciding with the course of the river. It also shows, graphically, the stratigraphic section of the rocks from the Sundance formation (Upper Jurassic) to the Fort Union formation (Eocene) and an enlargement of the lower 2,700 feet of the section in order to show in greater detail the position and relations of the oil and gas bearing sands.

SUNDANCE FORMATION.

Beds containing Sundance (Upper Jurassic) fossils have been recognized at many localities in the Bighorn Basin and in eastern Wyoming. They present similar lithologic features and are characterized by abundant fossils, notably of the genera Gryphæa, Ostrea, and Pentacrinus. A section of the formation has been examined in detail by Fisher[1] along Trail Creek, 8 miles northwest of Cody and within 6 miles of the point of exposure along Shoshone River. Along Trail Creek a thickness of 322 feet was measured, but along the river, if the lower and upper limits of marine Jurassic fossils are taken as the base and top, respectively, the thickness of the formation is 530 feet, the greatest which has been measured in Wyoming. The beds are well exposed along the south bank of the river and may be examined closely. There is no appreciable difference in dip or evidence of erosional unconformity between the Sundance formation and the underlying red sandstone of the Chugwater formation (Triassic?). There was, in fact, a gradual transition from conditions of Chugwater sedimentation to those of the marine Sundance formation.

The distinguishing features of the Sundance formation are the numerous alternations of fossiliferous marine shales and gypsum beds near the base, its evenly bedded condition throughout, and the gradual increase in content of glauconite and quartz sand toward the upper sandstone which limits it. In the following section the details of the lower part of the formation are those of the section made by Fisher and Woodruff.

Section of Sundance formation on Shoshone River.

	Feet.
Shale, gray, sandy, and sandstone, lower half shaly, upper half firm and massive; fossil collection 4997	42
Sandstone, gray, massive, cross-bedded, with several poorly indurated layers and a number of thin limestone beds composed of Ostrea fragments; fossil collections 4988, 4996	60

[1] Fisher, C. A., Geology and water resources of the Bighorn Basin, Wyo.: U. S. Geol. Survey Prof. Paper 53, p. 21, 1906.

	Feet.
Sandstone, gray, with numerous shale layers; fossil collections 4985, 4986	6
Shale, dark	15
Shale, green, highly fossiliferous near the base, becoming sandy above; the upper more sandy portions are uniformly glauconitic; fossil collection 4989	240
Shale, green, sandy, containing a number of fossiliferous layers	22
Shale, green, sandy, with several thin nodular limestones	16
Shale, red, sandy, traversed by numerous gypsum veinlets	48
Gypsum	12
Limestone, gray, fossiliferous, and greenish-gray shale in alternating beds	23
Limestone, gray, fossiliferous	2½
Clay, gray	1
Limestone, gray, fossiliferous	2
Limestone, gray, fossiliferous, and yellowish-gray clay, in alternating layers; fossil collection 4982	3½
Clay, dark	2
Limestone, gray, fossiliferous, composed largely of fossil fragments	5
Clay	3
Limestone, gray, fossiliferous, containing many fragments of fossils; fossil collection 4981	21½
Sandstone, gray, fossiliferous; fossil collection 4980	4½
Clay, gray, compact	1
	530

The following collections of fossils from the Sundance formation were made in 1907 by Stanton and Willard:

4997. Stanton:
- Trigonia sp.
- Astarte sp.
- Undetermined pelecypods.

4988. Willard:
- Rhynchonella sp.
- Ostrea sp.

4996. Stanton:
- Rhynchonella myrina H. and W.
- Ostrea strigilecula White.

4985. Willard:
- Rhynchonella.
- Camptonectes.

4986. Willard:
- Ostrea.
- Camptonectes.
- Modiola.

4989. Willard:
- Gryphæa calceola var. nebrascensis M. and H.
- Camptonectes pertenuistriatus M. and H.

4989. Willard—Continued.
- Gervillea sp.
- Arca (?) sp.
- Trigonia sp.
- Astarte meeki Stanton.
- Astarte sp.
- Pleuromya subcompressa Meek.
- Ammonite fragment.

4982. Willard:
- Ostrea strigilecula White.
- Obscure bivalves.

4981. Willard:
- Pentacrinus astericus M. and H.
- Camptonectes bellistriatus Meek.
- Trigonia.

4980. Willard:
- Lima sp.
- Trigonia americana M. and H.
- Trigonia sp.

MORRISON FORMATION.

The Morrison formation has been recognized at a number of localities throughout the Bighorn Basin by its characteristics and relations and in places by the presence in it of saurian bones. Measurements of its thickness have ranged from 130 to 382 feet.[1] The formation is well exposed along the north bank of Shoshone River, where its thickness has been determined to be 580 feet. At the base it is not clearly separable from the underlying Sundance formation, but the division is made at the top of the uppermost outcropping sandstone which contains marine Jurassic fossils. As no fossils other than saurian bones from the middle portion have been found in either this formation or the overlying "Cloverly," the upper limit is taken to be the base of the sandstone overlying the uppermost maroon clay. In describing the character of the overlying "Cloverly" formation in the vicinity of the Bighorn Mountains Darton [2] states that the base is usually marked by a conglomeratic sandstone and considers that this member limits the underlying Morrison. On this criterion several beds of maroon clay are included in the "Cloverly" formation, though beds of similar character occur throughout the Morrison. In the absence of a conglomerate at this horizon on Shoshone River it seems reasonable to consider that the uppermost red clay marks the limit of Morrison sedimentation.

There is a striking resemblance between the middle portion of the formation along Shoshone River and that in the region north of Thermopolis described by Darton.[2] Evidence of an unconformity between the Morrison and "Cloverly," noted by Fisher [3] in places has not been found on Shoshone River.

Besides the variegated color and alternations of several diverse types of material, a characteristic feature of the formation is the presence of gastroliths, or "stomach stones," which are found in intimate association with large saurian bones. In an area 20 feet in diameter on the cut bank where the beds are exposed on the north side of the river no less than 60 pounds of large bone fragments and 15 pounds of gastroliths were found. The gastroliths range from 2 to 5 inches in diameter and are faceted but highly polished. Most of them are chert, showing crinoid stems and Bryozoa, and one large pebble is hornstone, containing a few pyrite crystals, a rock not known to exist in place within 150 miles of this locality.

[1] Fisher, C. A., op. cit., p. 25.
[2] Darton, N. H., Geology of the Bighorn Mountains: U. S. Geol. Survey Prof. Paper 51, p. 50, 1906.
[3] Fisher, C. A., op. cit., p. 26.

Section of Morrison formation on Shoshone River.

	Feet.
Shale, maroon and gray, sandy	50
Sandstone, buff	6
Shale, gray, sandy	12
Sandstone, buff	4
Shale, gray, sandy	10
Sandstone, buff, cross-bedded	8
Clay, gray, sandy	50
Sandstone, buff, fine grained, evenly bedded, and ripple marked	6
Clay, maroon and yellow, sandy	44
Clay, dark brown to black, containing saurian vertebræ, limb bones, and gastroliths	20
Sand, gray, argillaceous, only locally indurated, containing wood silicified in place, as well as rounded pebbles of similar material; carbonized plant remains and small calcareous concretions	50
Clay, maroon, sandy	55
Sandstone, white, homogeneous, only locally indurated	25
Clay, prevailingly gray and olive-colored, but with three broad maroon bands, sandy	100
Shale, green, sandy, transitional to upper sandstone of the Sundance formation	140
	580

C. W. Gilmore reports that bones collected from the 20 feet of clay near the middle of the formation represent "the vertebra of a carnivorous dinosaur, not otherwise determinable."

"CLOVERLY" FORMATION.

The recognition of the "Cloverly" formation is based wholly on its lithologic character and relation to the overlying marine shale and the underlying Morrison formation. The name has been applied by Darton [1] to a group of beds which lie beneath the Colorado formation on the west side of the Bighorn Mountains and which he believed to include the equivalent of the Dakota sandstone, together with beds of Lower Cretaceous age. Fisher [2] has reported a collection of plants from shale overlying a coal bed below the base of the Colorado formation in the eastern part of the Bighorn Basin, which were determined to be of Kootenai (Lower Cretaceous) age, and on the basis of this determination he regards the "Cloverly" as the equivalent of the Kootenai of the Montana region. No fossils have been found along the west side of the basin, nor is there evidence of the presence of a coal bed with which the leaves are associated.

[1] Darton, N. H., op. cit., p. 53.

[2] Fisher, C. A., Southern extension of the Kootenai and Montana coal-bearing formations in northern Montana: Econ. Geology, vol. 3, p. 84, 1908.

On account of the nearly vertical walls of the canyon of Shoshone River these beds, although well exposed, can not be examined in detail.

The sandstones are fine grained and the grains are angular and fairly uniform in size, ranging from 0.1 to 0.25 millimeter in diameter. They are firmly held by a cement composed largely of carbonate of iron. No conglomerate beds such as have been recognized elsewhere in the basin were found in the section.

Section of "Cloverly" formation on Shoshone River.

	Feet.
Sandstone, buff, indurated, characteristically thin bedded and ripple marked. The beds range from half an inch to 20 inches in thickness and are composed of angular and subangular grains of quartz, with traces of muscovite near the top	60
Shale, gray, sandy	25
Sandstone, buff, massive	25
	110

COLORADO FORMATION.

GENERAL CHARACTER.

The entire Colorado formation is exposed in exceptional detail along Shoshone River and is separable lithologically into three members—the lowest, 1,026 feet thick, composed largely of shale; the middle, 494 feet thick, predominantly shaly but containing a number of massive sandstones from 3 to 40 feet thick; and the uppermost, 2,150 feet thick, principally shale. The lower two members contain but a few fossils, which do not serve to correlate them accurately with portions of the formation observed in near-by regions. The lower part of the upper member is highly fossiliferous. Most of the sections presented herewith are those exposed on the north side of the river, though a portion of the formation near the base has been examined on the south side. There is no evidence of unconformable relations such as have been inferred by Washburne[1] on the east side of the basin.

The section is interesting as containing the oil sands which have been struck in the well of the Shoshone Oil Co., the log of which is given on page 65. The sandstone referred to by Washburne as the source of gas in wells on the east side of the basin is undoubtedly the equivalent of the 20-foot sandstone near the base of the lower shale member on Shoshone River, which has also yielded oil in the Shoshone Oil Co.'s well. There is a close resemblance between the section given by Washburne[1] and that on Shoshone River.

[1] Washburne, C. W., Gas fields of the Bighorn Basin, Wyo.: U. S. Geol. Survey Bull. 340, p. 350, 1908.

LOWER MEMBER.

The most unusual feature of the lower member is the persistent occurrence of bentonite, a yellow unctuous clay, in beds from 1 inch to 4 feet thick. Near the base of the member there are numerous thin beds of bentonite, the 392-foot shale of the section below containing no less than 35 beds, whereas the upper portion contains fewer though much thicker beds. Bentonite is known to occur in many localities in Wyoming where the Colorado shale is well exposed,[1] but the number of beds in the Shoshone River section greatly exceeds that reported elsewhere. It appears to be at least possible that more beds of bentonite than have been reported exist in the Colorado shale in other parts of Wyoming, but that the conditions of exposure do not permit their recognition. The shale of this member is gray to blue-black, dense, fine grained, and near the base carbonaceous.

Section of the lower member of the Colorado formation on Shoshone River.

	Feet.
1. Shale, sandy	32
2. Shale, blue-gray, with fish scales	56
3. Sandstone, buff	4
4. Bentonite	4
5. Shale, gray, with fish scales and vertebræ	45
6. Bentonite	4
7. Shale, gray, with fish scales	151
8. Sandstone, buff, thin bedded	80
9. Shale, dark, dense	50
10. Sandstone	3
11. Shale, bluish black, containing several thin gray sandstones and numerous beds of bentonite from 1 inch to 4 feet thick	392
12. Sandstone, buff, massive; the lower portion cross-bedded and containing numerous crocodile teeth, several caudal vertebræ of dinosaurs, and a turtle, also many pieces of carbonized plant material; fossil collection 123	20
13. Shale, dark brown to black, containing thin beds of bentonite near the top	185
	1,026

Fossil collection No. 123 contained "caudal vertebræ of dinosaur; teeth of crocodile," according to C. W. Gilmore. O. P. Hay reports that the turtle "represents an undescribed species probably belonging to the genus Gyremys. This genus is known from a single specimen, *G. spectabilis* Hay, believed to be from the Judith River formation of Montana."

MIDDLE MEMBER.

The middle member is extraordinarily well exposed and accessible. The shale in the member is gray, sandy, and only locally carbonaceous. The sandstones are gray and buff and well indurated, and sev-

[1] Fisher, C. A., The bentonite deposits of Wyoming: U. S. Geol. Survey Bull. 260, p. 559, 1904.

eral of them contain persistent zones of chert pebbles, a feature which has been recognized elsewhere in the Bighorn Basin. Though the middle member contains several thick beds of bentonite, it lacks the great number of thin beds noted in the lower member.

Section of the middle member of the Colorado formation on Shoshone River.

	Feet.
1. Sandstone, buff, separated into three benches by thin brown shale bands; upper and lower benches contain chert pebbles, the largest half an inch in diameter	24
2. Sandstone, buff to gray, shaly	60
3. Shale, brown	1
4. Bentonite	8
5. Shale, brown	5
6. Sandstone, buff	6
7. Bentonite	6
8. Shale, brown, with 4 inches of coal	3
9. Sand, brown, shaly	8
10. Shale, brown, with two thin coal beds	2
11. Shale, dark	13
12. Sandstone, buff	3
13. Shale, sandy	30
14. Sandstone, buff	6
15. Shale, sandy	55
16. Sandstone, drab, separable into four massive benches by thin shale layers; second bench from the top contains black chert pebbles three-fourths of an inch in diameter	40
17. Shale, sandy	32
18. Sandstone, buff, thin bedded	18
19. Shale, sandy	22
20. Sandstone, buff, thin bedded	12
21. Shale	16
22. Sandstone, buff	8
23. Shale	16
24. Sandstone, buff	40
25. Shale	24
26. Sandstone, buff, thin bedded, containing nonpersistent zones of chert pebbles as much as 3 inches thick near the top and a highly persistent zone 6 inches thick near the middle; the pebbles range from three-fourths of an inch to 2 inches in diameter; fragments of bone and bivalve shells are common	36
	494

UPPER MEMBER.

The uppermost sandstone of the middle member is overlain by a great thickness of shale which, though increasingly sandy near the upper limit, does not contain any lithologic units clearly separable from the shale. The thickness of this member along Shoshone River is 2,150 feet, the upper limit being the first massive sandstone of the overlying Gebo formation. The beds may be most satisfactorily examined on the south side of the river east of the anticline on which the Shoshone Oil Co.'s well is situated.

The lower portion of the member contains many concretions, most of which contain numerous fossils. These definitely establish the age of the beds as upper Colorado.[1]

Though there are no separable lithologic units in this shale member, close examination shows that several diverse types are present. The basal 200 feet is predominantly dark blue-gray to black in color, fine grained, and free from sand. This portion contains relatively few fossils. The next 300 feet is olive-gray to pale green, is locally sandy, and contains the concretions from which most of the fossils are derived. Its color is due to a disseminated green mineral, which is probably glauconite. Above this zone the member contains an increasing proportion of quartz sand, and the 400 feet underlying the basal massive sandstone of the Gebo formation is essentially a succession of thin argillaceous sandstones. This portion is buff in color, evenly bedded, and locally ripple-marked. It has thus far only yielded a few gastropods too poorly preserved to permit identification.

The following collections of fossils from the upper member of the Colorado formation were made by Woodruff and Willard and by the writer:

4960. Woodruff:
- Inoceramus exogyroides M. and H.
- Inoceramus undabundus M. and H.
- Inoceramus acuteplicatus Stanton.
- Inoceramus sp.
- Legumen sp.
- Pholadomya papyracea M. and H.
- Baculites asper Morton (?)
- Baculites sp.
- Scaphites ventricosus M. and H.
- Ancyloceras (?) sp.
- Mortoniceras sp. related to M. shoshonense M. and H.

4991. Willard:
- Anomia sp.
- Avicula sp. cf. A. linguiformis E. and S.
- Inoceramus acuteplicatus Stanton.
- Inoceramus sp.
- Crassatellites n. sp.
- Corbula sp.
- Turritella n. sp.
- Baculites asper Morton?
- Baculites sp.
- Scaphites ventricosus M. and H.
- Mortoniceras sp.

5032. Willard:
- Avicula sp.
- Inoceramus umbonatus M. and H.
- Inoceramus acuteplicatus Stanton.
- Crassatellites n. sp.
- Corbula sp.
- Dentalium sp.
- Turritella sp.
- Gyrodes conradi M. and H.
- Fusus (?) sp.
- Baculites asper Morton.
- Scaphites ventricosus M. and H.

7369. Hewett:
- Anomia sp.
- Avicula sp. cf. A. linguiformis E. and S.
- Nemodon? sp.
- Veniella sp.
- Pholadomya papyracea M. and H.
- Corbula sp.
- Dentalium sp.
- Volutoderma sp.
- Cinulia sp.
- Baculites sp.
- Scaphites ventricosus M. and H.
- Mortoniceras shoshonense Meek.

[1] In the report by Fisher (U. S. Geol. Survey Prof. Paper 53) these beds, on the basis of meager fossil collections, were regarded as being equivalent to the Pierre of eastern Wyoming and Montana. Their age appears now to be established as Colorado.

GEBO FORMATION.

Overlying the thin-bedded shaly sandstones of the upper member of the Colorado is a mass of buff to cream-colored sandstone, in beds ranging from 18 to 65 feet in thickness, with thin intercalated shales, which near the base contain coal. On account of the indurated condition of the sandstone the river flows in a narrow gorge for the greater portion of the section and they can not be examined in detail. In the region south of the river, however, these beds constitute a well-defined lithologic unit and wherever they outcrop form high rugged ridges. The name is derived from the town of Gebo, near Thermopolis, in the south end of the Bighorn Basin, near which extensive mining operations have been conducted on a coal bed near the base of the formation.

The thickness assigned to the formation along Shoshone River is 1,120 feet, the basal and top members being assumed as the lowest massive sandstone above the upper member of the Colorado and the highest indurated sandstone below the Cody coal bed. This thickness compares with measurements of 1,250 to 1,430 feet, made in the region south of the river. The formation has yielded a meager flora and a few invertebrate fossils along the river, on the basis of which the lower portion is correlated with the beds referred to the Eagle, containing the coals near Bridger, Mont. This correlation is confirmed by the field work of Fisher, Washburne, and Woodruff, who have traversed and mapped the coal beds of the formation almost continuously from south-central Montana into Wyoming and around the Bighorn Basin. The formation contains a characteristic marine fauna in the upper Missouri River region [1] and in southern Montana,[2] but no invertebrate fossils have yet been found in the basal portion of the formation on Shoshone River. A few poorly preserved mollusks were collected from the sandstone overlying the lowest coal, 85 feet above the base of the formation at Thompson's coal mine, 15 miles south of Cody, but they are not diagnostic species.

Throughout central and southern Montana the thickness of the Eagle sandstone ranges from 200 to 370 feet. In the region north of Shoshone River, where the Eagle has been more carefully studied, it is overlain by the Claggett formation, from 400 to 760 feet thick. In the type locality in central Montana the Claggett formation is predominantly shale which yields a characteristic marine fauna, but, as shown by the sections given by Fisher,[3] in its southern extension the proportion of sandstone increases, and at Elk Basin, on the Montana-Wyoming line, the section shows only a minor proportion of

[1] Stanton, T. W., and Hatcher, J. B., Geology and paleontology of the Judith River beds: U. S Geol. Survey Bull. 257, p. 12, 1905.

[2] Unpublished notes of T. W. Stanton.

[3] Fisher, C. A., Southern extension of the Kootenai and Montana coal-bearing formations in northern Montana: Econ. Geol., vol. 3, p. 87, 1908.

shale. Though the beds yield a characteristic fauna as far south as Bridger, Mont.,[1] none of the fossils have thus far been found on Shoshone River nor in the region south of it. The conclusion appears justifiable that the upper sandstones of the Gebo formation correspond to the Claggett formation of Montana, and therefore that the Gebo formation, having a thickness of 1,120 feet on the river, is essentially the equivalent of both the Eagle and Claggett formations.

Section of Gebo formation on Shoshone River.

	Feet.
Sandstone, buff, massive	18
Shale, drab to brown; fossil collection 17, Knowlton (?)[2]	50
Sandstone, buff, massive	20
Sandstone, locally massive and indurated, with few beds of gray to brown shale; fossil collection 4972, and 38, Woodruff	720
Sandstone, buff, massive	40
Clay, gray to brown, homogeneous, sandy	20
Sandstone, buff, thin bedded	55
Shale, carbonaceous, with thin coal bed	20
Sandstone, thin, and shale	50
Shale, dark, with two thin coal beds	32
Sandstone, buff, massive	28
Shale, sandy	2
Sandstone, massive, cavernous outcrop	65
	1,120

The following collections of fossils from the Gebo formation were made by Woodruff and Knowlton in 1907:

4972. Woodruff:
- Unio sp.
- Sphærium sp.
- Corbula subtrigonalis M. and H.
- Goniobasis invenusta M. and H.
- Viviparus sp. related to V. conradi M. and H.

Comment by T. W. Stanton: "Judith River rather than Claggett."

38. Woodruff:
- Sequoia brevifolia.
- Protophyllum n. sp.
- Ficus (?) sp.
- Juglans (?) sp.

Comment by F. H. Knowlton: "I do not know this flora. It is not like what has come heretofore from the Eagle, though it may be an Eagle flora. The Protophyllum is of the type of certain species found in the Dakota, while the Sequoia is ordinarily an upper Montana form."

17. Knowlton:
- Platanus (?) wardii Kn.
- Ficus sp.

Comment by F. H. Knowlton: "If the above species is correctly determined, the age of this should be Eagle, but it is insufficient to be very positive about."

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[1] Unpublished notes of T. W. Stanton.

[2] The source of this collection can not be indicated with assurance.

MEETEETSE FORMATION.

The name Meeteetse is applied to a group of beds 1,110 feet thick which overlie the Gebo formation and which, being poorly exposed along the river, have been more thoroughly studied in the region south of it. From their lithologic character and relations in that region these beds have been recognized as a persistent formation, which is named from the town of Meeteetse, on Greybull River, the largest town in the southwestern portion of the basin. No fossils have been found in the formation along the river, but in the region south of it no less than 19 species of plants have been found. This flora is distinctly that of the Montana group, six species occurring in the upper part of the Mesaverde formation at Point of Rocks, Wyo., and five in the Judith River formation on Willow Creek, Mont. Most of the collections have been designated "Judith River" by F. H. Knowlton, and the beds are regarded by him as equivalent to the Judith River formation or Belly River beds of Canadian geologists. One collection containing five species of leaves, obtained 130 feet above the base of the formation, 15 miles south of the river, is reported by F. H. Knowlton to indicate "the approximate position of the Mesaverde." No vertebrate or invertebrate fossils have yet been found in the formation.

The conspicuous features of the formation are the presence of a number of beds of carbonaceous shale and coal and the general absence of induration of the beds. Along Shoshone River and also throughout the greater portion of the region south from the river to Owl Creek carbonaceous shale and coal beds are largely confined to the upper half of the formation, and though on the river there is but one bed of coal more than 14 inches thick—that which has been mined by the Cody Coal Co.—in the neighborhood of Meeteetse some sections contain as many as five beds. The beds are, however, highly lenticular and the coal is poor in quality compared to the coals in the underlying Gebo formation and the higher Fort Union formation. Somber colors prevail throughout the formation, the greater portion of the beds being gray to olive colored.

The material constituting the formation is characteristically poorly assorted; the sandstone contains much clay and the shale is sandy, features which partly account for the absence of induration. Mica is common throughout the formation, and some beds near the middle contain a large proportion of fresh biotite. Silicified wood is not common on the river, but is abundant in the lower 600 feet of the formation, where the beds are exposed in bad lands. Trunks of trees as much as 28 inches in diameter and 10 feet long, as well as roots silicified in place, have been found. The upper limit is the base of a bed of white, poorly indurated sandstone which is persistent throughout the west side of the Bighorn Basin.

Section of Meeteetse formation on Shoshone River.

	Ft.	in.
Shale, brown, carbonaceous	3	
Shale, gray	6	
Shale, carbonaceous	2	
Shale, gray	8	
Shale, carbonaceous	3	
Sand, olive-colored, argillaceous, with zones of sandy clay	210	
Shale, gray, sandy, with thin beds of carbonaceous shale	60	
Shale, carbonaceous	3	6
Sand, olive-colored, argillaceous	60	
Coal, Cody {Coal, 30 inches; Shale, 1 inch; Coal, 23 inches}	4	6
Sandstone, buff and pale olive-gray, argillaceous	750	
	1,110	

ILO FORMATION.

The Ilo formation presents poorer exposures along Shoshone River than any of the Upper Cretaceous formations. Its character is best displayed in the region south of the river, where several collections of invertebrate fossils have been made. Sandstone is the most abundant constituent, but the beds are so lacking in induration that except in small areas of bad lands where portions of the formation are shown there are few outcrops and it has not been possible to examine a complete section. The best exposures on the west side of the Bighorn Basin are in the open valley northwest of Ilo, a settlement 50 miles southeast of Cody, from which the name of the formation is derived. Here a thickness of 810 feet has been measured, compared to 850 feet 2 miles west of Meeteetse. As no fossil collections have been obtained on the river from the zone approximately 1,300 feet thick between the beds in which fossils were found by Woodruff (4959) and Willard (365), the upper limit of the Ilo formation has not been established. There is some reason, however, for believing that the lowest conglomerate zone in the Fort Union formation is approximately the equivalent of a persistent zone 400 feet above the base of the Fort Union throughout the region between Greybull River and Owl Creek, where data bearing on the relations between the Ilo and Fort Union are abundant. On Shoshone River, therefore, the top of the Ilo formation is provisionally assumed to be 400 feet below the lowest conglomerate of the Fort Union formation. The formation is regarded as approximately equivalent to the Lance formation in the eastern part of the State.

The Ilo formation consists of several groups of beds of massive yellow sandstone which range from 20 to 60 feet in thickness. Unindurated clay and argillaceous sand alternate with the sandstone, and zones 200 to 600 feet from the base contain invertebrate and vertebrate fossils which serve to establish the age of the formation. Thin beds of carbonaceous shale occur near the bottom, but are not persistent, and coal is conspicuously absent. The materials are more perfectly assorted than those of the Meeteetsè formation, but along Shoshone River there are few well-defined lithologic units capable of separation from the associated materials.

Section of Ilo formation on Shoshone River.

	Feet.
Sandstone with zones of conglomerate of the Fort Union formation.	
Sandstones, buff and olive-colored, unconsolidated, with minor zones of sandy clay; fossil collections 4976, 4990, 4959	1,555
Shale, carbonaceous	6
Sandstone, olive-colored, argillaceous	160
Shale, carbonaceous	4
Clay, gray, sandy	25
Sandstone, white, unindurated	40
	1,790

The following collections of fossils from the Ilo formation were made in 1907 by Woodruff and Willard:

4976. Woodruff:
  Sphærium sp.
  Campeloma multilineata M. and H.
  Physa sp.
    Comment by T. W. Stanton: "Horizon probably 'Ceratops beds.'"

4990. Willard. 1,125 feet east of Cody coal mine;
  Sphærium sp.
  Goniobasis tenuicarinata M. and H.
  Physa sp.
  Columna sp.
  Hydrobia (?) sp.
    Comment by T. W. Stanton: "Horizon probably 'Ceratops beds.'"

4959. Woodruff. 900 feet stratigraphically above Cody coal mine:
  Unio sp. related to U. priscus M. and H.
  Sphærium sp.
  Goniobasis (?) sp.
  Viviparus sp.
  Campeloma multilineata M. and H. (?)
    Comment by T. W. Stanton: "Horizon not closely fixed by these fossils, but it is believed to be about that of the 'Ceratops beds.'"

FORT UNION FORMATION.

From the point where Sage Creek enters Shoshone River from the south to the bend where the river turns northward around McCulloch Peak, a distance of 12,000 feet, a group of beds are exposed which have thus far yielded only a Fort Union flora and fauna. On account of the great thickness of this formation, 5,400 feet, and the minor importance of the stratigraphy at this horizon, it has not been deemed advisable to measure the section in great detail. The point at which these beds are overlain by those of Wasatch age lies east of the limit of this survey.

It is to be regretted that the valley of Sage Creek meets the river at a point near the base of this formation, for this fact, together with the poor exposures throughout the upper portion of the Ilo formation, prevents detailed examination of the relations of the two formations.

In degree of consolidation and lithologic character the beds of the Fort Union stand in contrast to those of the underlying Ilo and Meeteetse formations. Though they include many zones of relatively unconsolidated material, the beds of the lower portion of the Fort Union are compact and resistant and in the region south of Shoshone River form persistent high ridges. Beds of conglomerate occur at several horizons and are interesting as indicating the conditions of sedimentation as well as the lithologic types present. The lowest group of conglomerates contains six zones from 5 to 20 feet thick in a stratigraphic distance of about 250 feet. Each of these zones is composed of smaller zones or beds of conglomerate, which range from 2 to 10 feet in thickness. The dip section is well exposed and shows the single beds to be relatively persistent in the direction of the dip—northeast—whereas in the strike section, which is not so well shown, the separate beds are not persistent, but lenticular and characteristically anastomosing. Though definite conclusions can scarcely be based on this single exposure, these features suggest that the pebbles were deposited by streams flowing from the west or southwest toward the east or northeast. The pebbles are mostly subangular to rounded. The largest pebbles are indurated fine sandstones about 5 inches in diameter. Most of the pebbles are gray to black chert, from half an inch to 2 inches in diameter. There are a few pebbles of red and gray quartzite; limestone pebbles are rare, and pebbles of vein quartz and igneous rocks are conspicuously absent. A few of the chert pebbles contain fossils which can be referred broadly to the Carboniferous, but from the same zone of conglomerates within 10 miles south of the river a collection of chert pebbles containing no less than 11 species has been made. The age of these fossils ranges from Pennsylvanian to probably Permian (Phosphoria fauna), and it is evident that rocks of this age that were being eroded were the source of a part of the Fort Union sediments. It appears highly probable that the pebbles of silicified wood were derived from the Meeteetse formation. If this is true it is a factor in proving that local unconformities exist between the Fort Union formation and the underlying beds.

The higher conglomerate beds, such as occur in the 50-foot sandstone near the middle of the subjoined section, are thinner and contain lithologic types not found lower in the formation. Quartzites are more abundant than chert, and there are fair proportions of quartz schist and pink granite pebbles not represented in the lower beds. At one place a well-rounded pebble of coal 3 inches long was found.

The presence of red clay in the upper part of the Fort Union formation and the small amount of mica throughout the formation serve further to distinguish these beds from the Ilo and Meeteetse formations. There is no coal in the Shoshone River section of the Fort Union, but a bed is mined near Meeteetse at a horizon which corresponds closely with that of the lower conglomerate on the river.

Section of Fort Union formation on Shoshone River.

	Feet.
Sandstone, buff, massive	20
Clay, gray, and argillaceous sand, with thin zones of carbonaceous shale	185
Shales, maroon and gray, sandy	150
Clay, red	8
Clay, gray	6
Clay, red	6
Clay, gray	6
Clay, red (mouth of creek from south)	8
Clay, gray	8
Sandstone, buff, massive	15
Sand, drab, argillaceous	166
Clay, red	3
Clay, gray	1
Clay, red	2
Sand, gray, argillaceous	40
Sandstone, massive	8
Sand, gray to olive-gray, with conglomeratic layers	50
Sand, argillaceous	30
Sandstone, massive	40
Sand, argillaceous	30
Sand, buff to olive-gray, argillaceous; fossil collection 4994	558
Clay, red	3
Clay, gray	8
Clay, red	3
Sandstone, massive	24
Shale, gray, sandy	8
Sandstone, massive, conglomeratic	16
Sand, argillaceous, and unconsolidated clay, with thin carbonaceous shale; fossil collections Woodruff 40, Knowlton 16	1,760
Shales, gray and olive-gray, sandy, and sand with carbonaceous shale; fossil collection 4973	440
Sand, argillaceous, and clay	680
Sandstones, gray and buff, alternating with zones of unconsolidated sand	410
Sandstones, gray and buff, containing numerous zones of conglomerate in the lower 200 feet; fossil collection 366 Willard	500
Sandstone, buff; fossil collection 365 Willard	400
Mouth of Sage Creek.	
	5,592

The following collections of fossils from the Fort Union formation were made by Willard, Woodruff, and Knowlton in 1907:

366. Willard:
Populus sp. (?)
Fragments of dicotyledons.
Comment by F. H. Knowlton: "Horizon probably Fort Union."

365. Willard:
Platanus raynoldsii Newb.
Platanus haydenii Newb.
Platanus nobilis (?) Newb.
Comment by F. H. Knowlton: "Horizon Fort Union."

4973. Woodruff:
Viviparus trochiformis M. and H.
Goniobasis tenuicarinata M. and H.
Comment by T. W. Stanton: "Horizon Fort Union."

16. Knowlton:
Taxodium occidentale Newb.
Populus sp. probably P. speciosa Ward.
Populus arctica Heer of Lesq.
Hicoria antiquorum (Newb.) Kn.
Celastrinites sp. cf. C. grewiopsis Ward.
Juglans, probably new.
Comment by F. H. Knowlton: "Horizon Fort Union."

40. Woodruff:
Sequoia langsdorfii (Brgt.) Heer.
Sapindus grandifolius Ward.
Populus glandulifera? Heer.
Carpites sp. (Palmocarpon?).
Juglans sp.
Platanus nobilis (?) Newb.
Comment by F. H. Knowlton: "Horizon Fort Union."

4994. Woodruff:
Helix sp.
Physa sp.
Goniobasis tenuicarinata M. and H.
Viviparus trochiformis M. and H.
Comment by T. W. Stanton: "Horizon Fort Union."

CORRELATIONS OF THE FORMATIONS.

The Sundance formation has furnished a sufficient number of marine fossils to permit its correlation beyond any doubt with well-known sections throughout eastern and northern Wyoming and southern Montana.

Though the presence of saurian bones appears to establish the existence of the Morrison formation, it can not be stated with assurance that a part of the thickness here assigned to it does not represent the Kootenai formation, nor that the beds assigned to the "Cloverly" in this section are not also a part of the same formation.

The great thickness of the Colorado formation, 3,670 feet, compares with measurements of 2,775 feet in the Electric coal field, Mont.,[1] and 3,700 feet near Livingston, Mont.,[2] where faunas similar to that on Shoshone River have been obtained. In comparing the Shoshone River section of the Colorado with those in eastern Wyoming,[3] it is noted that though there is a lithologic resemblance the eastern Wyoming sections contain a Niobrara fauna that is absent in the Bighorn Basin. In southwestern Wyoming the combined Colorado and Montana sections are from 9,000 to 11,000 feet thick and are capable of division into three formations relatively distinct lithologically, as well as faunally, much resembling the three members of the Colorado recognized on Shoshone River. The coal near the top of the middle member would therefore occupy a stratigraphic position similar to the beds of the Kemmerer coal group in the Frontier formation[4] in Uinta and Lincoln counties, Wyo. Only two of the marine fossils of the upper member on Shoshone River are present in the southwestern Wyoming section. The Pierre shale of Fisher's report on the Bighorn Basin[5] and of Darton's report on the Bighorn Mountains[6] is the upper shale member of the Colorado formation.

The most interesting feature of the Shoshone River section is the apparent absence of marine beds above the sandstone overlying the lowest coal of the Gebo formation. No fossils have been found at this horizon on Shoshone River, but a small collection was obtained from the roof of Thompson's coal mine, 15 miles south of Cody. For correlating the formations above this horizon with those of near-by regions dependence must be placed on vertebrate and fresh-water invertebrate fossils and plant remains, and it is to be regretted that good collections have not been found near well-defined and persistent lithologic units, though small collections have been obtained. In the absence of more complete collections, it is at least possible that the Colorado formation should include the lowest two sandstones of the Gebo formation.

The marine faunas of the Eagle and Claggett formations[7] of central Montana have not been found south of the Montana-Wyoming line, though Claggett fossils have been found near Bridger, Mont. Commenting on collections of fossils made by himself and others along Shoshone River and northward into Montana, Stanton writes:[8]

[1] Calvert, W. R., The Electric coal field, Park County, Mont.: U. S. Geol. Survey Bull. 471, p. 413, 1912.

[2] Calvert, W. R., The Livingston and Trail Creek coal fields, Mont.: U. S. Geol. Survey Bull. 471, p. 387, 1912.

[3] Wegemann, C. H., The Salt Creek oil field, Natrona County, Wyo.: U. S. Geol. Survey Bull. 452, p. 45, 1911.

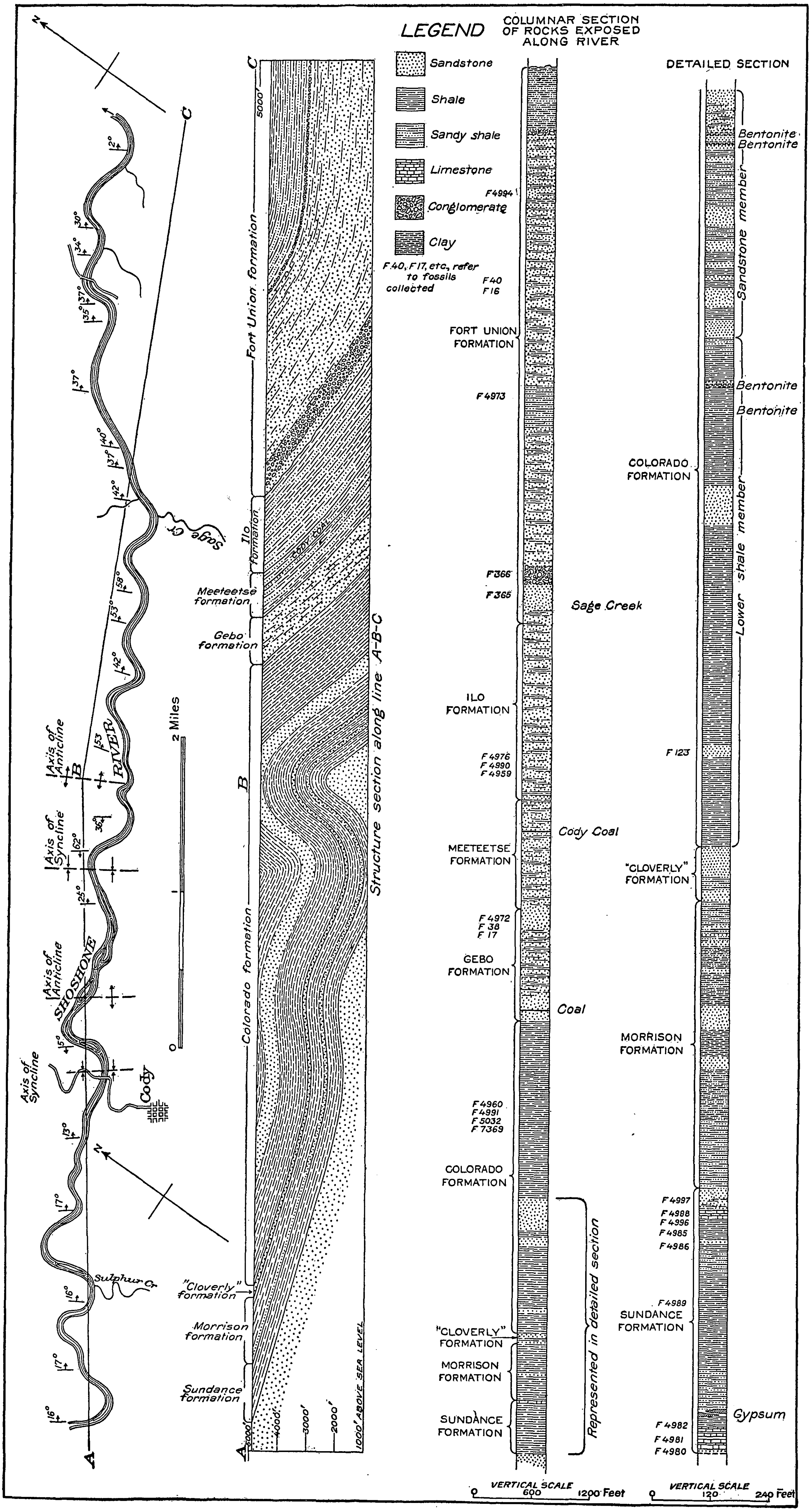
[4] Veatch, A. C., Geography and geology of a portion of southwestern Wyoming: U. S. Geol. Survey Prof. Paper 56, p. 115, 1907.

[5] Fisher, C. A., Geology and water resources of the Bighorn Basin, Wyo.: U. S. Geol. Survey Prof. Paper 53, p. 30, 1906.

[6] Darton, N. H., Geology of the Bighorn Mountains: U. S. Geol. Survey Prof. Paper 51, p. 58, 1906.

[7] Stanton, T. W., and Hatcher, J. B., Geology and paleontology of the Judith River beds: U. S. Geol. Survey Bull. 257, pp. 12, 13, 1905.

[8] Letter accompanying report on fossils to E. G. Woodruff, February, 1908.



STRUCTURE AND COLUMNAR SECTIONS OF ROCKS EXPOSED ALONG SHOSHONE RIVER NEAR CODY, WYO.

The Eagle, Claggett, and Bearpaw formations ought all to have marine faunas, but none such have been found in the Shoshone River section. Their absence indicates that possibly here and farther south in Bighorn Basin land conditions may have begun earlier than elsewhere and may have continued with little or no interruption to the end of the Cretaceous. Of course, it is recognized that there was more or less break in marine conditions during the deposition of the Eagle, even where that formation is mostly marine. This is indicated by the occurrence in it of land plants and vertebrates and of coal beds.

Further study appears to confirm this interpretation. The sandstone formation overlying the Colorado shale 750 to 900 feet thick in the Livingston coal field [1] and 1,000 feet thick in the Electric coal field [2] is undoubtedly the equivalent of the Gebo formation.

In view of the fact that the recognition of the Meeteetse and Ilo formations is based largely on data collected in field work in the Oregon Basin, Meeteetse, and Ilo quadrangles, south of Shoshone River, it is deemed advisable to present the discussion of their relations in the report on those areas.[3]

The incomplete section of the Fort Union formation, 5,592 feet thick, compares with a measurement of 8,500 feet by Woodruff in the Red Lodge coal field,[4] though there is no indication of coal beds in the Shoshone River section similar to the coal beds which occur in the upper portion of the Red Lodge section. Coal beds are present near the base of the Fort Union, however, near Meeteetse and Ilo, Wyo., a fact which, taken with other lithologic features, is proof of the great differences in the conditions of deposition existing in adjacent regions at the same relative epoch.

STRUCTURE.

The structure of the northern portion of the Bighorn Basin has been described by Eldridge [5] and Fisher [6] and has been illustrated by cross sections and a structural contour map. Rattlesnake and Cedar mountains, lying 3 miles west of the limits of the present survey, are portions of a broad asymmetric anticline through which Shoshone River has cut a deep narrow gorge. The section presented on Plate V shows two minor anticlines on the east flank of this major structural feature. On the west side of Rattlesnake Mountain the Madison limestone dips 55° SW., whereas on the east at the same level this formation dips 16° NE. From this point eastward to the out-

[1] Calvert, W. R., The Livingston and Trail Creek coal fields, Mont.: U. S. Geol. Survey Bull. 471, p. 387, 1912.

[2] Calvert, W. R., The Electric coal field, Park County, Mont.: U. S. Geol. Survey Bull. 471, p. 410, 1912.

[3] Hewett, D. F., Geology and coal resources of the Oregon Basin and Meeteetse quadrangles, Wyo.: U. S. Geol. Survey Bull. — (in preparation).

[4] Woodruff, E. G., The Red Lodge coal field, Mont.: U. S. Geol. Survey Bull. 341, p. 94, 1909.

[5] Eldridge, G. H., A geological reconnaissance in northwest Wyoming: U. S. Geol. Survey Bull. 119, 72 pp., 1894.

[6] Fisher, C. A., Geology and water resources of the Bighorn Basin, Wyo.: U. S. Geol. Survey Prof. Paper 53, p. 30, 1906.

crop of the middle member of the Colorado the dip varies from 16° to 17°, and then decreases until the axis of the syncline opposite the town of Cody is reached. Proceeding eastward, surface observations being made on beds of the upper shale of the Colorado, the strata rise over a low anticline and again descend at 22° to a second synclinal axis. There is then a broad belt within which exposures are poor. The first good exposures are in upper shale of the Colorado, dipping 62° SW., and a short distance east the axis of a narrow anticline is crossed. From this point northeast to the mouth of Sage Creek the dip varies from 42° to 58°, and then after remaining relatively uniform at 37° for 1½ miles decreases abruptly to 3°, an inclination which is maintained beyond the limits of the survey.

The areal extent of the anticlines exposed along Shoshone River has not been determined. Together with the Rattlesnake-Cedar Mountain anticline they form a portion of a belt of folded rocks which extends around the entire border of the basin. Throughout this belt the anticlines are from 8 to 15 miles long and from 3 to 6 miles wide and therefore may be regarded as elongated domes. Their axes, though essentially parallel, are successively offset and an anticlinal axis is commonly succeeded along the strike by a synclinal axis. As far as this examination has been carried the broad western anticline, which may be referred to as the Cody anticline, appears to be a minor structural feature, whereas the eastern or Shoshone anticline is a more extensive fold probably 5 or 6 miles long, and Shoshone River exposes a section across the extreme south end. The highest point of the fold probably lies several miles north of the river.

OIL AND GAS.

WELL OF THE SHOSHONE OIL CO.

One of the objects of the detailed measurement of the Shoshone River section was to ascertain the position and character of the sands from which oil and gas have been derived in the well of the Shoshone Oil Co., situated 1,700 feet north of the river, 3 miles east of Cody. This well is located approximately on the axis of the Shoshone anticline within 3 miles of its southern limit, at the point *B* on Plate V. Information concerning this well has been placed at the writer's disposal by Mr. C. L. Sheedy, at present in charge of operations for the company. A detailed record of the well was not kept during drilling operations and the following log represents notations made by one of the employees:

Log of Shoshone Oil Co.'s well No. 1.

	Feet.
Terrace bowlders	20
Muddy sands	10
Shales, little water	90
Mud, trace of oil	50
Slate	50
White sand, trace of oil	3
Dark shaly sands	77
Shaly sands and slate	60
Slate	225
Dark sandstone, No. 1 oil sand, trace of gas	10
Light sandstone	5
Slates with some thin sandstones	260
Dense sandy shales yielded a little oil	5
Slates	163
Sandstone, No. 2 oil sand; good gas flow at 1,262 feet	234
	1,262

This well was dry except for the small flows encountered above 300 feet. Drilling began November, 1909, and with relatively little interruption continued to 1,000 feet. It started again March, 1911, and was carried to a depth of 1,285 feet by June, 1911. A standard rig was used. Much trouble was experienced from the caving of the shales and swelling of bentonite, and the well was finally cased with 10-inch casing to 260 feet, 8-inch from 260 to 410 feet, and 6¼-inch from 410 to 1,028 feet. During the winter of 1911–12 this well was drilled to a depth of 1,700 feet, where a second gas sand was encountered, which corresponds closely with the 50-foot sandstone in the section of the Morrison formation on page 95. No attempt was ever made to pump from any of the oil sands. No record of production has been kept; it probably did not exceed 200 barrels. All the oil produced was stored and sold locally for lubricating.

OIL SANDS.

By comparison of the log of the well with the stratigraphic section of the lower two members of the Colorado, the "Cloverly" and the Morrison formations, exposed along the river and presented herewith, it has been possible to ascertain the beds which have yielded oil and gas. The top of the well approximately coincides with the top of bed 16 of the section of the middle member of the Colorado on page 98. If this basis is assumed for correlation, the first traces of oil, from 120 to 170 feet, appear to have come from one or more of beds 22, 23, and 24, but the exact sand can not be identified. The sand at 220 feet which yielded a trace of oil is probably a portion of the conglomeratic sandstone No. 26. The first sand which yielded more than a trace of oil, at 585 feet (see analysis No. 1 below), corresponds with bed 8 of the section of the lower member of the Colorado on page 97; this bed, though reported to be but 15 feet thick in the well, is 80 feet thick on the river. The shale bed which yielded a little oil at 860 feet lies in the bentonite-bearing shale, but can not be identified. The sandstone at 1,028 feet, from which of the total yield of this well to date the greatest amount of oil was derived, corresponds closely to bed 12 of the section of the lower member of the Colorado. The analysis of oil from this sand is given under No. 2 in the table. This sandstone lies between thick beds of carbonaceous shale and is that in which saurian bones, crocodile teeth, and a turtle were found. It underlies the shale bearing numerous fish scales and vertebræ which is probably the equivalent of the Mowry shale member of eastern Wyoming. The sandstone at the bottom of the hole, 1,285 feet, which yielded a good flow of gas, is the upper sandstone of the "Cloverly" formation. The oil from two of the oil sands, at 585 and 1,028 feet, rose in the well and flowed when the sands were struck, but soon ceased, and the sands were later cased off in order to drill deeper.

To summarize, it is interesting to note that though oil has been derived from several sandstones in the lower portion of the Colorado formation, the sandstone which has yielded the greatest flow in this well is in or near the position of the Mowry shale member, depending on the limits assigned to it in this section. The sandstones of the lower portion of the Colorado formation yield oil in the Garland,[1] Spring Valley,[2] Labarge,[3] Lander,[4] and Salt Creek[5] fields in Wyoming where structural and other conditions are favorable. In the first three of these fields the sandstones are in or near the position of the Mowry shale member. In the Shoshone anticline the oil has been found along the axis, and, though it can not be stated that pools do not occur at points on the flanks, it appears that structural conditions have been predominant in determining the location of the oil.

Prior to the drilling of the well of the Shoshone Oil Co., another operator drilled a well to a depth of 850 feet near Shoshone River (No. 2 on Pl. V). The log of this well could not be obtained. It was cased but never capped, and oil, water, and gas now issue in small amounts from the mouth.

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[1] Washburne, C. W., Gas fields of the Bighorn Basin, Wyo.: U. S. Geol. Survey Bull. 340, p. 355, 1908.

[2] Veatch, A. C., Coal and oil in southern Uinta County, Wyo.: U. S. Geol. Survey Bull. 285, p. 349, 1906.

[3] Schultz, A. R., The Labarge oil field, central Uinta County, Wyo.: U. S. Geol. Survey Bull. 340, p. 369, 1908.

[4] Woodruff, E. G., The Lander oil field, Fremont County, Wyo.: U. S. Geol. Survey Bull. 452, p. 27, 1911.

[5] Wegemann, C. H., The Salt Creek oil field, Natrona County, Wyo.: U. S. Geol. Survey Bull. 452, p. 71, 1911.

THE OIL.

Analyses of two samples of oil from the wells of the Shoshone Oil Co. are given below. These analyses were made in the laboratory of the United States Geological Survey, under the direction of David T. Day.

Analyses of samples of oil from wells of Shoshone Oil Co.

	1	2
Color	Dark green.	Green.
Specific gravity	0.8454	0.8335
Gravity ° B.	35.60	37.98
Begins to boil at ° C.	190	160
Boiling between 150° and 300° C. per cent.	37	48
Specific gravity of above fraction	0.8169	0.8009
Residue per cent.	59.6	52.4
Specific gravity of residue	0.9278	0.8696
Total per cent.	96.6	100.4
Paraffin do.	7.6	8
Water	Present.	0

1. 585 feet; middle sandstone member of Colorado formation.
2. 1,028 feet; lower shale member of Colorado formation.

Neither of these samples represents the oil as it came from the well. Sample 1 had been kept for some time in an open can and later in a bottle. Sample 2 was taken from an open tank. Neither of these oils is well adapted for lubricating in the raw state but would on distillation, as shown by the fraction distilling between 150° and 300° C., yield a good proportion of illuminating oil and a residue well adapted for lubrication. Sample 2 resembles the oil derived from the Wall Creek sandstone lentil of the Benton shale (lower Colorado) in the Salt Creek field,[1] and the oil from a sandstone in the Mowry shale member of the Mancos shale (lower Colorado) at the Plunkett well in the Lander field.[2] Oils of similar character, thought to have come from a sandstone in the Benton shale or "Cloverly" formation, have been found in wells in the Douglas oil field in central Wyoming (pp. 68–88). It is worthy of note that samples of oils from approximately the same geologic horizon in four fields in Wyoming should be of similar character.

[1] Wegemann, C. H., The Salt Creek oil field, Wyo.: U. S. Geol. Survey Bull. 452, p. 80, 1911.
[2] Woodruff, E. G., The Lander oil field, Wyo.: U. S. Geol. Survey Bull. 452, p. 29, 1911.