DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

BULLETIN 691—E

OIL AND GAS GEOLOGY
OF THE
BIRCH CREEK-SUN RIVER AREA NORTHWESTERN MONTANA

BY

EUGENE STEBINGER

Contributions to economic geology, 1918, Part II
(Pages 149-184)
Published August 13, 1918

WASHINGTON
GOVERNMENT PRINTING OFFICE
1918

DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

Bulletin 691—E

OIL AND GAS GEOLOGY
OF THE
BIRCH CREEK-SUN RIVER AREA NORTHWESTERN MONTANA

BY

EUGENE STEBINGER

Contributions to economic geology, 1918, Part II
(Pages 149-184)
Published August 13, 1918

WASHINGTON
GOVERNMENT PRINTING OFFICE
1918

CONTENTS.

ILLUSTRATIONS.

OIL AND GAS GEOLOGY OF THE BIRCH CREEK-SUN RIVER AREA, NORTHWESTERN MONTANA.

By Eugene Stebinger.

INTRODUCTION.

The area described in this paper lies adjacent to the front range of the Rocky Mountains in northwestern Montana and is part of a large region in the northern Great Plains of the United States and Canada which seems to deserve consideration as prospective territory for oil and gas development. The thick bodies of Upper Cretaceous shale, the sands of which have yielded the greater part of the oil produced in Wyoming and Colorado and large quantities of gas in Alberta, underlie much of this region, in many places at depths that can be reached by the drill. The outcrops of these Cretaceous formations afford unquestionable evidence of being petroliferous, so that drilling in places of favorable structure, such as on well-developed domes or anticlines, seems to offer a reasonable chance of success. It is certain that the plains of northwestern Montana can not be classed as barren of oil until a considerable number of the favorable localities have been carefully drilled. Random drilling regardless of the lay of the rocks, such as has been undertaken up to the present time, has been uniformly unsuccessful. Moreover, even though the region as a whole should eventually prove to contain fair amounts of oil, the area actually underlain by commercial pools might comprise much less than 1 per cent of the total area underlain by the Cretaceous formations, so that the chances of success by random locations are very slight.

Predictions of oil pools from a formation some hundreds of miles beyond localities where it has already proved productive, on the basis of identical geologic age and kind of rock and undoubted indications that it is petroliferous, have often proved unwarranted in the Rocky Mountain region, especially in parts of southern Wyoming and western Colorado, and also in other parts of the United States. Nevertheless under these conditions, if favorable anticlines or other structural features are present, the geologist seems forced into an attitude of persistent optimism until fair tests with the drill have been made on a reasonable number of the more pronounced folds. He can arrive at the general decision that a given area does or does not offer possibilities for production in certain anticlines or structural features, but a further refinement of his conclusions, based on a critical consideration of the specific character of the oil showings, possible variations in the porosity of the sands, or the general adequacy of the supposed source, seems futile in view of the slight progress made by the science of oil geology in evaluating these factors.

The area here discussed is believed not to offer any better chances of success in drilling for oil than the remainder of the broad plains region, extending eastward at least as far as the 110th meridian. It was selected for examination during the season of 1916 because it was thought that the disturbed belt of rocks close to the mountain front would afford the opportunity of examining the upturned edges of the Cretaceous and older formations which underlie the plains region. This supposition was borne out in the field, it being found possible to examine most of the Cretaceous and lower rocks across the entire area from north to south. Further significant data concerning the petroliferous character of the Colorado shale were thus obtained. The purpose of this paper is limited to a presentation of the field evidence having a bearing on the oil and gas prospects of the area, including a description of the broader features of the geology and more detailed accounts of local structural features that seemed to be possible sources of oil and gas.

The field evidence at hand seems to justify the conclusion that anticlines in the eastern part of the area examined beyond the limits of the highly disturbed belt near the mountains offer a better chance of success than those in the disturbed belt. Of the six anticlines found in the nearly horizontal rocks in the eastern part of the area the one lying just north of Willow Creek, in T. 24 N., Rs. 6 and 7 W., because of its size and the definiteness of its outline, offers the best inducements for "wildcat" operations. The unbroken folds in the disturbed belt have only small collecting area down the dip, and although they may contain oil and gas they will probably not yield large quantities.

The writer was assisted in the field work by M. I. Goldman. A large part of the map and many of the stratigraphic data here recorded are the result of his work. The uniform courtesy and hospitality of the residents of the area is hereby gratefully acknowledged. All well records and general information concerning prospect borings were supplied by individuals and companies operating in the area because of their public spirit and eagerness to further the development of the oil resources of Montana.

LOCATION AND SURFACE FEATURES.

The location and relative extent of the area described are shown on the index map (fig. 32). It lies east of the Continental Divide in the Missouri River drainage basin. The front range of the Rocky Mountains borders the area on the west, and Birch Creek, the south boundary of the Blackfeet Indian Reservation, is the limit on the north. The work was extended southward to Willow Creek, and on the east the boundary follows the survey lines of the General Land Office, being limited only by the time available for field work. The area has a maximum length of 53 miles and a maximum width of 21 miles and contains about 750 square miles, four-fifths of which lies in Teton County and the remainder in Lewis and Clark County. All or parts of Tps. 20 to 29 N., Rs. 6 to 10 W., are included in the area. The area is not a unit either topographically or with reference to oil and gas and should logically extend southward along the disturbed belt at least as far as Dearborn River and eastward over the large area occupied by the Sweetgrass arch.

Most of the area is an open, moderately fertile plain, and is readily accessible by wagon or automobile. It has long been used for stock

FIGURE 32.—Index map showing position of Birch Creek-Sun River area, Mont.

raising, and there are many old ranches along the principal streams. Since 1912, however, after the development of dry farming in this part of Montana, much of the unwatered interstream area has been settled and devoted to grain raising. Gilman, at the end of a branch line extending from Great Falls, is the only town with railway facilities and offers ready access to the entire Sun River district. The northern part of the area, in the Dupuyer Creek and Birch Creek drainage basins, is most readily accessible from Dupuyer, which has stage connections with Valier, a railway point to the east. Postal facilities are available at Gilman, Augusta, Strabane, and Blackleaf.

The surface of the area described contains two general divisions, the mountain division and the plains division, between which there is a remarkable contrast in relief. The mountains rise abruptly from the edge of the plains to an average altitude of about 8,000 feet; the frontal ridges rise nearly 4,000 feet above the adjacent plains. These ridges consist mainly of massive limestone and stand out in bold eastward-facing cliffs, many of them hundreds of feet high and visible at great distances from the plains. The more gentle mountain slopes are covered with a growth of timber, mainly of pines and spruces, few of which are over 2 feet in diameter.

In a general view from the mountains the plains present a monotonously even aspect. On closer examination, however, they show varied relief and considerable local detail. They are part of a general eastward continental slope extending to Missouri River, far beyond the limits of the area described. The average altitude near the mountains is about 4,500 feet, and that on the east edge of the area described is about 3,800 feet. The river valleys crossing the plains extend in a parallel system away from the mountains. High-level terraces are the most striking topographic features in the plains and present remarkably even eastward-sloping surfaces. They are occupied by extensive gravel deposits which completely conceal the underlying bedrock and make it impossible to decipher the structure over considerable areas. The larger areas of these gravel deposits lie (1) between Muddy Creek and Birch Creek, in the drainage basin of the Dry Fork and Marias River, (2) between Teton River and Deep Creek, mainly along the east edge of the field, and (3) on Deep Creek and Sun River, also along the east margin of the area described. There are also large tracts standing at lower levels along the valleys of all the streams, particularly that of Deep Creek.

The topography of the area is further diversified by the occurrence of moraines of probably the most recent (Wisconsin) stage of glaciation, which appear as irregular boulder-strewn tracts, some of considerable dimensions, extending eastward from the mountain front. In large parts of these drift-covered tracts also the bedrock is concealed, so that the details of the underlying structure can not be worked out. The largest of these moraine-covered tracts is that in the Sun River valley, where an extensive drift sheet extends eastward more than 25 miles from the mountains. In the valley of Teton River there is a similar moraine-covered tract extending to a point about 6 miles from the mountains, and the valley of Birch Creek, to a point about 20 miles from the mountains, is also completely obscured over all level areas by a thick covering of drift. There is no till of northeastern origin at any point in the area described. The Keewatin glacier did not extend nearer the east edge of the area here described than about 15 miles.

THE MAP.

The part of the accompanying map (Pl. XXIV, in pocket) showing the area east of longitude 112° 30′ was compiled from the township plats of the General Land Office surveys, there being no accurate base map available. In the field work on this area corners were found and from them the details of the geology were located by triangulation and traverse. The surveys were made many years ago and are of indifferent quality. On this part of the map sketch contours are presented, taken from a reconnaissance map prepared by C. A. Fisher in 1906.[1] These contours are generalized and serve only to give a general picture of the relief of the region. West of the 112° 30′ meridian the Heart Butte and Saypo topographic maps were available and were used directly in the field as the base on which to plot the geology. On the map presented herewith group patterns of the formations have been necessary because of the complexity of the structure in the disturbed belt, which made it necessary to combine the stratigraphic units of the map and in places made it impossible to subdivide the groups of formations present, and also because of the marked variations in the stratigraphy found in going from north to south across the area.

GEOLOGY.

STRATIGRAPHY.

GENERAL FEATURES.

All the formations in the Birch Creek-Sun River area are of sedimentary origin, there being no igneous rocks present except minor amounts of transported materials in the glacial drift and terrace gravels. Exclusive of the surficial rocks the formations present range in age from Carboniferous to probably lower Tertiary. Oil and gas possibilities of promise seem to be confined to the Cretaceous rocks. Other formations than Cretaceous are described only as an aid in identifying and appreciating the relations of the probably oil-bearing beds.

The geologic section presented shows the recurrence of purely marine conditions at four separate epochs. These were separated by considerable time intervals during which land and fresh-water deposits were accumulating; in the long interval between the Carboniferous and Jurassic erosion also was effective. Earth stresses of intensity great enough to fold and tilt the rocks appreciably from their originally horizontal attitude were developed in this region during Paleozoic or later time only after the end of the Cretaceous period.

Summary descriptions of the geologic formations, arranged in their proper sequence, are given in the following table.

[1] U. S. Geol. Survey Water-Supply Paper 221, pl. 1, 1909.

Formations exposed in the Birch Creek-Sun River area, Mont.

System.	Series.	Group and formation.		Thickness (feet).	Character.
	Recent.	Alluvium.			Silt, sand, and gravel, chiefly along stream bottoms.
Quaternary.	Pleistocene.	Glacial drift.		0–150	Boulder clay, gravel, and sand. Contains boulders and cobbles of limestone, sandstone, red quartzite and argillite, and a few granitoid rocks, derived from the mountains.
.... Tertiary.	Pleistocene and late Tertiary.	Terrace gravels.		5–50	Limestone gravels, locally cemented, on terraces and plains at various levels.
Tertiary (?).	Eocene (?).	St. Mary River formation.		650+	Clay, clay shale, and soft sandstone, gray to greenish gray.
Cretaceous.	Upper Cretaceous.	Montana group.	Horsethief sandstone.	250–400	Chiefly massive gray to buff and greenish-gray coarse-grained sandstone with slabby sandstone and shale in lower half. Contains one or more shell beds, mainly of oysters.
			Bearpaw shale.	0–500	Dark-gray shale with a few thin beds of gray sandstone. Contains marine shells of Pierre types. Present only in northern part of area described. To the south grades into brackish and fresh water clays and sandstones similar to the beds of the Two Medicine formation.
			Two Medicine formation.	1,800–2,200	Gray, greenish-gray, and red clay and clay shale with subordinate irregular coarse-grained sandstones, mainly in lower half. Bones of fossil reptiles of Judith River types and fragments of fossil wood are abundant. Thin beds of coal and coaly shale near the base.
			Virgelle sandstone.	200–380	Upper part, very massive coarse gray sandstone, much cross-bedded and with heavy irregular beds of magnetite sandstone at the top, weathering in deep rusty-red tints. Lower part, interbedded sandstone and shale. Contains gas at Medicine Hat and elsewhere in Alberta and at Havre, Mont.
		Colorado shale with Blackleaf sandy member at base.		1,800+	Upper part, dark marine shale with compact bituminous shale and thin maltha-bearing limestones near the base. Lower part, Blackleaf sandy member, coarse sandstones locally conglomeratic in beds 20 to 75 feet thick, alternating with dark marine shale, in part bituminous; thickness 610 to 700 feet.
	Lower Cretaceous.	Kootenai formation.		890–920	Red and green shales and clay shale with many beds of coarse gray sandstones. Contains a few fresh-water shells.

Formations exposed in the Birch Creek-Sun River area, Mont.—Continued.

System.	Series.	Group and formation.	Thickness (feet).	Character.
Jurassic.	Upper Jurassic.	Ellis formation.	240-310	Black to gray calcareous shale with thin tan-weathering limestone and sandstone. Contains many fossil shells. Marine.
		Unconformity		
Carboniferous.	Mississippian.	Madison and later limestones.	1,200+	Massive white to pale-gray fossiliferous limestone, cherty in middle and lower beds; pure coralline limestone in upper beds; bottom not exposed.

FORMATIONS OLDER THAN CRETACEOUS.

MISSISSIPPIAN LIMESTONES (INCLUDING MADISON AND LATER LIMESTONES).

The lowest formation exposed in this area is a great mass of whitish-gray to bluish-gray limestone, weathering white, which comprises the Madison limestone and some younger beds that should probably be correlated with the Brazer limestone. These rocks are remarkably uniform from north to south across the area and are known to persist over a large area in the northern Rocky Mountain region. They contain corals and brachiopods which, according to G. H. Girty,[1] represent two rather distinct faunas of Mississippian (lower Carboniferous) age. In the area here described a thickness of at least 1,200 feet of this limestone is exposed, but the base is nowhere visible and the total thickness is therefore not known. It is believed to be underlain by a considerable thickness of older Paleozoic rocks, chiefly limestones.

The Mississippian limestones are exposed along the entire western border of the area, forming conspicuous white cliffs of great height along the mountain front. The sandy and shaly beds that constitute the younger formations of the area rest upon this great thickness of limestone. The probably oil-bearing zone in the Cretaceous rocks is approximately 1,900 feet above its upper limit, and it therefore serves as a readily recognized datum point in tracing out the succession of formations in this area.

ELLIS FORMATION.

Immediately overlying the Mississippian limestones in this area there is a group of black to gray calcareous shales with a few thin, irregular beds of limestone and sandstone, all of which are Upper Jurassic in age and constitute the Ellis formation. The thickness of these shales ranges from 240 to 310 feet and is greatest in the northern part of the area. They form a distinct unit of predominantly shaly beds that is readily separated from the formations above and below it.

[1] Personal communication.

The Ellis formation contains an abundance of fossils of characteristic Upper Jurassic forms. *Gryphaea*, a small oyster-like shell with a prominently incurved beak, and pointed cylindrical fragments of *Belemnites* are particularly common on most good exposures and are very useful in identifying the Jurassic beds in this area. The shales of the Ellis, so far as the evidence in this area alone indicates, lie in apparent conformity on the Mississippian limestone, there being no indications of angular discordance or a period of erosion between the deposition of the Mississippian and that of the Ellis. This conformity is only apparent, however, for at several localities within a radius of 100 miles rocks of upper Carboniferous and probably Triassic age, aggregating as much as 2,000 feet in thickness, are known to be present in the interval between the lower Carboniferous limestone and the Jurassic of this general region.

FORMATIONS THAT PROBABLY CONTAIN OIL OR GAS.

KOOTENAI FORMATION.

It is believed that the sandstones in at least the upper part of the Kootenai formation, closely associated with the overlying petroliferous rocks in the lower part of the Colorado, offer a possibility of being productive of oil or gas. The Kootenai in the area here described has a total thickness of about 900 feet and is composed essentially of shale and clay shale that are mostly red and purple, alternating with six to eight beds of gray to greenish-gray medium to coarse grained sandstone between 30 and 60 feet in thickness and rather evenly distributed throughout the formation. The red color is characteristic of the Kootenai, making it readily identifiable in the field. The only other red beds in the section occur at a much higher horizon, near the center of the Montana group. A few unios and gastropods were found in the Kootenai in this area, which as a whole is believed to represent land and fresh-water types of sedimentation. In central Montana and farther southward soft vari-colored shales that probably belong to the Morrison formation, containing fossil bones of large species of dinosaurs, have also been recognized in the interval between the marine Jurassic and Colorado shale, all the rocks of which in the area here discussed are included in the Kootenai formation. The Morrison shales, like the Kootenai, are believed to represent essentially fresh-water and land conditions, and in the absence of fossils and of distinctive features in the lithology in this area it has not been possible to distinguish the Morrison. The section thus corresponds more nearly with that of the type area of the Kootenai in southern Alberta, where the Morrison likewise has not been recognized.

COLORADO SHALE.

GENERAL FEATURES.

The Kootenai formation of this area is overlain by a thickness of about 1,800 feet of dark bluish-gray to black shale, which contains a number of sandstone beds in its lower third and makes up a distinctive stratigraphic unit known as the Colorado shale. This accumulation of material was deposited in Upper Cretaceous time on the bottom of a great sea which occupied much of the Great Plains and Rocky Mountain region and in a general way divided North America into two parts in a north-south direction. Fossil shells in great variety, of types that live only in oceanic waters, can be found throughout the shaly formation. In parts of this sea, especially in South Dakota, eastern Wyoming, and Colorado, a considerable thickness of limy beds was laid down in the later part of the epoch during which these sediments were deposited. Wherever these limy beds, called the Niobrara formation, are present, the remainder of the Colorado is generally termed the Benton shale, the two units taken together forming the Colorado group. In western Montana, however, this limy phase of the group was never deposited, the entire formation being simply shale with subordinate sandstone.

The Colorado shale seems to be of first importance as a possible source of oil and gas in northwestern Montana and according to present information is the only promising source known. In the area here discussed the lower part of this shale was found to be petroliferous in every extensive exposure in a belt extending about 35 miles from north to south across the area between Deep Creek and Sun River. It contains bituminous shale, which yields oil on distillation, and soft maltha or natural tar in crevices of fractured limestone, which very probably is a residuum from the evaporation of petroleum. The evidence seems fairly conclusive that this shale offers a source for petroleum that may have accumulated in commercially valuable quantities either in the Colorado or in the sandy portions of the Kootenai and Virgelle sandstone in immediate contact with it.

Further evidence as to the importance of the Colorado shale as a possible source of oil and gas in northwestern Montana seems to be offered by experience in the adjoining regions to the north and south. In Wyoming the principal production in the Salt Creek field and in all the fields in the Big Horn Basin is derived from sandstones in or in contact with this formation. In southern Alberta the large quantity of gas produced in the Bow Island gas field, which is distributed by pipe line as far as Calgary, comes from a sandstone associated with the Colorado shale. On the Turner Valley anticline, in the Sheep River area southwest of Calgary,[1] and on

[1] Slipper, S. E., Boring operation in southern Alberta: Canada Geol. Survey Summary Rept. for 1915, pp. 116–120, 1916.

other closely compressed folds in that vicinity small yields, as much as 6 barrels a day, of very high grade light-green to colorless oil, in addition to large amounts of saturated gas, were obtained from sandy beds associated with this formation. At first thought the small amount of oil found does not seem very encouraging, but it should be noted that the folds that have proved productive are long and narrow, with high dips, are much faulted, and therefore probably have very small collecting areas down the dip. The productive anticlines in Wyoming have collecting areas that are 6 to 12 miles or more wide down the dip, and it is therefore possible that these small yields in the Sheep River field from very much smaller collecting areas indicate an original oil saturation in the Colorado shale as great as that in the Wyoming fields, the problem in this general region being to find structural features that have collecting areas comparable in size with those in Wyoming.

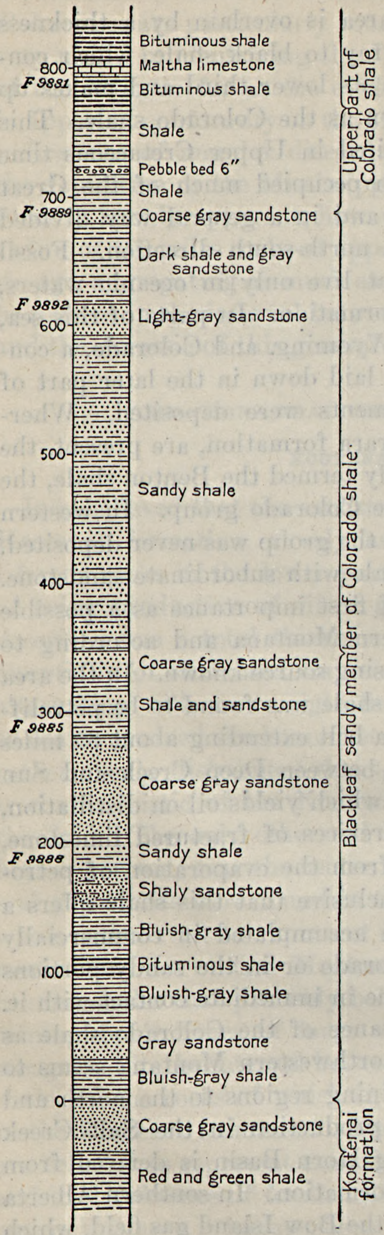

FIGURE 33.—Columnar section of portions of Kootenai formation and Colorado shale.

BLACKLEAF SANDY MEMBER.

The lower 600 to 700 feet of the Colorado shale comprises an alternation of dark marine shales and gray sandstone in beds 20 to 75 feet thick, forming a unit clearly distinguishable from the remaining shaly portion of the Colorado. For convenience in reference and description it is here designated the Blackleaf sandy member, the name being taken from Blackleaf Creek, along which the beds are well developed. A section of this sandy member, together with the adjoining portions of the Kootenai and the more petroliferous zone in the main shale body of the Colorado, thus showing the entire sequence of rocks in this region most likely to be productive of oil or gas, is given in figure 33. The dark shales throughout the Blackleaf member are very similar to those higher in the Colorado and comprise types ranging from hard fissile shale to material that is soft and not well bedded and more nearly a clay shale; the colors range from black and greenish black to bluish gray and even light gray in the more calcareous portions. All of this member is possibly of marine origin, for fossils of lower Colorado types were found within 50 feet above the top of the Kootenai. The 94-foot bed of shale in the lower portion of the section given is composed in part of compact black bituminous shale with conchoidal fracture, which yields a distinct odor of kerosene on fresh fracture and is very similar to the bituminous material in the principal petroliferous zone occurring higher in the section.

The sandstones of the Blackleaf member are gray to greenish-gray medium to coarse grained rocks, mainly with a silica cement and locally peppered with black grains of chert. They are ripple-marked in places. In the highly disturbed area near the mountains they are partly indurated and somewhat quartzitic. Their rather even distribution throughout the Blackleaf member is well shown in the columnar section. In places black carbonaceous stains and streaks appear on these sandstones, but no undoubted evidence of previous saturation with petroleum was found. These sandstones seem to be more or less lenticular when traced along the outcrops, all of which extend in a general north-south direction. In places they grade into quartzite and chert conglomerates with pebbles 2 inches or less in diameter, which in the northern part of the area consist mainly of white and black chert, probably from the Paleozoic limestones in this region, but which in the vicinity of Sun River consist chiefly of red and yellowish quartzite, probably from beds at much lower horizons. In the disturbed belt near the mountains many of these pebbles are faulted and sheared and also pressed into one another in a remarkable manner. These conglomerate beds were not found at any point at the base of the formation in contact with the red beds of the Kootenai, and their lenticular nature seems clearly indicated by the surface exposures. The sandy beds of the Blackleaf member are also characterized throughout the area by peculiar rootlet-like markings appearing as interlocking and superimposed irregular cylindrical masses about one-eighth of an inch in diameter, composed of sandstone identical with that of the main block upon which they rest. Locally these rootlet-like casts serve as excellent markers of these beds.

The fossils found in the Blackleaf member, as determined by T. W. Stanton, are listed on page 160, and the stratigraphic position of each lot is indicated in the columnar section (fig. 33) by its number.

9881. Sec. 18, T. 27 N., R. 8 W., middle fork of Dupuyer Creek:
Inoceramus labiatus Schlotheim.

9882. Sandstone at site of old sawmill on south fork of Dupuyer Creek half a mile east of limestone cliffs:
Ostrea anomioides Meek.
Ostrea sp.
Inoceramus labiatus Schlotheim?

9885. South fork of Dupuyer Creek, NW. ¼ sec. 36, T. 27 N., R. 9 W., Heart Butte quadrangle:
Ostrea congesta Conrad.
Inoceramus acutiplicatus Stanton?
Leda sp.

9888. East slope of West Teton anticline, near middle of canyon of north fork of Willow Creek, Saypo quadrangle:
Lingula sp.
Ostrea anomioides Meek.
Avicula gastrodes Meek?
Nemodon? sp.
Leda sp.
Cardium? sp.
Callista sp.
Tapes? sp.
Leptosolen sp.
Anatina sp.
Lunatia sp.
Anchura sp.
Fish vertebrae.

9889. Shell bed in lower part of Colorado shale, sec. 9, T. 24 N., R. 8 E., Saypo quadrangle:
Unio sp., small fragment.
Corbula perundata Meek and Hayden?, abundant.
Undetermined gastropod, two specimens.

9892. Shell bed in Colorado shale, SW. ¼ sec. 20, T. 23 N., R. 8 W.:
Lingula sp.
Ostrea anomioides Meek?
Ostrea sp.
Callista? sp.
Corbula sp.
Lunatia sp.
Anchura sp.

9901. NW. ¼ NE. ¼ sec. 17, T. 21 N., R. 8 W., Saypo quadrangle:
Ostrea sp.
Inoceramus labiatus Schlotheim.

The only exposures of the Blackleaf member are in the disturbed belt along the western margin of the area, close to the front of the mountains, where the outcrops are practically continuous from Birch Creek southward to and beyond Sun River. The formation appears in many good exposures, especially on the steepest slopes of the valleys of the larger streams. In the northern part of the area there are especially good showings on both the north and south forks of Dupuyer Creek, but on Birch Creek the drift from the extensive glacier that occupied the valley of that stream has left only incomplete exposures of these beds. Farther southward they can be studied in detail on the flanks of the Teton anticline south of Teton River, on both forks of Deep Creek, and on Sun River.

SHALE ABOVE THE BLACKLEAF SANDY MEMBER.

The remainder of the Colorado shale above the Blackleaf member forms the principal body of shale in this area and by its thickness alone is readily differentiated from the other shale units present. It is believed to be about 1,200 feet thick in this area. All the exposures of this shale are in the belt of disturbed rocks near the mountains, and even a fair estimate of the thickness can not be obtained on any of its outcrops in this belt, owing to the intense deformation, resulting in crumpling and faulting and even flowage, to which this mass of soft material lying between more resistant formations has been subjected. The estimate of its thickness must therefore be based on measurements made farther east, in central Montana, and the figure given above is an average of the known thicknesses.

The greater part of the shale of the upper part of the Colorado is fairly compact, bluish gray on dry outcrops, and of a medium degree of fissility. Smaller amounts of bituminous shale, gritty, sandy gray shale, and compact calcareous shale are also present, in addition to buff-weathering limestone in concretions and in thin lenticular beds, many of which contain good examples of cone in cone structure. Fossils are present throughout the shale and also in the limestone masses.

Except where covered by surficial deposits, these folded and crumpled beds of the Colorado come to the surface in a practically continuous belt of outcrops extending southward from Birch Creek completely across the field. West of Pine Butte there is a second belt, brought to the surface by faulting, which extends across the forks of Willow Creek for a distance of about 6 miles. Good exposures are present on both forks of Deep Creek and on Scoffin Creek, where the shale appears in many bank croppings over a large area; south of Antelope Butte on several branches of Muddy Creek; on the east flank of the Teton anticline, south of the moraine of the Teton Valley glacier; and on the forks of Deep Creek.

INDICATIONS OF OIL.

Except for minor amounts of bituminous shale in the Blackleaf member indications of oil in the Colorado shale occur only in the lower 150 feet of the main shale mass of the formation. Notwithstanding the intricately disturbed nature of this body of shale, which makes it impossible to determine the exact sequence and thickness of the beds—factors of prime importance to one drilling for the beds lying beneath it—the position of these bituminous beds immediately above the Blackleaf member is reasonably certain. There are at least three widely separated localities in the area examined where the structure and exposures are such that the basal shale beds of the upper Colorado are only slightly disturbed and their stratigraphic position can thus be ascertained. The petroliferous beds have a thickness probably averaging 50 feet throughout the area and consist of compact black bituminous shale containing thin beds of impure limestone which in places is impregnated along fractures with a soft tarry bitumen. This bituminous shale gives a distinct though transient odor of kerosene when freshly broken, especially after heating. Distillation tests made by D. E. Winchester, of the United States Geological Survey, on five samples of this material yielded between 1 and 2 gallons of oil to the ton. The shale has a conchoidal fracture, owing to the compactness of its structure, and in many places breaks out in long splintlike slabs.

The thin limestones in the shale occupy a zone not over 12 feet thick. The limestone is dark gray and impure, one-third to one-half of its bulk being composed of sandy and clayey material. It is irregularly fractured because of the deformation of the beds, and both walls of the fracture openings are lined with calcite crystals. The smaller openings are completely filled with calcite, forming veinlets in the rock. The larger openings are filled with a black tarry bitumen of high luster, which is soft enough to flow when the thicker accumulations are tilted. A thin film of this bitumen is transparent and has a rich reddish-brown color and a brown streak. It is readily soluble in carbon bisulphide and chloroform. On the weathered surface of the rock it appears as a deep brownish stain. The bulk of the rock is not petroliferous, the bitumen apparently having been forced in along the calcite veinlets after the deposition of the calcite. The bitumen was not forced into all parts of the smaller openings in these veins, the distance it was able to travel along individual veinlets being readily determinable on several hand specimens. It seems clearly evident that the bitumen is an impregnation from a source outside the limestone.

The northernmost exposure of these "oil showings" was found on a low cut bank on the south side of the middle fork of Dupuyer Creek, about a quarter of a mile above its junction with the north fork, in the SW. ¼ SW. ¼ sec. 18, T. 27 N., R. 8 W. At this locality the dark shades of the Colorado appear in intimately crumpled and faulted beds. About 10 feet of these shale beds, whose stratigraphic position, because of their intricate structure, can not be accurately determined, are highly bituminous and stained on fracture faces with a deep reddish-brown color. They are filled with impressions of *Inoceramus* shells and contain several beds of fine-grained impure limestone impregnated on fractures with tar and smelling strongly of petroleum. A pool of quiet water at the base of the outcrops at the time of the examination showed a thin iridescent film of oil. The amount of the free tarry matter in the limestone beds at this locality is greater than that seen at any other point in the area.

About 2½ miles southwest of the locality above mentioned, at a point a few yards east of the south fork of Dupuyer Creek, in the NW. ¼ sec. 36, T. 27 N., R. 9 W., beds of similar appearance were found, and fortunately at this locality some clue to the stratigraphic position of these oily beds was obtained. Upstream from this locality the sandy beds of the Blackleaf member, dipping regularly eastward at angles of 30° to 36°, crop out along the banks of the creek in such relations that it is evident that the petroliferous beds occupy a position only very slightly above them.

Further indications of these petroliferous beds were found on the north fork of Willow Creek about a mile above Young's ranch, in the NW. ¼ sec. 9, T. 24 N., R. 8 W. Here their stratigraphic position is clearly just above the upper sandstones of the Blackleaf member, the exposures appearing on the north side of the creek in low-cut banks.

Section of petroliferous beds on north fork of Willow Creek.

	Feet.
Dark bituminous shale with conchoidal fracture, grading upward into material with a much lower bituminous content; estimated thickness	25
Lighter-colored shale with thin layers of limestone carrying free bitumen	2
Compact dark bituminous shale	4
Lighter-colored shale with 2 to 6 inch layers of impure limestone carrying free bitumen	5
Dark compact bituminous shale filled with *Inoceramus* impressions and breaking off into long splintery slabs	25

These beds dip about 30° E., parallel to the underlying beds of the Blackleaf member except for a slight rolling structure which makes a short reverse dip.

About 8 miles south of the locality above described this zone of petroliferous beds is exposed on both forks of Deep Creek, but each exposure is so far from the outcrops of the Blackleaf member and the crumpling in the shale is so highly developed that the stratigraphic position of the material can not be determined. The lithology, however, especially the minuter details of the asphaltic limestones, is identical with that of the beds at the locality on Willow Creek, and these outcrops are believed to represent essentially the same stratigraphic horizon. On the north fork of Deep Creek the exposures, which are rather poor, occur in sec. 16, T. 23 N., R. 8 W., in banks on the east side of the stream about 2,000 feet southeast of the road crossing near the center of the section. Only about 5 feet of the thin limestone-bearing zone is here exposed. On the south fork similar exposures appear in a cut bank on the south side of the river, in the NW. ¼ sec. 28 of the same township. About 1,000 feet upstream from this exposure a 4-foot ledge of coarse gray sandstone, believed to be at the top of the Blackleaf member, is exposed in a broad, even-crested arch at the top of an anticline that trends northeast and has dips of 20° on either flank.

About 1½ miles southeast of the locality last mentioned, on a branch of Barrett Creek a few yards west of the line between secs. 32 and 33 of the same township, the petroliferous zone crops out and in general appearance the rocks are very similar to those on Deep Creek. At this locality the stratigraphic position of the bituminous beds is doubtless just above the uppermost beds of the Blackleaf member, the sandstones of which appear immediately below. The amount of free bitumen in the limestones here is less than that seen farther north.

The southernmost locality showing these bituminous beds was found in the cutting of the Sun River canal in the SW. ¼ sec. 29, T. 22 N., R. 8 W. The structure at this point is complex, and the exact position of these beds in the formation is not evident. It is possible that they may represent bituminous beds in the lower part of the Blackleaf member, for exposures of the Kootenai appear in an anticline about a quarter of a mile to the west. The rocks are the typical compact conchoidal bituminous shales, containing *Inoceramus* impressions very similar to those noted farther north, and they include a few feet of the calcareous beds with small traces of free maltha. In the following section of the beds at this point the thicknesses given are only approximate, because of the involved structure:

Section of bituminous beds on Sun River canal.

	Feet.
Pale-greenish shale, weathering with a whitish cast	10
Black bituminous conchoidal shale with a kerosene odor	18
Thin calcareous beds with traces of free bitumen	3
Platy sandy shales, weathering drab	5+

VIRGELLE SANDSTONE.

The Virgelle sandstone, consisting chiefly of massive gray sandstone, overlies the Colorado shale conformably, there being a gradation from beds made up wholly of shale in the one formation to the massive sandstone in the other. The boundary between the two formations was placed at the position where the amount of sandstone exceeds that of the shale in the transition beds. On this basis the thickness assigned to the Virgelle varies between 200 and 380 feet. In general the formation thins from the west toward the east in this part of Montana.

Because of its association with the Colorado shale the Virgelle sandstone may contain oil or gas in this general region. At Medicine Hat, in the southern part of Alberta, a gas field yielding more than 40,000,000 cubic feet daily from this sandstone has been producing for many years and has led to considerable industrial expansion in that city. More recently large amounts of gas have been obtained from the Virgelle at Havre, Mont.[1]

The prevailing rock of the upper massive portion of the Virgelle is a medium to fine grained feldspathic sandstone, the grains mostly subangular in outline, in part cemented with calcite, varying in color from gray to dark greenish gray. The upper part of this massive sandstone in many places includes thin irregular beds of a heavy greenish-black rock composed largely of magnetite and therefore forming a low-grade siliceous iron ore. Similar material on the Blackfeet Indian Reservation, but occurring in greater quantity and at a higher horizon in the Cretaceous rocks, has already been described.[2] Wherever present these iron-bearing beds form conspicuous iron-stained exposures.

All the exposures of the Virgelle in the area here described occur in the western half of the area, the principal outcrops lying between Teton and Sun rivers in a north-south belt extending as much as 6 miles eastward from the mountains and in most places adjoining the outcrops of the Colorado shale. In R. 8 W. the Virgelle crops out continuously for nearly 8 miles between Deep and Willow creeks, forming cliffs and ledges of sandstone, in places capped by dark reddish-brown iron-bearing beds. A few miles to the east it forms a distinct hogback ridge of sandstone dipping westward at a high angle above the dark shale of the Colorado and extends for many miles in a northwesterly direction. On Sun River in T. 22 N., R. 8 W., the Virgelle is also well exposed, forming the crests of three of the anticlines that cut across the river valley, and can be seen in excellent exposures of anticlinal arches along the river banks. Just off the east edge of the area mapped the Virgelle forms a pronounced escarpment that extends northward from Sun River to and beyond Bynum, in the area of nearly horizontal rocks, and forms eastward-facing cliffs as much as 300 feet high, the most conspicuous topographic feature in the plains of this part of Montana. From this

[1] Stebinger, Eugene, Possibilities of oil and gas in north-central Montana: U. S. Geol. Survey Bull. 641, pp. 66–76, 1916.

[2] Stebinger, Eugene, Titaniferous magnetite beds in the Blackfeet Indian Reservation, Mont.: U. S. Geol. Survey Bull. 540, pp. 329–337, 1912.

outcrop the sandstone extends westward under all the nearly horizontal rocks of the area described.

FORMATIONS ABOVE THE VIRGELLE SANDSTONE.

The formations lying above the beds that probably contain oil and gas in this region include the Two Medicine formation, Bearpaw shale, Horsethief sandstone, and St. Mary River formation. They comprise a great thickness of clay, shale, and sandstone, all of Upper Cretaceous age except the St. Mary River formation, which is doubtfully referred to the Tertiary (lowermost Eocene). The maximum thickness of these formations is not over 3,750 feet, and the minimum not less than 2,700 feet. They are of interest to those searching for oil and gas in this region because they are present in many of the promising structural features. In places they must be pierced by the drill in order to reach the underlying formations, and their thickness is therefore of special importance. Summary descriptions of each of these formations will be found in the table on page 154.

The Two Medicine formation overlies the Virgelle sandstone conformably and consists of about 2,000 feet of rudely bedded gray and greenish-gray and red clay shale, with irregular amounts of lenticular gray sandstone. The well log on page 183 gives a record of nearly all of this formation. The easily eroded soft clay shale in this formation is carved into small badland tracts on some of the slopes in this area, as typically shown in the exposures in red and gray clay along the crest of the Willow Creek anticline in T. 24 N., R. 6 W.

The dark-gray marine shales of the Bearpaw are present only in the northern part of the area, where they crop out in good exposures on Birch Creek and to a lesser extent on the dry fork of Dupuyer Creek. North of these localities this shale extends continuously across the international boundary into Alberta and is well exposed and easily traced. Toward the south, however, this dark shale grades within a short distance into light-colored sandstone and clay shale that are identical with the prevailing materials in the Two Medicine formation and south of Dupuyer Creek can not be separated from that formation. Because of this it has been necessary in the mapping to group the beds constituting the Two Medicine and Bearpaw formations from Dupuyer Creek southward.

In the southern two-thirds of the area, with the disappearance of the Bearpaw shale, the entire section above the Virgelle sandstone becomes a unit of light clay shale and sandy beds. In this great thickness of rocks, however, the thick massive sandstone beds forming the Horsethief sandstone can still be identified. On Deep Creek and Sun River the upper part of this formation includes a bed 30 to 40 feet thick which weathers to a deep reddish-brown color and contains many fossil shells, principally of oysters. On Sun River this bed forms the prominent topographic feature known as Black Reef; farther south, in the vicinity of Barr Creek, it crops out in a number of ridges showing dark ferruginous stains.

SURFICIAL DEPOSITS.

Surficial deposits, mostly of unconsolidated materials, cover the bedrock formations over large parts of this area. They are of three types—terrace gravels, glacial drift, and alluvium. The distribution of these materials is indicated on the geologic map (Pl. XXIV). These deposits are of no interest in connection with the problem of winning oil and gas in this area except that where they cover the underlying beds they greatly increase the difficulty of deciphering the structure. The uncertainty of operations in these covered tracts can not be too strongly emphasized, especially to investors and land owners on the extensive "benches" covered with terrace gravels.

STRUCTURE.

EFFECT OF STRUCTURE ON THE ACCUMULATION OF OIL OR GAS.

It is generally conceded that the accumulation of oil in pools is due to some irregularity in the rock beds. If the beds lie flat or if they dip slightly but regularly in a certain direction, the oil that circulates through the pores of the rock will not tend to accumulate in any particular place, but if the beds have been disturbed—that is, warped into folds or broken—the oil may find a resting place and form a pool.

The structural form that is most favorable to the accumulation of oil is an upwarp or bulge, a feature that is generally known as an anticline, but if the anticline has about the same width as length it is generally called a dome. Other structural forms that are less favorable to the accumulation of oil are terraces, monoclines, synclines, or tilted blocks of rock that have been separated from the adjacent strata by faults. The degree of deformation of rock beds, however, varies greatly. In some places, as in the Kansas, Oklahoma, and Texas fields, it is so slight as to be imperceptible to casual inspection and can be detected only by close instrumental work; in others, as in the California and Wyoming fields, the tilting may be so pronounced that it can be ascertained at a glance by a trained observer.

The presence or absence of water in the "sands" is a further qualifying factor in determining the location of pools. The following statements concerning the presence of water have been verified again and again in developed fields:

1. If the pay sands are saturated with water, the gas and oil, which are lighter than the water, will be found above it in the crest of a dome or anticline or on the flat or terrace of a monocline.

2. If only parts of the sands are saturated with water, the gas and oil will be found at the upper level of saturation, and this level may be on the crest of an anticline or part way down its side.

3. If the sands are dry, the oil will have migrated downward either to the trough of a syncline or to a point where further shifting has been prevented by the closeness of the sand.

4. If oil and gas occur in the same stratum, gas, which is the lighter, will generally though not invariably be found above the oil.

STRUCTURE OF THE BIRCH CREEK-SUN RIVER AREA.

SALIENT FEATURES.

The area described in this report can be readily divided into two large structural units which differ greatly in the degree to which the strata have been deformed. A slightly curving line, in general parallel to the mountain front, extending northward from a point near the southwest corner of sec. 10, T. 20 N., R. 7 W., to a point on Birch Creek in sec. 9, T. 28 N., R. 9 W., a distance of nearly 60 miles, would mark a sharp transition from an area on the east in which the beds are nearly horizontal or at most only very gently folded to an area on the west in which the rocks have been severely compressed into folds and broken by faulting. The area on the west thus forms a belt of disturbed rocks lying adjacent to the mountains, which in the complexity of its structure and the confusing array of the formations that crop out along it presents a notable contrast to the undisturbed area on the east. Being of sedimentary origin, all these deformed strata originally lay nearly horizontal, but at some time after the deposition of the St. Mary River formation they were subjected to earth stresses which acted in a general east-west direction, at right angles to the present strike of the rocks, and which finally crumpled and crushed the beds into their present attitudes.

AREA OF NEARLY HORIZONTAL ROCKS.

Although on casual inspection in the eastern area the formations seem to lie practically horizontal, they are as a whole, except for minor undulations, tilted gently westward at an average angle of 2° to 3°, the dips generally ranging from less than 1° to 8°. As a result of this general westward inclination the oldest formations—that is, those in the lowest position in the geologic section of the region—crop out on the east, followed toward the west by successively higher beds.

Thus the Colorado shale, followed by the Virgelle sandstone, appears a short distance east of the area mapped, and the Virgelle is followed in turn by the Two Medicine and higher formations. This general westward inclination continues to the edge of the disturbed belt, where it is abruptly terminated by sharply reversed dips accompanying folding and crumpling, the effect being a syncline with an extensive gently tilted east limb and a narrow west limb with subordinate crumpling and folding. (See structure sections, Pl. XXIV.) The widespread westward-tilted beds offer collecting areas for the accumulation of oil and gas in folds that lie up the dip to the east from the edge of the disturbed belt that are much more extensive than those of the comparatively narrow and short-limbed folds on the edge of and within the disturbed belt. It should also be recognized that lenticular sands in the area of nearly horizontal rocks, which pinch out eastward up the dip of the formations, might serve as effective reservoirs. These would naturally bear no relation to the local structure at the surface, the general monoclinal inclination alone being sufficient to produce accumulations of oil or gas.

In considering the details of the minor undulations and thickness of the beds in the area of nearly horizontal rocks, it must be borne in mind that the readings on dips of 3° or less shown on Plate XXIV are less accurate than those of higher inclination. This is due to the soft nature and lack of persistent even-bedded harder layers in the outcropping formations. Clinometer readings on color bands in the clays and on the edges of the irregular sandstones were therefore the only means that seemed practicable for structure determinations. However, even though the true dip in this direction can not be accurately known in many places, the general lay of the beds in the direction indicated is believed to be approximately correct. An original component of dip is also presumably present but is believed to represent only a small fraction of any of the readings given.

Eastward inclinations of the beds, reversing the general westward dip in the area of nearly horizontal rocks, are present in many places and as a rule probably produce gentle folds or anticlines of varying extent. All the reverse dips in this monoclinal structure, however, can not be assumed to indicate the presence of anticlines or domes. Such reverse dips may be produced by three general types of structures—(1) troughs or spoon-shaped depressions producing downwarps below the general level of the monocline, (2) the reverse structure, producing a bulging area rising above the general level of the monocline, and (3) a type in which both these are combined. (See fig. 34.) Types 2 and 3 produce only anticlines or domes; type 1 might produce a terrace, a structural form that is to some extent effective for the accumulation of oil on a monocline, although the area of the terrace thus formed may be very small. Where the exposures are extensive enough to allow a complete determination of the lay of the rocks the problem of defining the type of structure in-

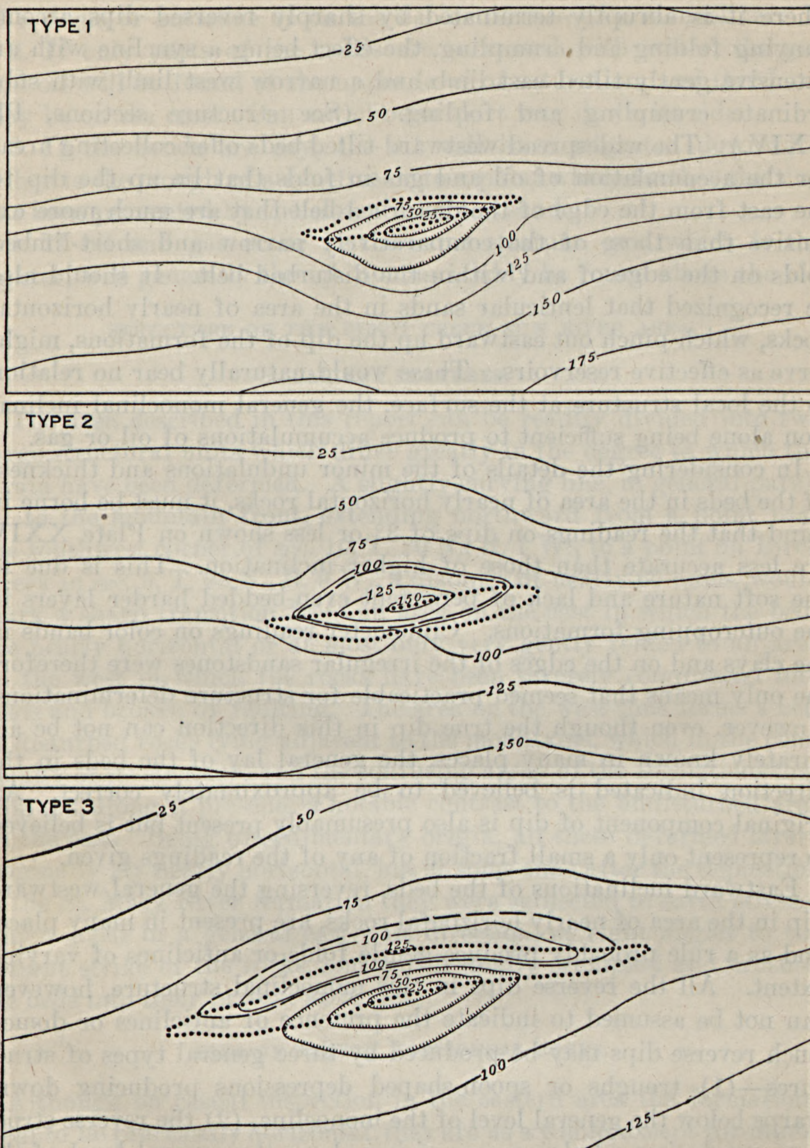

FIGURE 34.—Diagrams illustrating three types of structure produced by reverse dips on a monocline. Dotted line outlines area of reverse dip. Dashed line outlines area of bulge forming a "trap." In type 1 a bulge is not developed.

dicated by reverse dips is comparatively simple. Most monoclinal areas of interest for oil prospecting, however, are in regions of low relief, affording only meager exposures, and the possibility of gaining a complete understanding of any single structural feature from surface outcrops alone is the exception rather than the rule. The desire for results might lead to the conclusion that an anticline is present in such an area of reverse dips, whereas in fact only a structural depression is present, and failure to obtain oil after forming such an erroneous conclusion might be attributed to other causes. In general, however, it is true that reverse dips due to anticlines rising above the general level of the monocline—type 2 or its combination with a depression, type 3—are of much more common occurrence than the simple depression form.

The larger of the well-defined anticlines standing alone above extensive areas of accumulation down the dip, to the west, in the area of nearly horizontal rocks, are believed to offer the best chances of success in the search for oil and gas in this region. Their size is determined by the extent of the area in which the eastward dips prevail and the height of the anticline—that is, the elevation of its apex above its lowest "closing contour" (the lowest contour that entirely surrounds it). In the area of nearly horizontal rocks there are six large anticlines, described in detail on succeeding pages, whose structure is probably continuous in depth far enough to form traps in sands in the Virgelle, Colorado, and Kootenai formations. The largest of these, the Willow Creek anticline, has a length along its axis of probably as much as 6 miles and a collecting area down the dip of slightly over 5 miles.

Numerous smaller areas of reverse dips, producing only minor undulations in the beds, are present in the area of nearly horizontal rocks. Inclinations on the north and northeast sides of many of these small folds are considerable, dips as high as 60° being present. These high dips, however, especially those in the soft clays of the Two Medicine formation, are believed to be very shallow—that is, they represent only very local crumplings that do not extend in depth to the lower, more resistant sandstones. Examples of such minor folds occur on Sun River, in secs. 25, 26, and 36, T. 21 N., R. 6 W.; south of Deep Creek, in sec. 17, T. 22 N., R. 6 W.; on Deep Creek, in secs. 23 and 24, T. 23 N., R. 7 W., and sec. 9, T. 23 N., R. 6 W.; and on Blackleaf Creek, in sec. 10, T. 26 N., R. 8 W.

BELT OF DISTURBED ROCKS.

The belt of disturbed rocks in the Cretaceous and Tertiary (?) formations adjacent to the mountains in the Birch Creek-Sun River area is a small part of a large structural province that extends northward far beyond the Canadian boundary into Alberta, a distance exceeding 200 miles, and southward to the valley of Dearborn River. Throughout the area here discussed this belt averages rather uniformly 8 miles in width, but in the Blackfeet Indian Reservation, adjoining on the north, it is as much as 20 miles wide. In the Blackfeet area it is limited on the west by the Lewis overthrust, a great fault whose trace extends along the front of the mountains, and reverse faulting accompanying the development of this overthrust is the principal feature in the structure of the disturbed belt. Toward the south, however, with the intervention of a mountain range of Paleozoic rocks between the Lewis overthrust and the plains region, folding becomes more prominent and faulting becomes subordinate in the Cretaceous and Tertiary formations. In the Blackfeet Indian Reservation fairly open folding appears only on the east edge of the disturbed belt. In the Sun River district it extends throughout the belt up to the base of the mountains.

In the southern part of the area, in the vicinity of Deep Creek and Sun River, there are 12 fairly open anticlines, all of which are underlain by the Colorado and Kootenai formations under a cover of younger rocks in which oil and gas may have accumulated to some extent. It should be noted, however, that these anticlines are in a series of closely parallel folds and therefore have very small collecting areas. Unless the rocks originally had a high degree of saturation it does not seem probable that these folds could have collected very large amounts of oil. More extended accounts of these anticlines are given below.

North of Deep Creek, in the belt of disturbed rocks, there are a number of anticlinal folds, some of them of great magnitude, but they are all eroded below the probable oil and gas horizons of this region and therefore are of doubtful value as sources of petroleum and gas. The largest of these, the Teton anticline, is an immense symmetrical arch over 20 miles long, which is superbly exposed for most of its length, especially on Teton River and south from that stream to Willow Creek.

ANTICLINES THAT MAY CONTAIN OIL AND GAS.

ANTICLINES IN THE AREA OF NEARLY HORIZONTAL ROCKS.

WILLOW CREEK ANTICLINE.

In T. 24 N., Rs. 6 and 7 W., slightly over a mile northeast of Willow Creek, there is a fold, here designated the Willow Creek anticline, which is believed to be the most promising for oil and gas prospecting of those found in the area here described. Beginning in the NW. ¼ sec. 32, T. 24 N., R. 6 W., and extending in a general northwest direction for about 5 miles, at least as far as the NW. ¼ sec. 11, T. 24 N., R. 7 W., the axis of this anticline is fairly well developed, especially along the middle 3 miles of this distance. Red and gray clay shales of the middle portion of the Two Medicine formation crop out along the crest of the anticline and for a part of the distance are carved into badlands in which the exposures are very good, allowing a close examination of the details of the disturbance in the rocks. The lowest bed in the Two Medicine formation exposed along the crest of this fold is believed to lie about 1,000 feet above the Virgelle sandstone, which crops out to the east in a north-south escarpment near Chouteau. The depths to the uppermost sandstone of the Blackleaf member of the Colorado shale are therefore probably between 2,250 and 2,850 feet. The area of reverse dips, which in the generally westward-tilted rocks of this region defines the size of the trap produced by a reverse fold, is fortunately very well defined in the badlands, both the axis of the anticline and the trough of the corresponding syncline on the east being very clearly shown in secs. 19, 20, 29, and 30, T. 24 N., R. 6 W. In these sections the eastward-tilted beds can be studied in detail. Their general lay is indicated by the numerous dip readings presented on the map (Pl. XXIV), averaging between 3° and 10° throughout the exposures mentioned, although there are a few extremely sharp flexures in which the dips are higher. In sec. 24, T. 24 N., R. 7 W., there is a slight secondary anticline adjacent to the main one. It is not over a few thousand feet long, however, the corresponding syncline on the east being well exposed in the SW. ¼ sec. 19, T. 24 N., R. 6 W. Northwest of sec. 24, T. 24 N., R. 7 W., the exposures along this fold are poor, but in sec. 13 opposite dips of about 10° and in the NW. ¼ sec. 11 similar dips between 15° and 25° locate the axis. In sec. 12 the area of reverse dips lying to the east, upon which the size of the fold in this locality must depend, remains as broad as in the areas to the southeast, where the rocks are better exposed. The northwestward extent beyond sec. 11 is not known, there being no outcrops for many miles. The southeastward extent of the fold is quite certainly limited to a point not far east of the line between secs. 32 and 33, T. 24 N., R. 6 W. Along the coulee in the SE. ¼ sec. 33 small exposures of red and green clay shales dipping about 5° SW. suggest that the fold has flattened out before reaching that locality.

Because of the lack of key rocks or any horizon that can be followed more than a few hundred feet in the soft badland-forming beds in the Two Medicine formation, it is practically impossible to do the structural work that would be necessary to draw accurate structure contours on this fold, and therefore the attempt was not made. However, a rough approximation of the position of the lowest closing contour around this uplift, which it is believed will be of considerable practical value, is indicated on the map. The north limits of this line are necessarily very indefinite. On the east the line is practically an extension of the axis of the syncline as defined in secs. 19, 20, and 29, T. 24 N., R. 6 W.

The initial test of the Willow Creek anticline can probably be best made in the badland area on the crest of the fold near the line between secs. 19 and 30, T. 24 N., R. 6 W. Slightly converging dips on either flank of the fold to the southeast of this locality indicate that this is structurally the highest part of the anticline, at least in the portion where it is well exposed. In view of the uncertainties regarding the degree of saturation of oil-bearing beds in this region an apex location would seem best for an initial test. At the locality suggested the depth to the Virgelle sandstone, which may supply gas in large quantities, is estimated to be about 1,000 feet. This estimate is based on surface measurements extending 6 miles northeastward across an area of low dips, averaging 2° to 3°, to the outcrop of the Virgelle sandstone west of Chouteau, and the actual depth may be found to vary several hundred feet from the figure given. The distance below the top of the Virgelle to the uppermost sandstone of the Blackleaf member will probably be between 1,250 and 1,850 feet, the assumed thickness of the upper member of the Colorado shale being averaged from measurements farther east in Montana.

ANTICLINES SOUTH OF DEEP CREEK.

Across the next township to the south from the Willow Creek anticline there are indications of anticlinal folds, which extend southeastward nearly parallel to the trend of the Willow Creek anticline and which if oil and gas were eventually obtained elsewhere in this area would probably deserve consideration for prospecting. The northernmost exposures on these folds appear in secs. 33, 34, and 35, T. 23 N., R. 6 W. In the northern half of sec. 34, south and southeast of the sharp bend of Deep Creek, the rocks are tilted 10° E. in good exposures. About 2,000 feet farther southeast the inclinations still remain eastward, and dips as high as 35° appear locally. There is apparently a considerable area of reverse dips here, which may extend as far eastward as the axis of the syncline indicated in the W. ½ sec. 35, beyond which the prevailing westward dip of this region reappears. The westward dips appear in the W. ½ sec. 34 and remain continuous across nearly all of sec. 33. The fold indicated by the reverse dip extends with a trend of about N. 19° W. through a point very near the center of sec. 34.

For 2 miles south of these exposures, in secs. 3 and 10, the exposures are very poor and the southward extent of the fold above described can not be definitely ascertained. However, in sec. 15, T. 22 N., R. 6 W., about 3 miles to the south, there are good indications of anticlinal structure nearly on the trend of this fold and probably an extension of it. The eastward-trending dips cover much of the NE. ¼ sec. 14, and the corresponding westward-trending dips appear in nearly all of sec. 15. Immediately to the south this fold if extended disappears beneath an extensive mantle of gravel, and no further trace of it could be found. The northward extension of this fold beyond Deep Creek is likewise very indefinite. It is too far offset to the southwest, however, to make it very probable that it is an extension of the Willow Creek anticline. The depth to the Virgelle sandstone in this structure is probably as much as 500 feet more than the figure given for the Willow Creek anticline (1,000 feet).

Two miles to the west, in secs. 16 and 17, T. 22 N., R. 6 W., there is a sharp anticlinal flexure extending N. 50° W., which is probably only a very shallow fold, the steepest dips on the northeast being as high as 60°.

ANTICLINE ON DUPUYER CREEK.

Indications of a small anticline whose axis trends about N. 17° W. appear on Dupuyer Creek near the center of sec. 27, T. 28 N., R. 8 W. On the north side of the creek there are good exposures of coarse gray sandstone lying practically horizontal along the crest of this fold. East of this locality an eastward dip as great as 3° extends for a distance of about 2,000 feet, thus suggesting the width of the area of reverse dips on this structure. Farther east, in the NW. ¼ sec. 26, westward dips of about 1° appear in the low butte of the sandstone, and the general westward monoclinal dip beyond this point is indicated in the exposures for several miles around. The westward dips to the west of the axis of the anticline appear farther up the stream. In the SE. ¼ sec. 28 there are faint exposures in clays tilted 2° SW. This fold is exposed only along the valley of Dupuyer Creek, the exposures both to the north and south being so poor that it is impossible to trace the extent of the structure. At least two-thirds of the thickness of the Two Medicine formation overlies the Virgelle in this locality.

SCOFFIN BUTTE ANTICLINE.

In the vicinity of Scoffin Butte there is a well-developed anticline whose axis trends about N. 7° W. through sec. 36, T. 28 N., R. 9 W., and into the township on the south. The surface exposures along this fold are in the Horsethief sandstone, the characteristic oyster beds of the formation occurring along the ridges on both flanks.

This fold, however, is very close to the edge of the belt of disturbed rocks, and its collecting area is therefore very small. Moreover, there is a thick cover of rock over the probably productive beds, the depth to the Virgelle sandstone along the crest probably being not less than 2,500 feet. The dips on the east flank of the fold are as high as 26°, and those on the west as high as 20°. The northward extension of this anticline is obscured by the glacial drift which covers much of this vicinity. However, it probably does not extend beyond sec. 25, because the dips observed near the center of that section are all westward. South of the axis indicated along the trend of the fold the dips are likewise mainly westward

ANTICLINES ON BIRCH CREEK.

Six miles northwest of the Scoffin Butte anticline there is a well-defined anticline crossing Birch Creek in secs. 4 and 9, T. 28 N., R. 9 W., trending about N. 11° W. This fold is also near the edge of the belt of disturbed rocks and has a thick cover over the possibly productive beds, thus presenting the same difficulties as the Scoffin Butte anticline. The Horsethief sandstone also crops out along the crest of the fault. In the SE. ¼ sec. 4 eastward dips as high as 4½° are exposed along the north bank of the stream in gray sandstone. On the west limb dips as high as 9½° in the Horsethief appear continuously for over half a mile along both banks of the creek in a northwesterly direction, thus outlining an anticlinal axis with a well-defined trend. The corresponding syncline to the east of this fold is outlined by dips along the creek, also in the Horsethief sandstone, near the line between secs. 3 and 4. On the west this fold is terminated against a fault which has brought a considerable body of the Two Medicine formation against beds at a higher horizon. Both the northward and southward extensions of this fold are concealed by a thick cover of glacial drift. Only a very general production of petroleum in this area would seem to warrant drilling on either this fold, the Scoffin Butte anticline, or the fold on Dupuyer Creek.

A small fold of very doubtful value parallel to the one on Birch Creek just described and lying about a mile to the east is well exposed in the NW. ¼ sec. 3, opposite dips of about 2° appearing in the Horsethief sandstone along both sides of the creek.

ANTICLINES IN THE BELT OF DISTURBED ROCKS.

ANTICLINES ON DEEP CREEK.

On Deep Creek there are three parallel folds trending north, underlain by the Virgelle sandstone and lower formations which seem to offer the possibility of a small production of oil. One-third to one-half of the thickness of the Two Medicine formation overlies the Virgelle along the crests of these folds. The axis of the easternmost anticline crosses the creek about 1,000 feet west of the east line of sec. 30, T. 23 N., R. 7 W., and is well exposed, especially on the south side of the valley. The area of eastward dips on the east flank of this fold extends continuously downstream for over 1½ miles, and the corresponding synclinal axis lies in the W. ½ sec. 28, thus giving a considerable collecting area for this fold. In this respect it seems to offer better possibilities than the other anticlines along the creek at this locality. To the north the structure probably extends into the folded area of Virgelle sandstone appearing in the northwest quarter of the same township, which in turn farther north extends to the faulted area of Colorado shale extending beyond Pine Butte. It is thus apparent that toward the south the faulted structure seen in the vicinity of Pine Butte has developed into a series of folds which finally appear as a single fold on Deep Creek, the entire structural feature having a distinct southward plunge.

Another fold crosses Deep Creek slightly west of the center of sec. 30, about 1,000 feet west of the anticline just described. The crest of this fold is outlined by gentle opposite dips appearing in ledges of gray sandstone on the south side of the valley, inclinations on the east being about 7° and those on the west about 5°, within 500 feet of the axis. On the west, however, at a distance of about 1,500 feet from the axis, the inclinations increase very abruptly to an angle of nearly 45°, and this angle extends westward upstream to the base of the corresponding syncline, about 800 feet beyond the west line of the section. The northern and southern extensions of this fold are obscured by the glacial drift laid down by the Sun River Glacier on the south and by the terrace gravels immediately to the north.

A third fold crosses the valley of Deep Creek in a northerly direction near the old Goodwin ranch, extending through the SW. ¼ sec. 25, T. 23 N., R. 8 W. The anticline is finely exposed, especially on the north side of the creek, and probably connects to the south with the Blackleaf anticline on Sun River, although the extensive cover of glacial drift between the two folds makes this somewhat uncertain. On the east limb dips near the crest of this fold are as high as 40°, and these dips continue eastward for about half a mile to the corresponding syncline on the west, along whose axis the dark ferruginous member in the upper part of the Horsethief sandstone is well exposed. The west flank of the fold is also well developed, the dips varying between 14° and 35°, and the corresponding syncline appearing about 1,500 feet from the anticline. About half the thickness of the Two Medicine formation is probably present above the Virgelle sandstone along the crest of this fold.

ANTICLINES ON SUN RIVER.

Exposures along the banks of Sun River up to 8 miles eastward from the mountain front, principally in T. 22 N., R. 8 W., show a group of north-south parallel anticlines in which the Two Medicine formation and Virgelle sandstone are the chief surface formations. The closely spaced parallel nature of these anticlines limits their collecting areas, and there does not seem to be a possibility of more than a small production of oil along their axes. Their general relations are shown on the profile section D–D, Plate XXIV.

Near the line between secs. 19 and 20, T. 22 N., R. 7 W., there is a small fold that exposes the Horsethief sandstone along its crest and is therefore underlain by the total thickness of the Montana group. Buff-gray Horsethief sandstone crops out in prominent cliffs along the river and shows gentle opposite dips, indicating a fold whose axis trends in a general northerly direction, though its exact position is rather indefinite. If it extends northward, this fold may connect with the easternmost one of the prominent anticlines on Deep Creek, and it has a collecting area on the east comparable with the collecting area of that fold. To the south the extension of this anticline can not be followed beyond the exposures along the river, the thick cover of glacial drift concealing the bedrock for several miles.

The topographic feature known as Black Reef lies on the east limb of a prominent fold that extends across the Sun River valley. The axis of this anticline trends about N. 10° W. and where it crosses the river lies about 1,000 feet west of the township line between Rs. 7 and 8 W. On the banks of Sun River an arch in sandstones along the crest of this fold is well exposed. The northward limits of the fold are indistinct, owing to the covering of surficial deposits. On the south opposite dips in the SW. ¼ sec. 31 indicate that it probably extends at least to that locality. The dips along the east limb of this fold on Black Reef range from 30° to 45°. The west limb is apparently very short, the area for several miles up the river being occupied by gently undulating beds.

The most extensive fold of this part of the Sun River valley trends in a northerly direction very close to the line between secs. 26 and 27, T. 22 N., R. 8 W. The Virgelle sandstone crops out along the surface on the crest of this fold, and if the upper shale of the Colorado is not greatly thickened on this arch the depth to the top of the Blackleaf member is not much more than 1,500 feet. The crest of this fold as developed in the Virgelle sandstone is finely exposed from Sun River, where it is curved into a distinct arch, northward for nearly 2 miles. The fold is somewhat compressed, the dips on each limb ranging from 35° to 55°. Its northward extension is obscured by the thick glacial drift in the northern part of the township. Its southward extension also is much obscured for the first 2 miles by the surficial material that covers the extensive area of Alkali Flat. Farther south, however, along the trend of this fold opposite dips in secs. 2 and 3, T. 21 N., R. 8 W., indicate its extension at least to that locality, and with a slight change in trend to the southeast it probably extends several miles farther, as indicated on the map (Pl. XXIV).

In the W. ½ sec. 27 a sharp fold near an old coal prospect is exposed along the river banks. On its east flank the dips are as high as 70°, and on the west it is cut off by a longitudinal fault which brings the Virgelle sandstone to the surface. To the north in the partly covered area the Virgelle sandstone again appears, folded and much faulted.

Near the center of sec. 28 a northerly anticline with a curving trend can be traced for over 4 miles across the valley of Sun River. The northernmost exposures along this fold are of beds of the Colorado shale, followed on the south by the Virgelle sandstone, which is the surface formation at the point where the fold crosses the river, and still farther south by the Two Medicine formation. This succession indicates a southward-plunging anticline, as is probably true of all the folds in this district. This fold is also closely compressed, the dips on the flanks being as high as 65°. On the west it is terminated by a sharp syncline which exposes the Virgelle sandstone and Two Medicine formation lying above a long linear outcrop of the Colorado shale.

ANTICLINES IN THE VICINITY OF BARR CREEK.

Three well-defined anticlines in the vicinity of Barr Creek, all of which show a plunge toward the south, are probably extensions of the folds on Sun River, though the cover of glacial drift and the apparent change in the trend of the structural lines make the exact determination of this fact impossible. Two wells were drilled on the flanks of the easternmost of these folds, but because of their shallow depth they did not go beyond the Two Medicine formation. On account of the greater depths to the underlying probably productive beds and the sharp plunge to the south none of these folds seem to offer as good an opportunity for prospecting as those on Sun River. The axis of the easternmost of these three folds extends across secs. 24 and 25, T. 21 N., R. 8 W., with a trend of about

N. 18° W. Exposures along this fold consist mainly of prominent hogback ridges of the dark ferruginous member in the upper part of the Horsethief sandstone. On the east flank the dips range from 30° to 45°; on the west from 16° to 25°. In the S. ½ sec. 25 southwestward dips in the Horsethief sandstone along the axis of the fold clearly indicate its sharply plunging nature. The northward extensions of this anticline beyond the area in which it is well defined are somewhat indefinite, the dips in the N. ½ sec. 24 along the trend of the axis apparently indicating a continuous westward-dipping series of rocks whose nature can not be determined from the scattered exposures of the bedrock formations appearing above the glacial drift. Further mention of the drilling activities along the flanks of this fold is made on pages 183–184.

In sec. 26, T. 21 N., R. 8 W., along Barr Creek, excellent exposures in the soft gray clays and sandstones of the Montana group clearly outline a southward-plunging anticline whose axis trends nearly due north. Where the axis of the fold crosses the creek, in the NW. ¼ sec. 26, there is probably not over one-half the thickness of the Two Medicine formation above the Virgelle sandstone. This probably represents the shallowest depth to the Virgelle on all the folds in this vicinity. On the steeper slopes in the SW. ¼ sec. 26 there are good exposures of gray sandstones arching over the crest of this fold. Along the east limb of the fold the principal outcrops appear in a prominent northeasterly strike ridge in the ferruginous portion of the Horsethief sandstone, which connects directly with the ridges on the flanks of the prospected fold lying to the east, already described. The west limb of this fold is much shorter than the east limb, being terminated abruptly by steep dips as high as 85° along the syncline that extends through the southwestern part of sec. 26. The north and south extensions of this fold are much obscured by glacial till.

The axis of the third prominent fold in this vicinity extends through the low eminence known as Black Butte, in sec. 35, T. 21 N., R. 8 W., and exposes the Horsethief sandstone along its flanks. On the west this fold is terminated, probably by faulting, against more steeply inclined beds of the Two Medicine formation, and on the south it is cut off by cross faulting just south of Black Butte. Because of the small size and broken condition of this anticline it seems to offer small inducements for prospecting.

ANTICLINE IN T. 20 N., R. 7 W.

In sec. 15, T. 20 N., R. 7 W., just south of the edge of the area examined, there is a well-exposed anticline trending about N. 22° W.

in a small badland area in the Two Medicine formation. This fold lies on the eastern edge of the belt of disturbed rocks, and the corresponding syncline is about a mile to the northeast, in sec. 14. On the east limb of this fold there are good exposures showing dips as high as 48° to 60°, which, however, flatten abruptly to the low dips in the trough of the syncline. The crest of the fold lies near the center of sec. 15, as indicated by many exposures of horizontal beds. Farther southeast the beds are inclined at an angle as high as 33° SE., thus outlining a rather flat-crested, steep-limbed fold. In the NW. ¼ sec. 15 gentle southwestward dips along the west limb indicate the extension of this fold at least to the north line of this section, but beyond this line it passes beneath the thick morainal drift of the Sun River Glacier. The southwestward extension of this fold was not followed. The isolated nature of these exposures makes it difficult to estimate what proportion of the Two Medicine formation overlies the Virgelle sandstone in this area, but it seems likely that the greater part of the formation is present.

ANTICLINES OF DOUBTFUL VALUE FOR OIL OR GAS.

North of Deep Creek there are a number of anticlines, some of large dimensions, in the west edge of the disturbed belt close to the mountain front. All these folds expose formations below the Kootenai, some being eroded to the Madison limestone, and they are therefore of very doubtful value for oil or gas. The general relations of these folds are indicated on the cross sections in Plate XXIV. The northernmost of the larger folds crosses the three forks of Dupuyer Creek near the mountains and is here designated the Dupuyer anticline. This fold can be traced for a distance of 6 miles along its axis, and is developed mainly in the lower beds of the Colorado formation and the red shales of the Kootenai. Arching beds of a symmetrical anticline appear along the crest of this fold on both the north and south forks of Dupuyer Creek. The dips on either flank average about 40°. On the north the fold extends into a faulted area in which the relations are much obscured. On the south it reaches at least the north side of Blackleaf Creek and there is likewise obscured by faulting.

The Teton anticline, lying parallel to the Dupuyer anticline and about 1½ miles to the west, is by far the largest fold in the area mapped. Its axis can be followed for a distance of over 20 miles in a general direction N. 10° W. It plunges southward, the Mississippian limestone and Ellis and Kootenai formations and Colorado shale appearing in turn along the crest of the fold toward the south.

The northern 6 miles of the anticline is faulted on the east and thrust over the west limb of the Dupuyer anticline. The identity of this large fold is lost on the south not far beyond the point where it reaches the area of Colorado shale in the vicinity of Deep Creek.

RESULTS OF DRILLING.

All the drilling so far undertaken in this field has been done in the southern part of the area mapped, in the valley of Sun River. None of the wells up to the time of the preparation of this report were driven either to the Virgelle sandstone or to the probably oil-bearing beds associated with the lower part of the Colorado shale, nor were any of them located on the more favorable structural features in this area.

In the later part of 1915 drilling was begun on Sun River about 8 miles northwest of Gilman, in the NW. ¼ NE. ¼ sec. 6, T. 21 N., R. 6 W., by the Sun River Oil & Gas Co. By the fall of 1916 a depth of 1,600 feet had been reached, and drilling, to be resumed early in the spring, was expected to be carried to a depth of 2,000 or 2,100 feet. This well is in the area of nearly horizontal rocks on the gently westward-dipping monocline. None of the outcrops within several miles of the well site indicate a reversal of the general southwestward dip of the beds. Good exposures along the cuts of the Sun River canal in the adjacent sections to the north and east show outcrops of beds belonging to the upper part of the Montana group, probably as high as the Horsethief sandstone, dipping southwestward at angles of 3° to 8°. Three-quarters of a mile west of the well site, in small exposures along the river banks, the dips are also southwestward at low angles in beds in the upper part of the Montana group. It is evident that at least the full thickness of the Two Medicine formation overlies the Virgelle sandstone at this point, which is at a depth probably in excess of 2,000 feet, and the probably oil-bearing beds in the lower part of the Colorado shale are not less than 3,500 feet below the surface. A log of this well, kindly furnished by Mr. W. M. Fulton, the president of the company, is given below. The entire absence of water below the glacial drift is noteworthy as further proof of the lenticular nature of the sandstones in the Two Medicine formation. Apparently very few of these sandstones were continuous enough up the dip to reach the surface in that direction and there absorb water.

Log of well drilled in sec. 6, T. 21 N., R. 6 W., Sun River, Teton County, Mont.

Probable geologic division and driller's description.	Contents reported.	Thickness.	Depth.
Glacial drift:		*Feet.*	*Feet.*
Sand, gravel, and mud	Fresh water	60	60
Montana group:			
Blue shale and sand		115	175
Gray sand, hard		25	200
Light-gray shale		55	255
Gray sand, very soft		20	275
Blue clay		5	280
Sand		10	290
Gray shale, soft		30	320
Gray sand		15	335
Gray shale, sticky		20	355
Sandy shale		25	380
Sand, sharp		10	390
Light-gray shale, sticky		20	410
Gray shale		26	436
White sand		9	445
Soft white stone		5	450
Sand, greenish		7	457
Rock, reddish		18	475
Gray shale	Small continuous flow of gas	15	490
Rock, reddish or brown		15	505
Gray shale		31	536
Sand, hard on top, with black specks		24	560
Gray shale		20	580
Lime shells		5	585
Red rock, pink at bottom		15	600
Gray shale		20	620
Sand	Small showing of oil, rainbow colors	15	635
Gray shale		25	660
Blue shale		45	705
Sand		10	715
Blue shale		45	760
Light-pink shale		5	765
Blue shale		45	810
Red rock		20	830
Blue shale		30	860
Sand	Oil showing, rainbow colors	25	885
Blue shale		125	1,010
Hard lime shell		2	1,012
Blue shale		8	1,020
Red rock, hard at top		35	1,055
Sand	Considerable oil showing	13	1,068
Blue shale	Second flow of gas, stronger in volume than first.	52	1,120
Dark shale		90	1,210
Red rock		20	1,230
Black shale		15	1,245
Sand, white pebbles	Oil colors	10	1,255
Red rock		10	1,265
Drab sandy shale		20	1,285
Light sandy shale		5	1,290
Lead-colored sandy shale with red streaks.		80	1,370
Lead-colored shale		20	1,390
Red rock		10	1,400
Gray sand	Third flow of gas	35	1,435
Lead-colored shale		17	1,452
Sand		18	1,470
Lead-colored shale		30	1,500
Hard shell rock		20	1,520
Gray shale		15	1,535
Red rock, soft		15	1,550
Gray shale		5	1,555
Sand		10	1,565
Red rock		17	1,582
Gray shale	Fourth flow of gas, some pressure	18	1,600

The three wells in the vicinity of Barr and Willow creeks, south of Sun River, in T. 21 N., R. 8 W., and T. 20 N., R. 7 W., were drilled many years ago, and none of them, according to local reports, was more than 1,000 feet deep. The two wells in T. 21 N., R. 8 W., were drilled on the opposite flanks of the same anticline, one in the NW. ¼ sec. 25, in rocks dipping 35° NE., and the other in the NW. ¼ sec. 36, where the dip is about 30° SW. Each of these borings begins near the top of the Montana group, and if they are less than 1,000 feet in depth they come far short of reaching the Virgelle sandstone. Small amounts of gas were reported from these holes.

The third well in this vicinity also reported small yields of gas. It was drilled at Wood's ranch, in the N. ½ sec. 6, T. 20 N., R. 7 W. The immediate vicinity of this locality is covered by glacial drift, but the underlying formations, as indicated by exposures in the surrounding area, very probably belong to the upper part of the Montana group, and if this well was drilled as reported to a depth of only 700 feet its bottom is likewise much above the position of the oil and gas bearing beds of this area.

O

GEOLOGIC MAP AND SECTIONS OF BIRCH CREEK-SUN RIVER REGION, MONTANA

Topography west of 112° 30' by T. M. Bannon, R. T. Evans, O. H. Nelson, and D. H. Watson
Surveyed 1911, 1914
Remainder reconnaissance by geologists

Geology by Eugene Stebinger and M. I. Goldman
Surveyed in 1916

Scale 1/125000

Contour interval 100 feet.
Datum is mean sea level.

1918