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DEPARTMENT OF THE INTERIOR

FRANKLIN K. LANE, Secretary

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, Director

BULLETIN 641—L

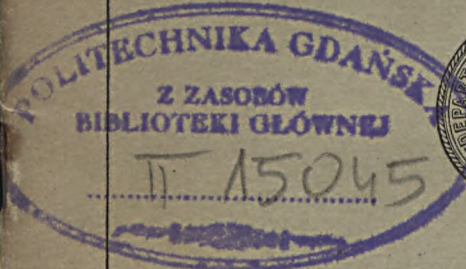
OIL RESOURCES OF BLACK SHALES OF THE  
EASTERN UNITED STATES

BY

GEORGE H. ASHLEY

Contributions to economic geology, 1916, Part II  
(Pages 311-333)

Published February 8, 1917

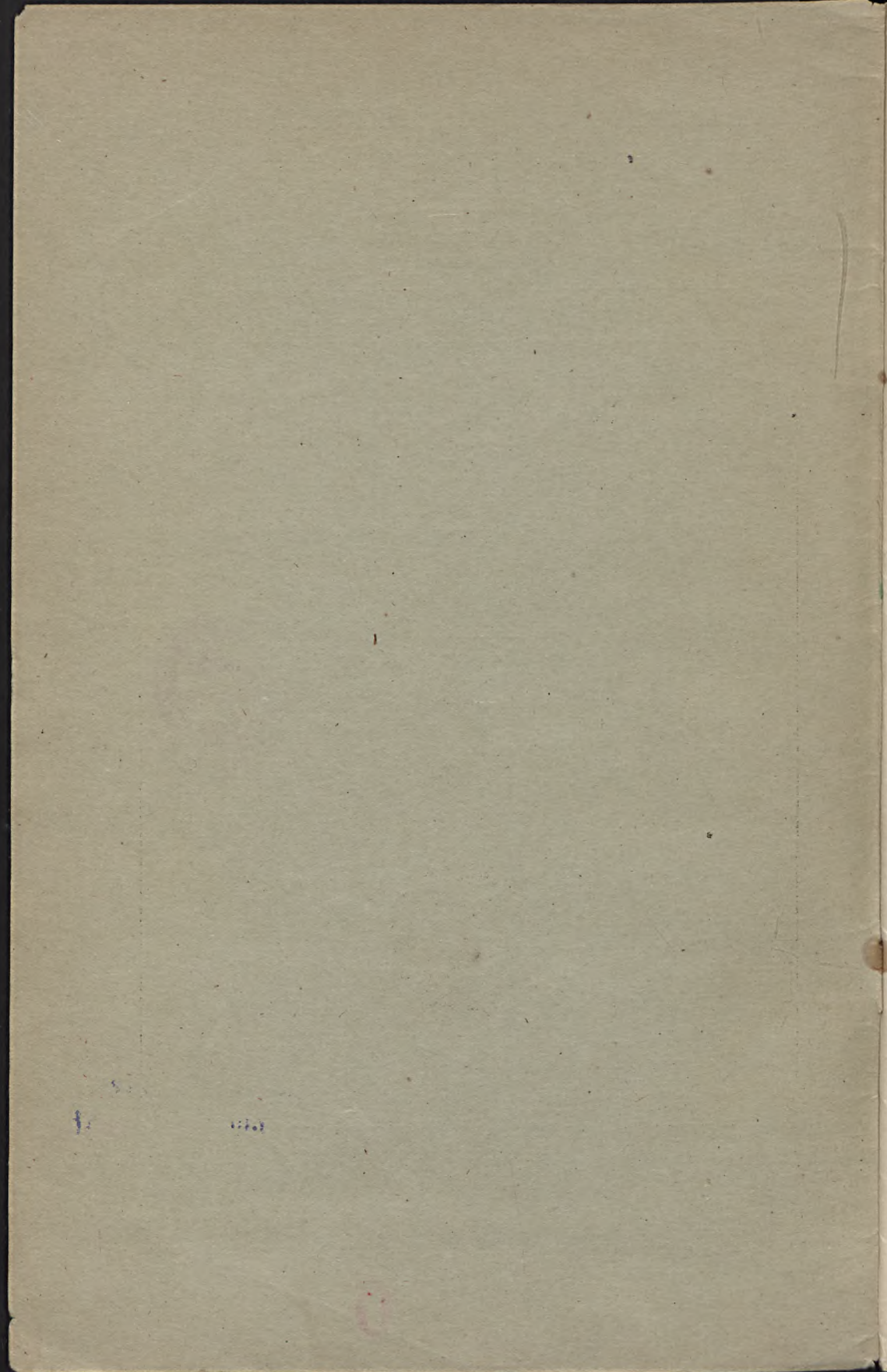


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CONTENTS.

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	Page.
Purpose and scope of investigation.....	311
Occurrence of the shales.....	312
Samples of the shales.....	313
Indiana.....	313
Illinois.....	314
Kentucky.....	314
Ohio.....	314
Pennsylvania.....	315
Tennessee.....	316
West Virginia.....	318
Distillation tests.....	318
Oil content.....	320
Future development.....	322
Analyses.....	322
Government investigations.....	324

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# OIL RESOURCES OF BLACK SHALES OF THE EASTERN UNITED STATES.

By GEORGE H. ASHLEY.



## PURPOSE AND SCOPE OF INVESTIGATION

It has long been known that black shales owe their color to bituminous or carbonaceous matter and that most such shales, if heated, will yield gas, oil, and other by-products. For many years such shales have been distilled for oil in Scotland and other European countries. The Scotch distilleries are reported to have been of the greatest aid to England during the present war in supplying the oil-burning ships of her navy, thus saving the excessive cargo rates on oil from America. It has long been recognized in this country that the time would come when the decline of yield in the oil fields would lead to tests of the black shales as a possible source of oil. The recent great increase in the use of light oils in internal-combustion engines has renewed interest in the black shales and has led to definite exploratory work on certain oil shales of the West and preliminary studies on the black shales of the East. Preliminary reports on the results of the studies of the western oil shales by the United States Geological Survey have already appeared.<sup>1</sup>

In 1914 the writer visited and sampled black shales at a number of places east of the Mississippi River. Later other samples were obtained in Pennsylvania by R. V. A. Mills and William R. Cameron, in Ohio by Wilbur Stout, in Illinois by Wallace Lee, in Kentucky and Indiana by Charles Butts, and in Tennessee by F. R. Clark. The samples are described and the results of their distillation given in this report. The writer's samples were all cut on the outcrop with an army adz. First a trench was dug through the weathered surface of the shale until the hard surface of the apparently unweathered shale had been reached. Then a shallow trench the width of the adz was cut in the unweathered rock, and

<sup>1</sup> Woodruff, E. G., and Day, D. T., Oil shale of northwestern Colorado and northeastern Utah: U. S. Geol. Survey Bull. 581, pp. 1-21, 1915. Winchester, D. E., Oil shale in northwestern Colorado and adjacent areas: U. S. Geol. Survey Bull. 641, pp. 139-198, 1916 (Bull. 641-F).

the material thus obtained was broken down and quartered after the manner of taking coal or other samples, until a 5-pound sample was obtained, and this was sent to Washington in a canvas bag. In most places where samples were taken the soft, weathered portion of the shale proved to be very thin and the underlying rock very firm and tough. In a few places the shale was exposed as a vertical face, with little or no weathered material on the face.

#### OCCURRENCE OF THE SHALES.

The black shales of the Eastern States are mainly at one general horizon, in the Upper Devonian or possibly in part lower Carboniferous, which extends from New York to Alabama and westward to Mississippi River. Other extensive deposits of black shale occur at one or more horizons in the lower part of the Devonian and at one horizon in the Ordovician. In addition, black shales overlie some of the coal beds, especially certain beds in the eastern interior coal field.

The principal body of black shale is known as the Chattanooga, New Albany, or Ohio shale. This bed underlies the eastern coal fields and crops out in a long line from central Alabama northeastward through Tennessee and Virginia and all around the Nashville Basin, in central Tennessee. West of the Appalachian coal field its outcrop extends from north to south across central Ohio, passing close to Columbus and reaching Ohio River near Vanceburg. Thence the outcrop makes a loop through central Kentucky, past Lebanon, and northward to Louisville, from which it stretches in a broad belt northwestward across Indiana, past Indianapolis nearly to Chicago. From this western belt of outcrop the shale extends eastward under eastern Ohio and underlies nearly all of Kentucky except the area within the loop described and all of Indiana west of the outcrop. Samples of this shale were cut at Cumberland Gap, Rockwood, and Chattanooga, Tenn., on the eastern front of the coal field; at Bakers station and near Newsom station, Tenn., in the Nashville dome area; and near Columbus, Ohio, and at New Albany, Ind., on the western outcrop.

The Middle and Lower Devonian of New York, Pennsylvania, Maryland, and West Virginia contain thick beds of dark shale that is locally black and fissile. Samples were cut near Hancock station, W. Va., in the black layers of the Onondaga shale member of the Romney shale.

Black shales overlying coal beds were sampled near Boonville, Ind., where the No. 5 bed was being stripped by a steam shovel, and at Springfield, Ill. Few of the black shales over the coals have a thickness of more than 5 feet.

## SAMPLES OF THE SHALES.

## INDIANA.

Samples were cut at two places in Indiana, at New Albany in the New Albany black shale, which is there about 100 feet thick, and northeast of Boonville, where black shale makes the roof of the No. 5 coal.

Sample 1 was cut in the upper part of the New Albany black shale in the bank of Ohio River at the mouth of Falling Run, just below New Albany. The sample represents a 10-foot section, of which the upper 5 feet was taken in the face of a vertical cliff on the east side of the run and the lower 5 feet from the shelving exposure just below. About 20 feet of black shale, carrying many thin streaks of hard, apparently limy shale, is exposed here, of which the sample represents the lower 10 feet. The shale in the vertical face was very tough. The shale in the shelving river bank breaks out into quadrangular plates 2 to 4 inches thick, which may be as much as 3 or 4 feet in length or width. The edges follow jointing planes that run S. 65° W. and S. 30° W.

Sample 2 was cut in 1915 by Charles Butts at the same place as sample 1.

Sample 3. Many large boulders or concretions of the black shale occur on the river bank at New Albany. The outside portions of these boulders for a variable distance in are weathered to a gray color. The central portions are still a dark bluish black and give off a marked oily odor when broken. Sample 3 was made up of fragments from the black centers of a number of these boulders. The boulders appear to be concretionary.

Sample 4. At low water the immediate bank of the Ohio under the Kentucky & Indiana Railroad bridge at New Albany is a gentle slope, exposing about 25 feet of New Albany black shale. A trench 15 feet long and 6 to 10 inches deep was cut in this rock near the upper edge of the exposure. Sample 4 was cut in the bottom of this trench and represents a vertical thickness of about 5 feet.

Sample 5 was cut just above the Kentucky & Indiana Railroad bridge at New Albany in 1915 by Charles Butts.

Sample 6. A short distance northeast of Boonville the No. V coal bed is being stripped on a large scale by the Ohio Valley Coal Co. The coal is from 6 to 9 feet thick, and over it is 4 feet of black shale. Sample 6 was cut from the full thickness of the shale where freshly dug by the steam shovel. The black shale is overlain by 9 feet of drab to dark shale, 10 inches of limestone, 6 feet of light-gray shale, and 10 feet of light-brownish clay and soil. This sample should be as unweathered as any to be obtained by such stripping.

Sample 7 was obtained from a 5-foot cut in the lower part of the 9 feet of dark shale immediately overlying the shale cut for sample 6.

The sample was cut to determine if the dark shales carried even a small amount of oil.

Sample 8 was obtained from a second cut in the black shale immediately over the coal at a point near the power house at the upper end of the stripping. At this place the black shale is 6 feet thick and is overlain by 3 to 4 feet of gray shale and 10 feet or less of clay and soil. The black shale at this point had been exposed for many months, if not a year. It is of interest, however, to note that notwithstanding this fact and the small thickness of covering, the sample gave a larger yield of oil than sample 6. It may be noted that this shale is dead black on the fresh surface instead of having the chocolate-brown color of many of the shales sampled.

#### ILLINOIS.

Sample 9 was obtained from the black shale roof of No. 5 coal at the East Capitol mine, in Springfield, Ill., by breaking up a number of large blocks of black shale that had been removed from the mine about a week before in cleaning up a roof fall. Only the "hearts" of the blocks were taken to avoid including any shale that might have been weathered along the joints after the removal of the coal. The breaking down of the shale would naturally follow the joints, and the joint faces would form the outside surfaces of the blocks. The shale appeared to be massive, nonfissile, and blackish drab.

Sample 10 was cut by Wallace Lee in the roof shales of the No. 5 coal at the Saline mine, Gallatin County.

#### KENTUCKY.

Sample 11 was obtained by Mr. Butts in 1915 from an 8-foot cut in the New Albany black shale at the west end of the canal at Louisville.

Sample 12, taken by Wallace Lee, consists of the so-called coal rash or mother of coal associated with the coal bed at the Barnaby mine, Crittenden County.

Sample 13, also taken by Wallace Lee, represents carbonaceous shale that lies 50 feet above the Bell coal at Caseyville, Ky.

#### OHIO.

On the recommendation of Prof. J. A. Bownocker, State geologist of Ohio, samples were cut in the Ohio shale in a ravine at Glen Mary, 8 miles north of Columbus. The cuts were made in the nearly vertical face of a wash, about 200 yards below the pike.

Sample 14 represents a cut 5 feet long. The shale, after the removal of 6 inches of weathered rock, broke out in small chips, which had a drab color outside or where cut but black cross sections where broken.



Sample 15 represents a 3-foot cut at the same place but lower in the section. Instead of taking all the material, it was prepared by using only the "heart" of the largest chips, in the hope of obtaining a sample more nearly representative of the rock away from the outcrop. About 15 feet of shale shows at this point.

Sample 16. The Sunbury shale in Ohio is in the lower part of the Carboniferous system, overlying the Berea sandstone, one of the principal "oil sands" of the State. Sample 16 was cut by channeling from the middle of the Sunbury by Wilbur Stout, at Columbus, on the Broad Street pike near Black Lick Creek.

Sample 17 was cut from the base of the Sunbury shale by Mr. Stout on Rock Fork, above the covered bridge northeast of Gahanna. The shale is 6 to 8 feet thick and was sampled by channeling.

#### PENNSYLVANIA.

Sample 18. The Upper Kittanning coal is a cannel coal at many places in Pennsylvania. Near Cannelton, Beaver County, a deposit of cannel coal at this horizon occupies a narrow, oblong oxbow channel, 5 miles in length and 600 feet wide. The coal is 15 feet thick in the center of the basin, but thins to 2 feet or less at the edges. It is underlain by 1 foot of bituminous coal. Over the coal is a black shale that in places in the mine has broken down for several feet. Sample 18 was cut from the edge of one of these breaks, where the shale had been exposed to the air for 60 years or more. The black shale roof may have a much greater horizontal extent than the minable coal beneath. I. F. Mansfield, who has mined the coal here for many years, estimates that there is a thousand acres of shale from 3 to 5 feet thick.

Samples 19 to 24 were taken by R. V. A. Mills in Butler County but in connection with the geological survey of the Butler quadrangle. Probably none of these samples represents sufficient thickness to indicate a workable deposit, but they are of interest as showing what may be obtained from such shales.

Sample 19 represents a cannel-like shale, 1 foot thick, underlying 16 inches of thin-bedded black shale and overlying 15 inches of mottled clay that in turn overlies the Lower Freeport coal 2 feet thick, in the southwest corner of Clay Township. The yield from this sample suggests a true cannel coal.

Sample 20 was taken from the dump of an old mine 1 mile north of Muddy Creek, three-quarters of a mile west of the Bessemer Railroad, 1 mile northwest of Queen Junction. The material is probably a low-grade cannel coal, apparently about 2 feet thick.

Sample 21 represents 1 foot of cannel-like shale or cannel coal in a weathered outcrop beside the road in the southwest corner of Clay Township, 1,000 feet west of the Butler and Mercer Pike.

Sample 22 represents 1 foot of cannel shale and 3 inches of cannel coal from the unmined roof over the Upper Freeport coal in the Muntz mine, just south of Butler.

Sample 23 was gathered from the dump of an abandoned mine on the north bank of Swamp Run, on the eastern edge of the Zelienople quadrangle. The bed is reported to have been lenticular, to have had a maximum thickness of 6 feet, and to have consisted entirely of black shale at the Lower Freeport horizon.

Sample 24 represents the lowest 10 feet of a black shale over the Upper Freeport coal exposed on the old State road on the hill just south of Butler. The upper part of the shale grades into sandy shale.

#### TENNESSEE.

The Chattanooga black shale underlies nearly all the upland region of middle Tennessee. It crops out along the foot of the escarpment east of the coal field and near the foot of the escarpment facing the Nashville Basin. West of the Nashville Basin and along Tennessee River are many areas where the black shale underlies gentle slopes. It was sampled at Cumberland Gap; at Rockwood, where the writer was taken to the best exposures by Mr. George E. Sylvester, formerly State mine inspector; at the south end of the ridge south of Alton Park, near Chattanooga, in some old workings for "phosphate"; at Bakers station, on the Louisville & Nashville Railroad, north of Nashville; and at the top of a quarry about halfway between Newsom and Pegram stations, on the Nashville, Chattanooga & St. Louis Railway, west of Nashville.

Samples 25 and 26 were taken at Cumberland Gap in the railroad cut at the mouth of the tunnel. At this point a fault crosses the mountain and the shales are much crushed and contorted. Where sample 26 was cut nearly a quarter of the rock is sandy and calcareous material. All the rock has been crushed until it mines out in slickensided flakes. These samples do not afford a fair test of what this shale should yield away from the fault.

Sample 27. The samples obtained at Rockwood give a better test of the oil contents of the Chattanooga shale along the front of the Cumberland escarpment. Sample 27 was taken from a 2-foot cut at a corner one block north of the main street, near the railroad, where the shale has a high dip and is much crumpled.

Sample 28 represents a 5-foot cut at a point north of Rockwood and west of the iron mines. The shale here also has a high dip and is much crumpled.

Sample 29. A connecting spur built northeast of Rockwood station about 1900 cut through the black shale, which at this point has a dip of about  $15^\circ$ , but is contorted so as to resemble material having cone

in cone structure. Sample 29 represents a 3-foot trench at the west end of this cut.

Samples 30 and 31. Some years ago a mine was opened in the Chattanooga black shale a few miles south of Chattanooga, close to the road at the south end of a ridge extending south from Alton Park. The shale at this place is only 6 feet thick. It is underlain by 10 feet or more of light-drab clay and overlain in order by 18 inches to 2 feet of cream-colored clay, 6 inches to a feather edge of dark-drab to black shale, 18 inches of drab shale, 2 feet 6 inches of cream-colored cherty clay, and 20 feet or more of gray chert. The rocks at the mine have a dip of about  $12^\circ$ . Sample 30 was cut 30 or 40 feet from the entrance to the mine and sample 31 about 15 feet from the entrance. The black shale here is not typical. Sample 30, for example, resembles a hard grayish-black massive to fissile clay.

Samples 32 to 34 were taken at Bakers station, where the Louisville & Nashville Railroad crosses the Chattanooga black shale in descending from the highland rim to the Nashville Basin. The top of the black shale at this point rises above the railroad track a short distance above the station, and the whole of it is exposed a short distance below the station. The shale has a thickness of 27 feet, of which the upper 11 feet is jointed and "sheety"—that is, it breaks out in large thin sheets—and the lower 16 feet is fissile. Over the black shale is 1 foot of green shale with concretions (Maury glauconitic member of Ridgetop shale), then 30 feet or more of characteristic Ridgetop shale. The railroad cut is only a few years old, having been made in a realignment and regrading of the road. The dip is less than  $1^\circ$ .

Sample 32 includes 5 feet of the top of the bed where it reaches that height above the drain. Part of the rocks come out in plates one-fourth to one-half inch thick, but most of it breaks out as irregular massive chunks several inches thick. In places partly weathered pieces indicate that this massive phase weathers into the characteristic thin flakes. The rocks were shattered by blasting in making the cut, and the action of weathering has penetrated along the fracture planes to a slight extent. The top 18 inches has a chocolate-brown streak where cut across, but the next 30 inches gives a blackish-gray to grayish-black streak.

Sample 33, taken at the west end of the bluff below the station, includes 5 feet of a section starting 6 feet below the top of the formation. The shale is hard and massive and of a dark chocolate color. It is strongly jointed, and the long or face joints run N.  $63^\circ$  W. and the short or butt joints N.  $48^\circ$  E.

Sample 34 represents 5 feet in the middle of the lower 16 feet of thinly laminated shale. The color is a grayish black. On the joint faces the shale has the appearance of a dull-black clay.

Sample 35. Around Newsom and between Newsom and Pegram are a number of large limestone quarries. At one of these, about

halfway between the two stations, the limestone is overlain by 10 feet or more of black shale, which is exposed only at the top of the vertical face of the quarry. Sample 35 was taken at one side where the black shale reaches the slope of the hill and is obviously weathered, as after a preliminary trench several feet deep had been cut the material taken out below it was soft.

Sample 36 was taken at the same place as sample 35, but from the vertical face of the shale at the top of the quarry by cutting steps down to a slight quarry shelf. The shale, though dull brown and weathered, had the usual firmness.

Sample 37 was cut by F. R. Clark and represents 6 inches of bituminous shale overlying the cannel coal at Newcomb, Tenn.

#### WEST VIRGINIA.

Samples 38 to 42 were cut in the black shale of the Onondaga member of the Romney shale, of Middle Devonian age, at a locality well east of the coal fields, in what has been called the Appalachian Valley. In this region the rocks have been closely folded, and it was therefore thought that the oil in the black shale must have been driven out and that the black color was due entirely to the residue of carbon. The distillation tests confirm this opinion. The samples were cut on the West Virginia side of the Potomac, near Hancock station. In the large cut half a mile above the station the rocks dip  $40^{\circ}$  S.  $45^{\circ}$  E. The section shows 25 to 30 feet of black fissile shale, 25 feet of olive-drab shale, and 40 feet of grayish-black shale with rusty joint faces, underlain by the Oriskany sandstone.

Sample 38 represents a 40-foot cut in the black fissile shale about 100 feet above the railroad track. This shale was cut out in pieces ranging from plates 1 inch thick down to thin scales. The plates are rusty on the bedding faces but black on cross faces when broken.

Sample 39 was taken from a 5-foot cut at a bold outcrop of the olive-drab shale.

Samples 40 and 41 represent two cuts in the grayish-black shale.

Sample 42 was cut in grayish-black shale beside the road to Berkeley Springs, about a quarter of a mile from the station.

#### DISTILLATION TESTS.

Two sets of tests of the writer's samples were made under the direction of David T. Day by means of an electric furnace or a gas heater, in which the temperature was raised slowly until all the oil appeared to have been driven off, when the temperature was raised further to drive off the remainder of the gas. The first series of tests were of a preliminary nature and were made at the Geological Survey by J. A. Dorsey; the second series were made at the Bureau of Mines by C. R. Bopps. The samples collected in 1915 were tested

at the survey by D. E. Winchester. In order to show how the yields of these samples compare with the yields of cannel coal, results obtained from a number of cannel coals that were distilled at the same time and in the same manner are included in the subjoined table. These coals are described in a bulletin on cannel coal to be published by the Survey. With the possible exception of the Cannelton cannel they are not as rich as many of the Kentucky cannels.

*Tests of black shale and of some cannel coals from the eastern United States.*

[By David T. Day, except those marked \*, which were made by D. E. Winchester.]

Sample No.	Locality.	Preliminary test.			Final test.				
		Amount used (grams).	Oil obtained (cubic centimeters).	Yield per short ton (gallons).	Amount used (ounces).	Yield per short ton.			Ammonia (pounds).
						Oil (gallons).	Water (gallons).	Gas (cubic feet).	
SHALE.									
1	New Albany, Ind. ....	100	3	7	6	3.5	5.6	719	0.08
2	do. ....				6	9.1	4.2	958	0
3	do. ....	100	7	16	6	11.2	7	2,043	.15
4	do. ....	100	3	7	6	4.9	8.4	1,097	0
5	do. ....				6	11.9	6.3	1,197	0
6	Boonville, Ind. ....	100	3	7	6	14	11.2	2,522	.97
7	do. ....	100	0	0	6	None.	9.8	479	0
8	do. ....	100	9	21	6	15.4	12.6	2,922	.61
9	Springfield, Ill. ....	100	5	12	6	11.9	9.8	2,186	.65
*10	Gallatin County, Ill. ....				8½	16	7.5	Not det.	3.44
11	Louisville, Ky. ....				8	11.2	4.2	1,016	0
*12	Crittenden County, Ky. ....				8½	14	12	Not det.	2.58
*13	Caseyville, Ky. ....				8½	Trace.	Trace.	Not det.	2.28
14	Glen Mary, Ohio. ....	100	3	7	6	7.7	5.6	1,199	.11
15	do. ....	100	4	9	6	5.6	5.6	958	0
*16	Columbus, Ohio. ....				8½	4	18	Not det.	1.02
*17	Gahanna, Ohio. ....				8½	11	18	Not det.	1.61
18	Cannelton, Pa. ....	100	12	28	6	27.3	9.1	2,905	.92
*19	Clay Township, Pa. ....				8½	45	15	Not det.	3.72
*20	Queen Junction, Pa. ....				8½	43	13	Not det.	4.99
*21	Clay Township, Pa. ....				4½	34	18	Not det.	5.21
*22	Butler, Pa. ....				8½	24	11	Not det.	9.43
*23	Zelienople quadrangle, Pa. ....				4½	18	10	Not det.	2.53
*24	Butler, Pa. ....				8½	1	11	Not det.	1.66
25	Cumberland Gap, Tenn. ....	100	1	2	6	1.4	8.4	598	.28
26	do. ....	100	1	2	6	Trace.	3.5	230	0
27	Rockwood, Tenn. ....	100	4	9	6	7.7	9.8	1,488	.15
28	do. ....	100	3	7	6	5.5	7	1,128	.17
29	do. ....	100	1	2	6	2.8	14	1,077	0
30	Alton Park, Tenn. ....	100	0	0	6	Trace.	14	835	0
31	do. ....	100	Trace.	0	6	.7	9.1	1,437	0
32	Bakers station, Tenn. ....	100	4	9	6	9.1	4.2	1,916	.33
33	do. ....	100	3	7	6	9.1	4.9	1,485	.10
34	do. ....	100	3	7	6	6.3	8.4	1,557	.10
35	Newsom, Tenn. ....	100	0	0	6	None.	12.9	835	.15
36	do. ....	100	3	7	6	4.2	8.4	835	.21
*37	Newcomb, Tenn. ....				8½	21	2	Not det.	5.07
38	Hancock station, W. Va. ....	100	0	0	6	Trace.	7	538	0
39	do. ....	100	0	0	6	7	9.8	636	1.00
40	do. ....	100	0	0	6	Trace.	11.2	393	0
41	do. ....	100	0	0	6	7	8.4	230	0
42	do. ....	100	0	0	6	None.	7	319	0
CANNEL COAL.									
	Altoona mine, Indiana County, Pa. ....	100	10	24	6	20.3	7.7	4,790	5.57
	Bostonia mine, Armstrong County, Pa. ....	100	17	40.8	6	33.6	7	5,029	5.37
	Pine Run No. 1, Armstrong County, Pa. ....	100	14	33.6	6	25.2	9.8	5,029	5.06
	Pine Run No. 3, Armstrong County, Pa. ....	100	8	19	6	31.5	8.4	4,311	3.68
	Cannelton, Beaver County, Pa. ....	100	21	50.4	6	37.3	10.5	5,268	2.24

According to these figures the Devonian black shale can be expected to yield not over 10 or 12 gallons of oil, 2,000 cubic feet of gas (as a by-product), and one-third of a pound of ammonia to the ton. Shales that are highly folded yield less oil or none at all, though the first sample cut at Rockwood, Tenn., gave an unexpectedly high result, notwithstanding the folded condition of the rocks at that place. Later experiments show that by distillation under steam the yield of ammonia may be increased above the figures given in the table.

It seems possible, if not probable, that many of the apparently unweathered samples have lost some or much of their oil. The black shale was found to be unexpectedly tough, so that the attempt to cut samples in the same manner as coals or clays are sampled proved extremely slow, and, moreover, doubt remained as to whether the shale face had been trenched deeply enough to be beyond the reach of surface weathering. This toughness will have a marked influence on the cost of mining. At the stripping near Boonville it has been found that the steam-shovel teeth ordinarily used wear out at once in digging the black shale, so that it is necessary to use special teeth of manganese steel, and even these last only two weeks.

#### OIL CONTENT.

To give some idea of the amount of oil in this shale a few figures are given for the body of black shale in southwestern Indiana. The weight of this shale is not known. Common shale weighs about 160 pounds to the cubic foot, or practically twice as much as coal, but this weight is reduced by the presence of hydrocarbons, and high-grade oil shales weigh as little as 100 pounds to the cubic foot. If a weight of 130 pounds to the cubic foot is assumed, it will require about 15.4 cubic feet of shale to weigh a short ton. If 1 ton of shale is assumed to yield 10 gallons of oil, 100 cubic feet of shale may be assumed to yield 64.9 gallons, or say roughly  $1\frac{1}{2}$  barrels (of 42 gallons).

The following table gives some measurements of the thickness and depth to the top of the black shale at places in Indiana, as obtained in drilling oil wells:

*Reported thickness and depth of New Albany black shale in Indiana.*

Locality.	Thickness.	Depth to top
	<i>Feet.</i>	<i>Feet.</i>
Albion, Noble County .....	65+	<sup>a</sup> 375
Bloomington, Monroe County .....	120	790
Bridgeport, Marion County .....	124	140
Brownstown, Jackson County .....	147	318
Columbus, Bartholomew County .....	87+	26
Crawfordsville, Montgomery County .....	80	550
Fowler, Benton County .....	92	<sup>a</sup> 280
Kentland, Newton County .....	100+	<sup>a</sup> 100
La Fayette, Tippecanoe County .....	120	100
Martinsville, Morgan County .....	120	408
New Albany, Floyd County .....	104	80
Oxford, Benton County .....	100+	<sup>a</sup> 385
Remington, Jasper County .....	85	5
Rockville, Parke County .....	102	1,044
Salem, Washington County .....	103	627
Seymour, Jackson County .....	130+	<sup>a</sup> 75
Thornton, Lawrence County .....	87	303

<sup>a</sup> Roof of black shale is glacial clay.

These figures give an average thickness of not far from 100 feet. As exposed from Jeffersonville to and beyond New Albany, the shale shows little variation from top to bottom. It is not certain that the black shale as reported in the well logs is all of the same character. In fact, some of the exposures of the "black shale" in the northern part of the State indicate that the shale in that region is not uniformly black, as is shown by the following section:<sup>1</sup>

*Section of "black shale" at Delphi, Ind.*

	Ft.	in.
Drift .....	7	0
Bluish-black shale, sheety and tough .....	45	0
Drab-grayish, slightly sandy shale .....	4	6
Band of gray concretions .....	6	14
Drab sandy shale .....	10	6
Bluish-gray sandstone .....	4	10
Drab sandy shale .....	5	6
Covered .....	8	(?)
Devonian limestone.		

The log of a deep well at Terre Haute, believed to have gone through this black shale, shows the following beds:

*Partial record of deep well at Terre Haute, Ind.*

	Thickness	Depth.
	<i>Feet.</i>	<i>Feet.</i>
Blue shale .....	40	1,622
Black shale .....	15	1,637
Red shale .....	5	1,642
Black shale .....	15	1,657
Limestone .....	5	1,662
Black shale .....	5	1,667
Limestone.		

<sup>1</sup> Kindle, E. M., Indiana Dept. Geology and Nat. Res. Twenty-fifth Ann. Rept., p. 533. 1900.

It is a very moderate assumption to place the average thickness of the oil-yielding rock at say 30 feet, of which it might be possible to mine out one-half, or 15 feet. The New Albany black shale underlies about 16,000 square miles. If 15 cubic feet of rock weighs 1 ton and yields 10 gallons of oil, 10 gallons of oil should be obtainable for every square foot of this area in southwestern Indiana. As a square mile contains roundly 28,000,000 square feet, the yield would be 280,000,000 gallons or nearly 7,000,000 barrels of oil to the square mile, or say 100,000,000,000 barrels for the total area underlain by the shale in southwest Indiana.

#### FUTURE DEVELOPMENT.

If it costs as much to mine a ton of shale and distill the oil from it as it does to mine a ton of coal, say \$1 (as a matter of fact the cost is likely to be higher), a barrel of crude oil obtained in this way will cost about \$4.20. This estimate assumes that the gas yielded is used in the distillation of the oil and takes no account of the value of by-products nor of the possibility that the oil may yield products of higher value than the crude oils now obtained by drilling.

At present interest in the mining of the eastern black shales as a source of oil must confine itself to localities where one of three conditions is met. The shale can be utilized, first, where it outcrops in a position to permit mining on a large scale by steam shovel at a minimum cost; second, where coal that is overlain by bituminous shale is being stripped; and third, where a coal bed that is being mined has a black shale roof that comes down and must be removed from the mine in large amounts. Of these the second condition seems to offer the best opportunity for a trial plant, as the overlying black shale must be removed in mining the coal. At such pits it would require only that another shovel be installed to lift the shale, or the small shovel now used to lift the coal could be used to lift the black shale first. This black shale over the coal appears to have the advantage of a higher oil yield. Where the roof shale is as rich as at Cannelton, Pa., it may pay to mine the shale with the coal.

#### ANALYSES.

In the Twenty-first Annual Report of the Department of Geology and Natural History of Indiana Hans Duden gives two analyses of black shale obtained at New Albany, and as that report is now out of print, they are quoted here:



*Analyses of black shale from New Albany, Ind.*

[By Hans Duden.]

	1	2
Water expelled at 100° C.....	0.50	.....
Water expelled at 100° C. during 4 hours.....	.....	0.56
Volatile organic matters.....	14.16	14.30
Fixed carbon.....	9.30	23.60
Fixed organic matters.....	.....	9.30
Silica.....	50.53	.....
Silicates insoluble in HCl.....	.....	65.43
Pyritic iron and alumina <sup>a</sup> .....	25.30	.....
Ferric oxide.....	.....	8.32
Calcium oxide.....	.09	.09
Magnesium oxide.....	.12	.12
Sulphur.....	.....	2.08
	100.00	100.00

<sup>a</sup> The amount of pyrite and alumina changes considerably in different layers. This piece had 10.367 per cent iron pyrite and 14.933 per cent alumina.

In the same report Duden gives the results of experiments in making illuminating gas from the shale, using as a retort a 4-inch pipe 6 inches long, capped at both ends and connected by a  $\frac{3}{4}$ -inch pipe with washing and refining apparatus.

*Gas produced from black shale and Pittsburgh coal.*

	Gallons.
5 pounds of Pittsburgh coal.....	105
8.5 pounds of black slate.....	45
8.5 pounds of black slate, Ohio banks.....	50
8.5 pounds of black slate, Falling Run banks.....	65
15 pounds of freshly broken slate.....	105
15 pounds of the same after exposure to air for 14 days.....	100

He also quotes from a letter describing an experiment in the production of gas at the New Albany Gas Light & Coke Co.'s plant:

I carbonized 3 tons of the New Albany black slate and obtained a yield of 2.20 cubic feet per pound of 22-candlepower gas. Ordinary unenriched coal gas is about 18 candlepower. The quality of gas, therefore, is better and the yield 45 per cent of that obtained from Pittsburgh coal. Of the amount of oil or tar obtained I know nothing, as I did not make any measurements. The slate does not materially change its color or form by being carbonized. The residue contains much sulphur and, so far as I know, is useless for fuel. I made no scientific test. With the arrangement we have for making gas, it would not pay us to use the slate, even though we could obtain it for nothing. The slate was obtained from near the exposed surface of a creek bottom, and I am sure that if a sample was gotten at a greater depth, a much better yield of gas would be obtained.

Duden then describes the oil obtained in his experiments:

Crude oil obtained by atmospheric pressure from the slate exhibits a black coloration, has a very bad smell, and is very difficult to refine. In oil obtained with stills provided with a vacuum pump the vapors are removed from the hot still walls as quickly as formed. At the same time the temperature necessary

to form the vapors is materially lowered (about 100° C.). A vacuum of 15 inches gave very good results. The oil is nearly colorless and without much smell. By leading into the still a small amount of steam and the vacuum apparatus left as in the last case, then in the watery part of the distillate ammonia was increased materially and can be used for manufacturing sulphate of ammonia.

#### GOVERNMENT INVESTIGATIONS.

In 1916 Mr. Winchester continued his studies of the oil shale in the Uinta Basin of Utah, and it was planned that C. F. Bowen should examine the black shale in southwestern Montana, near Dillon. In addition to these studies, samples of black shales are being collected by other members of the Survey as opportunity offers and tested by Mr. Winchester.

In addition to this work by the Geological Survey, the Bureau of Mines proposes to erect a shale retort of the Del Monte type in the navy yard at Washington, D. C., for the purpose of carrying on preliminary investigations of the commercial possibilities of oil shales. This work will be under the direction of David T. Day. If the results justify further investigation on a large scale, the bureau will probably erect a large retort, with a capacity of possibly 500 pounds, at either the petroleum experiment station at San Francisco or the Pittsburgh station, for the purpose of obtaining complete information upon the value and possible by-products to be derived from the distillation of shale. This work will be predicated upon the results of the distillation of shale in other countries. The bureau contemplates sending an expert to Scotland to study the Scottish practice at first hand.

DEPARTMENT OF THE INTERIOR

FRANKLIN K. LANE, Secretary

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, Director

Bulletin 641

CONTRIBUTIONS TO ECONOMIC  
GEOLOGY

(SHORT PAPERS AND PRELIMINARY REPORTS)

1916

PART II.—MINERAL FUELS

DAVID WHITE, G. H. ASHLEY, AND M. R. CAMPBELL

GEOLOGISTS IN CHARGE



WASHINGTON

GOVERNMENT PRINTING OFFICE

1917

**NOTE.**—The Survey's annual volumes entitled "Contributions to economic geology" are issued in parts, and the last part will include a volume title-page, table of contents, and index for the use of those who may wish to bind the separate parts. A small edition of the bound volume will also be issued, but copies can not be supplied to those who have received all the parts.

## CONTENTS.

[The letters in parentheses preceding the titles are those used to designate the papers for advance publication.]

	Page.
Introduction-----	vii
(A) Ozokerite in central Utah, by H. M. Robinson (published June 13, 1916)-----	1
(B) The oil and gas geology of the Foraker quadrangle, Osage County, Okla., by K. C. Heald (published August 21, 1916)-----	17
(C) Possibilities of oil and gas in north-central Montana, by Eugene Stebinger (published July 17, 1916)-----	49
(D) Structure of the Vicksburg-Jackson area, Miss., with special reference to oil and gas, by O. B. Hopkins (published July 18, 1916)-----	93
(E) An anticlinal fold near Billings, Noble County, Okla., by A. E. Fath (published July 15, 1916)-----	121
(F) Oil shale in northwestern Colorado and adjacent areas, by D. E. Winchester (published December 18, 1916)-----	139
(G) Geology of the Upper Stillwater Basin, Stillwater and Carbon counties, Mont., with special reference to coal and oil, by W. R. Calvert (published November 17, 1916)-----	199
(H) Geology of the Hound Creek district of the Great Falls coal field, Cascade County, Mont., by V. H. Barnett (published October 9, 1916)-----	215
(I) Anticlines in central Wyoming, by C. J. Hares (published December 16, 1916)-----	233
(J) Anticlines in the Blackfoot Indian Reservation, Mont., by Eugene Stebinger (published January 22, 1917)-----	281
(K) Coals in the area between Bon Air and Clifty, Tenn., by Charles Butts (published January 19, 1917)-----	307
(L) Oil resources of black shales of the eastern United States, by G. H. Ashley (published February 8, 1917)-----	311
Index-----	325

## ILLUSTRATIONS.

	Page.
PLATE I. Map of ozokerite field in central Utah-----	16
II. Topographic and structure map of the Foraker quadrangle, Okla-----	20
III. Stereogram of the Foraker quadrangle, Okla-----	32
IV. Geologic sketch map and section showing oil and gas prospects in north-central Montana-----	64
V. Geologic map and sections of the vicinity of Havre, Mont-----	70

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	Page.
PLATE I. Map of ozokerite field in central Utah-----	16
II. Topographic and structure map of the Foraker quadrangle, Okla.-----	20
III. Stereogram of the Foraker quadrangle, Okla.-----	32
IV. Geologic sketch map and section showing oil and gas prospects in north-central Montana-----	64
V. Geologic map and sections of the vicinity of Havre, Mont.-----	70

	Page.
PLATE VI. Sketch map showing tilted and folded structures north of the Bearpaw Mountains, Mont-----	82
VII. Sketch map showing tilted and folded structures south of the Bearpaw Mountains, Mont-----	88
VIII. Map of Vicksburg-Jackson area, Miss-----	In pocket.
IX. Map showing structure of anticlinal fold near Billings, Okla----	122
X. Key map of northwestern Colorado and adjacent areas-----	142
XI. A, Oil shale northeast of Watson, Utah; B, Oil shale on east side of Piceance Creek near White River, Colo-----	144
XII. A, Book Cliffs west of Rifle, Colo.; B, Green River formation north of White River, 9 miles west of Rangely, Colo-----	145
XIII. A, Green River formation east of Green River city, Wyo.; B, Green River formation in T. 10 S., R. 15 E., about 25 miles north of Sunnyside, Utah-----	146
XIV. A, Sampling bed of oil shale south of Green River, Wyo.; B, Sampling bed of oil shale near Watson, Utah-----	147
XV. Field apparatus for distilling oil shale-----	148
XVI. A, Characteristic weathering of rich, massive oil shale; B, Characteristic weathering of oil-yielding paper shale-----	149
XVII. Sections of Green River formation in northwestern Colorado and northeastern Utah-----	In pocket.
XXVIII. Map of northwestern Colorado and northeastern Utah----	In pocket.
XIX. Map of southwestern Wyoming-----	In pocket.
XX. Topographic map of the Upper Stillwater Basin, Mont-----	200
XXI. Geologic map of the Upper Stillwater Basin, Mont-----	202
XXII. Geologic map and sections of the Hound Creek district, Mont--	216
XXIII. Map showing anticlines in Natrona and Fremont counties in central Wyoming-----	278
XXIV. Geologic sketch map of Blackfeet Indian Reservation, Mont., and vicinity, showing sections and wells drilled for oil or gas--	284
XXV. Map of anticlines on the Blackfeet Indian Reservation, Mont--	302
FIGURE 1. Index map of Oklahoma showing location of Foraker quadrangle-----	18
2. Hill slope showing alternating hard and soft strata-----	19
3. Stratigraphic section of rocks exposed in the Foraker quadrangle, Okla-----	21
4. Skeleton logs of wells in north-central Oklahoma, showing correlation of sands-----	30
5. "Pay streaks" of oil in level strata-----	43
6. Cross section illustrating theoretical pinching out of oil-bearing strata-----	43
7. Cross section illustrating theoretical accumulation of oil on terrace-----	44
8. Cross section illustrating theoretical accumulation of oil in anticline-----	44
9. Cross section illustrating theoretical accumulation of oil due to faulting-----	44
10. Cross section illustrating theoretical accumulation of oil in syncline-----	45
11. Index map of Montana showing areas covered by Plates IV-VII-----	50
12. Sections showing sandstones in lower half of Colorado shale, north-central Montana-----	58



	Page.
FIGURE 13. Section from Grand River near Rulison, Colo., to the Book Cliffs on the north, showing the position of the oil shale.....	145
14. Diagram showing structure in the Green River formation near the mouth of Yellow Creek, Colo.....	190
15. Key map showing location of the Hound Creek district, Mont.....	215
16. Index map showing position of area designated central Wyoming.....	233
17. Section through the Sheep Mountain anticline, Wyo.....	251
18. Section through the Big Sand Draw, Alkali Butte, and Conant Creek anticlines, Wyo.....	252
19. Section through the Buck Springs anticline, Wyo.....	255
20. Section through the Dutton anticline, Wyo.....	256
21. Section through the north end of the Rattlesnake anticline, Wyo.....	257
22. Section through the Rattlesnake anticline at Arthur Peak, Wyo.....	258
23. Section through the Alcova anticline, Wyo.....	263
24. Section through the Goose Egg anticline, Wyo.....	265
25. Section through the Iron Creek anticline, Wyo.....	266
26. Section along the axis of the Oil Mountain anticline, the minor anticlines between Poison Spider and Casper creeks, and the Pine dome, Wyo.....	267
27. Section through the Oil Mountain anticline, Wyo.....	267
28. Section through the Pine dome, Wyo.....	267
29. Section through the Cottonwood Creek anticline, Wyo.....	271
30. Section through the Big Sulphur Springs anticline, Wyo.....	272
31. Section through the south end of the Emigrant Gap anticline, Wyo.....	273
32. Section near the middle of the Emigrant Gap anticline, Wyo.....	273
33. Section through the North Casper Creek anticline, Wyo.....	274
34. Section through the Castle Creek anticline, Wyo.....	276
35. Index map showing location of the Blackfeet Indian Reservation, Mont.....	282
36. Map showing location of coal mines and prospects in the Pikeville quadrangle, Tenn.....	308

---

INSERT.

---

	Page.
Sections showing occurrence of oil and gas in some of the Rocky Mountain fields.....	238

ALLEGATIONS

- 1. That the said ...
- 2. That the said ...
- 3. That the said ...
- 4. That the said ...
- 5. That the said ...
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- 7. That the said ...
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- 39. That the said ...
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- 41. That the said ...
- 42. That the said ...
- 43. That the said ...
- 44. That the said ...
- 45. That the said ...
- 46. That the said ...
- 47. That the said ...
- 48. That the said ...
- 49. That the said ...
- 50. That the said ...

INDEX

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# CONTRIBUTIONS TO ECONOMIC GEOLOGY, 1916.

## PART II. MINERAL FUELS.

DAVID WHITE, M. R. CAMPBELL, and G. H. ASHLEY,  
*Geologists in charge.*

### INTRODUCTION.

The Survey's "Contributions to economic geology" have been published annually since 1902. In 1906 the increase in the number of papers coming under this classification made it necessary to divide the contributions into two parts, one including papers on metals and nonmetals except fuels and the other including papers on mineral fuels. In 1915 the year included in the title was changed from the year in which the field work reported in these papers was done to the year of publication, and in consequence there was no volume entitled "Contributions to economic geology, 1914." The subjoined table gives a summary of these bulletins.

*United States Geological Survey "Contributions to economic geology."*

Date in title.	Date of publication. <sup>a</sup>	Bulletin No.	Date in title.	Date of publication. <sup>a</sup>	Bulletin No.
1902.....	1903	213	1910, Part I.....	1911	470
1903.....	1904	225	Part II.....	1912	471
1904.....	1905	260	1911, Part I.....	1913	530
1905.....	1906	285	Part II.....	1913	531
1906, Part I.....	1907	315	1912, Part I.....	1914	540
Part II.....	1907	316	Part II.....	1914	541
1907, Part I.....	1908	340	1913, Part I.....	1915	580
Part II.....	1909	341	Part II.....	1915	581
1908, Part I.....	1909	380	1915, Part I.....	1916	620
Part II.....	1910	381	Part II.....	1916	621
1909, Part I.....	1910	430	1916, Part I.....	1917	640
Part II.....	1911	431	Part II.....	1917	641

<sup>a</sup> The date given is that of the complete volume; beginning with Bulletin 285 the papers have been issued as advance chapters as soon as they were ready.

As the subtitle indicates, the papers included in these volumes, are of two classes—(1) short papers giving comparatively detailed descriptions of occurrences that have economic interest but are not of

sufficient importance to warrant a more extended description; (2) preliminary reports on economic investigations the results of which are to be published later in more detailed form. These papers are such only as have a direct economic bearing, all topics of purely scientific interest being excluded.

Brief abstracts of the publications of the year are given in the annual report of the Director. The complete list of Survey publications affords, by means of finding lists of subjects and of authors, further aid in ascertaining the extent of the Survey's work in economic geology.

The reports on work in Alaska have been printed in a separate series since 1904, the volumes so far issued being Bulletins 259, 284, 314, 345, 379, 442, 480, 520, 542, 592, 622, and 642.

## INDEX.

A.	Page.		Page.
Albertson (coal) mine, Mont.....	207	Birch Creek, Mont. :	
coal, analysis.....	210	anticlines .....	303
Alcova anticline, Wyo.....	262-264	Bitter Creek, Wyo. :	
section, structural .....	263	Green River formation, section..	188
Alkali Butte anticline, Wyo.....	252-254	Blackfeet anticlines, Mont.....	298
Ammonium sulphide :		Blackfeet Indian Reservation, Mont. :	
distillation from shale.....	151-154,	anticlines .....	281, 294-303
	158-160	map .....	302
Antelope Creek anticline, Okla.....	40	Canada, correlation .....	282, 290-291
Anticlines :		Colorado shale.....	285, 287-289
definition .....	248	oil and gas .....	287-289
<i>See also</i> Mississippi; Oklahoma ;		Cretaceous rocks .....	285-290
Wyoming; Blackfeet		gas .....	287-290
Indian Reservation.		geography .....	282-283
Ashley, G. H. :		geology .....	284-303
Oil resources of black shales of		Kootenai formation.....	285, 286-287
eastern United States		map .....	302
	311-324	map, geologic.....	284
Aspen shale (Wyo.) .....	238	oil .....	287-289
oil .....	237	structure .....	291-303
		Virgelle sandstone .....	285, 289-290
		gas .....	290
		wells .....	303-305
		Black shales :	
		oil .....	311-324
		<i>See also</i> Oil shales.	
		Blacktail Creek, Mont. :	
		anticlines .....	302-303
		Blackwell field, Okla. :	
		oil and gas .....	130
		Bon Air coal (Tenn.).....	307-308, 310
		Book Cliffs, Colo. :	
		Green River formation, sec-	
		tions.....	182
		Bopps, C. R. :	
		work .....	318
		Bow Island gas field, Canada :	
		structure.....	88
		Boxelder anticlines, Mont.....	70
		Brooks anticline, Okla .....	35
		Brown anticline, Okla.....	35-36
		Brown Bear (ozokerite) group,	
		Utah.....	14
		Browns Coulee, Mont. :	
		structure.....	80
		Buck Springs anticline, Wyo.....	255-256
		section, structural.....	255
		Butts, Charles :	
		Coals between Bon Air and	
		Clifty, Tenn .....	307-310
		Byram, Miss. :	
		section.....	105
			C.
		Calvert, W. R. :	
		Geology of Upper Stillwater	
		Basin, Mont .....	169-214

Cambrian rocks (Wyo.):	Page.	Colorado shale:	Page.
oil -----	242	Montana -----	53, 54, 56-58, 69,
Campbell, M. R.:			88-91, 222-223, 285, 287-289
on oil shale in northwestern		map -----	64
Colorado -----	139-140	Colton, Utah:	
Canada:		ozokerite -----	1-2
Montana, correlation -----	61-62,	Conant Creek anticline, Wyo -----	254-255
	282, 290-291	Cooke, C. W.:	
Cannel coal:		work -----	95
distillation -----	319	Cottonwood Creek anticline, Wyo -----	270-271
Carboniferous rocks:		section, structural -----	271
Montana -----	218-220	Cottonwood limestone:	
Casper Oil Co.'s well, Wyo -----	242, 276	Foraker quadrangle, Okla -----	22-23
Castle Creek anticline, Wyo -----	275-276	section -----	23
section, structural -----	276	Cretaceous rocks:	
Catahoula sandstone:		coal -----	202
Vicksburg-Jackson area, Miss --	97,	Montana -----	53, 54, 56-60,
	105-106		201-203, 220-223
sections -----	105-106	section, stratigraphic -----	64
Cedars, Miss.:		oil -----	237-238, 244-245
section, stratigraphic -----	119	Wyoming -----	239, 244
Ceresin. <i>See</i> Ozokerite.		Crouse limestone:	
Chattanooga shale:		Foraker quadrangle, Okla -----	22
eastern United States -----	312	Culmer Bros.' (ozokerite) mine, Utah --	12
Chinook, Mont.:		Cut Bank Creek, Mont.:	
section, stratigraphic -----	81	anticlines -----	298-299, 300
structure -----	814		
Chugwater formation (Wyo.) --	239, 243-244		
oil -----	237, 243		
Claggett shale:			
Havre field, Mont -----	53, 67, 72		
Claiborne group:			
Vicksburg-Jackson area, Miss --	97-		
	98, 116		
Clifty coal (Tenn.) -----	308-310		
Cloverly sandstone (Wyo.):			
oil -----	237, 244		
Coal:			
Eagle sandstone -----	142, 207-209		
Hound Creek district, Mont.			
(q. v.) -----	229-231		
Kootenai formation -----	229-231		
Upper Stillwater Basin, Mon-			
tana (q. v.) --	142, 205-213		
Coal Creek, Mont.:			
structure -----	82		
Collins, A. C.:			
work -----	235		
Colorado, northwestern -----	144-146		
Green River formation (q. v.)			
162-182, 189-190			
maps -----	142; in pocket		
oil shale --	139-142, 147-182, 189-190		
analyses -----	161		
distillation -----	141-142		
geology -----	162-182, 189-190		
maps -----	In pocket		
sections, stratigraphic --	167-168,		
	170-182; in pocket		
views -----	144, 145		
section, structural -----	190		
structure -----	189-190		
Colorado & Wyoming Land & Oil			
Co.'s (oil) well, Wyo --	239		

## D.

Dakota sandstone (Wyo.) --	238, 244, 245
oil -----	244
Davis, C. A.:	
on oil shale -----	163-165
work -----	143
Day, D. T.:	
ozokerite tests -----	5-8
work -----	139, 140, 143, 147, 318
Devonian shales:	
eastern United States -----	312-320
oil content -----	320-322
Dog Creek, Mont.:	
structure -----	86-88
Dorsey, J. A.:	
work -----	318
Dragon, Utah:	
gilsonite -----	140
Duden, Hans:	
analyses of black shale -----	322-324
Dutton anticline, Wyo -----	256-258
oil -----	243, 244
section, structural -----	256

## E.

Eagle sandstone:	
coal -----	142, 207-209
analyses -----	210
gas -----	68, 72-76
Havre field, Mont. (q. v.) --	68-69,
	72-73
section -----	69
Montana -----	53, 58-59,
	68-69, 72-73, 201-203
Edwards city well, Miss -----	120
Eldorado monocline, Miss -----	111
oil -----	114-115

- | Eldridge, G. H. :                   | Page.         | Fort Union formation :                 | Page.                        |
|-------------------------------------|---------------|--|------------------------------|
| on origin of ozokerite-----         | 10            | coal -----                             | 143, 205-206                 |
| Elk Creek, Mont. :                  |               | Upper Stillwater Basin, Mont.--        | 203                          |
| coal -----                          | 229-230       | Fossil Butte, Wyo. :                   |                              |
| section, stratigraphic -----        | 229           | Green River shale, section-----        | 189                          |
| Elliott, F. A. :                    |               | Fourteenmile Creek, Colo. :            |                              |
| work -----                          | 143           | Green River shale, sections-----       | 180                          |
| Ellis formation :                   |               | Franco-American (oil) well, Wyo--      | 241-242, 262                 |
| fossils -----                       | 219           | Frontier formation (Wyo.)-----         | 238, 246                     |
| Montana -----                       | 219           | oil -----                              | 237, 246                     |
| Elm Creek anticline, Okla-----      | 39-40         |  |                              |
| Embar formation (Wyo.)-----         | 238, 243      | G.                                     |                              |
| oil -----                           | 238, 243      | Galicia (Austria) :                    |                              |
| Emigrant Gap anticline, Wyo-----    | 272-274       | ozokerite -----                        | 10                           |
| sections, structural-----           | 273           | Gas :                                  |                              |
| Eutaw formation :                   |               | distillation from shale-----           | 151-153                      |
| oil and gas-----                    | 116, 117      | Gas, natural :                         |                              |
| Vicksburg-Jackson area, Miss--      | 117           | accumulation, effect of faulting--     | 75                           |
| Evacuation Creek, Utah :            |               | Blackfeet Indian Reservation,          |                              |
| Green River shale, section---       | 183-184       | Mont. (q. v.)-----                     | 287-290                      |
| F.                                  |               | Chouteau County, Mont-----             | 90-91                        |
| Fath, A. E. :                       |               | Eagle sandstone-----                   | 68, 72-76                    |
| Anticlinal fold near Billings,      |               | Havre field, Mont. (q. v.)-----        | 66-67, 68, 72-76             |
| Okla -----                          | 121-138       | Kevin, Mont-----                       | 89-90                        |
| Faulting :                          |               | Medicine Hat, Alberta-----             | 74                           |
| effect on gas accumulation-----     | 75            | Milk River valley, Mont-----           | 75-76                        |
| Finch, E. H. :                      |               | Sweetwater Hills, Mont-----            | 88-89                        |
| work -----                          | 94, 95        | <i>See also</i> Oil and gas.           |                              |
| Fitzhugh (oil) wells, Wyo---        | 241, 242, 277 | Gilsonite :                            |                              |
| Flossie Running After Arrow (oil)   |               | Dragon, Utah-----                      | 190                          |
| well, Okla-----                     | 134           | Girty, G. H. :                         |                              |
| Foraker anticline, Okla-----        | 39            | on fossils of Montana-----             | 219                          |
| Foraker limestone :                 |               | Goose Egg anticline, Wyo-----          | 264-265                      |
| contour map-----                    | 20            | section, structural-----               | 265                          |
| Foraker quadrangle, Okla-----       | 25            | Gosling, E. B. :                       |                              |
| <i>See also</i> Foraker quadrangle. |               | on origin of ozokerite-----            | 9                            |
| Foraker quadrangle, Okla-----       | 17-20         | Grainola anticline, Okla-----          | 34                           |
| anticlines -----                    | 33-40         | Graneros shale (Wyo.)-----             | 238                          |
| Cottonwood limestone -----          | 22-23         | oil -----                              | 237                          |
| section, stratigraphic -----        | 23            | Great Falls, Mont. :                   |                              |
| correlation -----                   | 29-30         | Hound Creek district (q. v.)--         | 215-231                      |
| Crouse limestone -----              | 22            | section, stratigraphic-----            | 58                           |
| Foraker limestone-----              | 25            | Green River, Wyo. :                    |                              |
| contour map-----                    | 20            | shale -----                            | 168                          |
| correlation -----                   | 29-30         | distillation -----                     | 169                          |
| stereogram -----                    | 32            | sections-----                          | 168-169                      |
| geography -----                     | 19-20         | Green River formation-----             | 3-4, 162                     |
| geology -----                       | 21-31         | analyses -----                         | 161                          |
| map -----                           | 20            | Colorado (q. v.)-----                  | 139-190                      |
| Neva limestone-----                 | 23-24         | distillation -----                     | 142                          |
| correlation -----                   | 29-30         | maps-----                              | In pocket.                   |
| oil and gas -----                   | 47            | oil -----                              | 139-140                      |
| prospecting -----                   | 45-47         | sections, stratigraphic-----           | 167-168, 170-189; in pocket. |
| Red Eagle limestone-----            | 24-25         | structure-----                         | 189-191                      |
| section, stratigraphic-----         | 24            | Utah -----                             | 3-4, 152, 161, 189-190       |
| sections, stratigraphic-----        | 21, 28        | Wyoming (q. v.) 152, 161, 168-169, 191 |                              |
| stereogram -----                    | 32            | <i>See also</i> Oil shale.             |                              |
| structure -----                     | 32-45         | Guthery (oil) well, Wyo-----           | 240, 245                     |
| synclines -----                     | 40-41         |  |                              |
| Wreford limestone-----              | 21-22         | H.                                     |                              |
| section, stratigraphic -----        | 22            | Hares, C. J. :                         |                              |
| Fort Assinibone, Mont. :            |               | Anticlines in central Wyo-             |                              |
| gas -----                           | 72, 75        | ming -----                             | 233-279                      |
| section, stratigraphic -----        | 72            |  |                              |

Havre field, Mont.:	Page.	J.	Page.
Bearpaw shale -----	53, 54, 68, 72	Jackson, Miss.:	
Claggett shale -----	53, 67, 72	sections, stratigraphic -----	100, 106
Colorado shale -----	69	Jackson anticline, Miss. -----	109-110
Eagle sandstone ----	53, 68-69, 72-73	oil -----	113-114
gas -----	68, 72-76	Jackson area. <i>See</i> Vicksburg-Jack-	
section, stratigraphic -----	69	son area.	
gas -----	66-67, 68, 72-76	Jackson formation:	
analysis -----	74	Vicksburg-Jackson area, Miss. --	97,
geology -----	67-72		98-101
Judith River formation -----	53,	sections, stratigraphic -----	100
	67-68, 72-73	Judith River, Mont.:	
map, geologic -----	70	structure -----	85-86
sections, structure -----	70	Judith River formation:	
structure -----	69-72	Havre field, Mont. --	53, 67-68, 72-73
Havre Natural Gas Co.'s well, Mont.	73	Jurassic rocks:	
gas, analysis -----	74	Montana -----	220
Hay Creek anticlines, Okla. -----	36-37		
Heald, K. C.:		K.	
Oil and gas geology, Foraker		Kast, H., and Seidner, S.:	
quadrangle, Okla. ----	17-47	on origin of ozokerite -----	9
work -----	235	Kay, F. H.:	
Hells Hole Canyon, Utah:		work -----	139
Green River formation, sec-		Kentucky:	
tion -----	185-186	oil shale -----	314, 319
Higgins (ozokerite) shaft, Utah --	16	Kevin, Mont.:	
Holmes (oil) well, Wyo. -----	241	oil and gas -----	89-90
Hopkins, O. B.:		section, stratigraphic -----	58, 90
Structure of Vicksburg-Jackson		Kimball sand (Wyo.) -----	238
area, Miss. -----	93-120	oil -----	237
Hound Creek district, Mont. -----	215-217	Kimberly-Wing Co.'s well, Miss. -----	119
Carboniferous rocks -----	218-220	Kootenai formation:	
coal -----	229-231	coal -----	229-231
quality -----	230-231	Montana -----	53,
section -----	229		54, 55, 221-222, 285, 286-287
Colorado shale -----	222-223	map -----	64
geology -----	217-228	Kyune Canyon (ozokerite) claims,	
igneous rocks -----	223-225	Utah -----	16
Jurassic rocks -----	220		
Kootenai formation -----	221-222	L.	
Madison limestone -----	218	Lee, Y. K.:	
map, geologic -----	216	work -----	143
Morrison formation -----	220-221	Lehner (coal) mine, Mont. -----	208
section, stratigraphic -----	221	Lewistown, Mont.:	
Quadrant formation -----	218-220	section, stratigraphic -----	58
fossils -----	219	Linley conglomerate:	
section, stratigraphic -----	219	Upper Stillwater Basin, Mont. --	203-204
section -----	216	Little Belt Mountains, Mont. -----	225
structure -----	225-228	Livingston formation (Mont.) -----	201-203
Humphreys Petroleum Co.'s (oil)		coal -----	202, 206-207
wells, Okla. -----	128-129	Lodge Creek, Mont.:	
Hundred and One (101) Ranch Co.'s		structure -----	80-81
(oil) wells, Okla. --	134, 136	Loffer (coal) mine, Mont. -----	207-208
		coal, analysis -----	210
I.		Lone Tree dome, Okla. -----	34
Illinois:		M.	
oil shale -----	314, 319	Madison limestone:	
Indiana:		Montana -----	218
New Albany shale -----	320-322	Margaret Primeaux (oil) well,	
oil shale -----	313-314, 319-322	Okla. -----	135-136
analyses -----	323	Mary Hess (oil) well, Okla.:	
supply -----	322	log -----	28
Iron Creek anticline, Wyo. -----	265-266		
section, structural -----	266		



Massey, J. N.:	Page.	Montana, north central—Contd.	Page.
work	143	Canada, correlation	61-62,
Matson, G. C.:			282, 290-291
work	94, 95	Colorado shale	53, 54,
Medicine Hat, Alberta:		56-58, 69, 88-91, 285, 287-289	
gas	75	map	64
analysis	75	Cretaceous rocks	53-54,
Meili fault, Mont.	70-71	56-60, 285-290	
Mid-Co Petroleum Co.'s (oil) well,		section, stratigraphic	64
Okla.	128-129, 133	drilling, recognition of forma-	
Midnight (ozokerite) claim, Utah	15	tions	60-61
Midwest Oil Co.'s (oil) wells, Wyo.	240,	Eagle sandstone	53, 58-59
	275-276	gas	68, 72-74, 287-290
Milk River, North Fork, Mont.:		geology	52-91, 285-303
anticline	299-300	glacial drift	60
Milk River anticline, Mont.	294-297	Havre field (q. v.)	66-76
Milk River valley, Mont.:		Kootenai formation	53, 54,
gas	75-76	55, 285, 286-287	
Miller (ozokerite) claim, Utah	15	map	64
Miller (James) ranch well, Mont.	90, 305	map, geologic	64
Mississippi:		maps	82, 88
anticlines	112-114	oil and gas	49-50,
correlation	115-116	63-64, 66-91, 287-290	
oil and gas	93-94, 112-120	map, geologic	64
section, stratigraphic	97	stratigraphy	52-60
structure	108-112	structure	63-66, 291-303
Vicksburg-Jackson area (q. v.)	93-120	Tertiary rocks	143-144, 285
Missouri River, Mont.:		Virgelle sandstone member	53, 54,
structure	84-85	58-59, 285, 289-290	
Monongahela Oil Co.'s (oil) well,		map	64
Wyo.	241, 245, 274	wells	303-305
Montana:		Morris, Colo.:	
Blackfeet Indian Reservation		Green River formation, section	182
(q. v.)	281-305	Morrison formation:	
coal	229, 231	Montana	220-221
Colorado shale	53-58,	section	221
69, 88-91, 222-		Wyoming	238, 244
223, 285, 287-289		oil	243
Cretaceous rocks	53-54,	Mowry shale (Wyo.)	238, 245
56-60, 201-203		oil	237, 238, 245-246
section, stratigraphic	64	Muddy sand (Wyo.)	238
Eagle sandstone	53, 58-59, 201-203	oil	237
Ellis formation	219		
fossils	219	N.	
geology	52-91, 200-205, 284-303	Neva anticline, Okla.	36
Havre field (q. v.)	66-76	Nevada:	
Hound Creek district (q. v.)	215-231	oil shale, analysis	161
igneous rocks	62, 204	distillation	152
Jurassic rocks	220	Neva limestone:	
Kootenai formation	53-55,	correlation	29-30
221-222, 285, 286-287		Foraker quadrangle, Okla.	23-24
Madison limestone	218	New Albany shale:	
Morrison formation	220-221	analysis	323
oil and gas	49-50,	eastern United States	312
63-64, 66-91, 213-214		Indiana	320-322
Quadrant formation	218-220	Niobrara formation (Wyo.)	238
structure	63-66, 205, 291-303	oil	237
Tertiary rocks	143-144, 203-204, 285	North Bird Creek anticline, Okla.	38-39
Upper Stillwater Basin (q. v.)	199-214	North Casper Creek anticline,	
See also Montana, north central.		Wyo.	274-275
Montana, north central	50-51	section, structural	274
Bearpaw Mountains	65-88	Northwestern Oil Co.'s (oil) well,	
Blackfeet Indian Reservation		Wyo.	239, 260
(q. v.)	281-305		

Nye, Mont.:	Page.	Oklahoma:	Page.
coal	147-149, 211-212	anticlines	33-40, 126-128
analyses	150	Billings (q. v.)	121-138
	O	Foraker quadrangle (q. v.)	17-47
Ohio:		oil and gas	45-47, 121, 129-132
oil shale	314-315, 319	Ozokerite:	
Ohio Oil Co.'s (oil) wells, Wyo.	240-241, 245, 253, 268	Galicia (Austria)	10
Oil. <i>See</i> Shale oil; Oil shale; Oil and gas.		imports	10-11
Oil and gas:		Utah, central (q. v.)	1-2, 4-16
accumulations	41-45	map	16
anticlines	126-128, 248-279		P.
Billings, Okla. (q. v.)	121-138	Pearl River, Miss.:	
Blackfeet Indian Reservation (q. v.)	281-282, 287-305	section, stratigraphic	104
Foraker quadrangle, Okla. (q. v.)	45-47	Peary sand (Wyo.)	238, 246
Montana, north central (q. v.)	49-50, 63-64, 66-91, map, geologic	oil	237, 246
sources. <i>See</i> Shale oil.	64	Pennsylvania:	
Upper Stillwater Basin, Mont.	213-214	oil shale	315-316, 319
Vicksburg-Jackson area, Miss. (q. v.)	93-120	Philip (T. E.) (coal) mine, Mont.	206
Wyoming, central (q. v.)	233-279	Piceance Creek, Colo.:	
<i>See also</i> Gas; Oil shale; Shale oil.		oil shale	165
Oil Mountain anticline, Wyo.	266-268	distillation	168
Oil shale	139-142, 147-191	sections	167, 177-178, 180-181
ammonium sulphate	151-154, 158-160	view	144
analyses	161, 322-324	Pikeville quadrangle, Tenn.:	
bibliography	191-198	coal	307-310
Colorado, northwestern (q. v.),	139-142, 147-190	Pine dome, Wyo.	268-269
distillation	141-142, 151-160, 318-320, 322	section, structural	267
by-products	142	Pine Dome Oil Co.'s (gas) well, Wyo.	243, 269
cost	322	Plain, Miss.:	
field apparatus	147-150	section, stratigraphic	104-105
view	148	Pleasant Valley (ozokerite) mine, Utah	15
methods	147-150	Pole Gulch, Colo.:	
results	151-161	Green River formation, section	181
gas	151-153	Ponca City field, Okla.:	
Indiana	313-314, 319	oil and gas	129
investigation	324	Potato Creek anticline, Okla.	38
Illinois	314, 319		Q.
Kentucky	314, 391	Quadrant formation:	
maps	In pocket	fossils	219
Nevada, distillation	152	Montana	218-220
Ohio	314-315, 319	section	219
oil	139-140, 151-158, 320-322		R.
fractionation	156-158	Rattlesnake anticline, Wyo.	258-261
Pennsylvania	315-316, 319	oil	243-248
sampling, views	147	sections, structural	257, 258
sections	167-168, 170-189	Red Eagle limestone:	
structure	189-191	Foraker quadrangle, Okla.	24-25
Tennessee	316-318, 319	section	24
Utah. <i>See</i> Utah, northeastern, Green River formation.		Red Rock Coulee, Mont.:	
views	144, 145, 146, 147, 149	structure	78
West Virginia	318, 319	Redwood, Boverton:	
Wyoming. <i>See</i> Wyoming, Green River formation.		on ozokerite	4, 10
<i>See also</i> Green River formation; Shale oil.		Reeside, J. B., jr.:	
		work	235
		Ripley formation:	
		oil and gas	116, 117
		Vicksburg-Jackson area, Miss.	117
		Robinson, H. M.:	
		Ozokerite in central Utah	1-16
		work	143

Rocky Mountains, Mont.:	Page.
structure-----	66
Rulison, Colo.:	
Green River formation, section--	182
S.	
Saddle Post Canyon, Utah:	
Green River formation, section--	184
St. Clair, Stuart:	
work-----	235
Schramm, E. F.:	
work-----	199
Scotland:	
oil-shale distillation-----	141
by-products-----	142, 159
Seidner, S. See Kast and Seidner.	
Selma chalk:	
Vicksburg-Jackson area, Miss--	117
Shale, black:	
analyses-----	322-324
distillation-----	318-320
eastern United States-----	311-327
oil-----	311, 320-322
Shale oil-----	141, 151-158
Colorado, northwestern	
(q. v.)-----	139-142, 147-168
fractionation-----	156-158
sources-----	141
supply (Indiana)-----	322
Utah, northeastern (q. v.)--	152, 161
Wyoming (q. v.)-----	152, 161
<i>See also</i> Oil shale.	
Shannon sandstone (Wyo.)-----	238
oil-----	237
Sheep Mountain anticline, Wyo--	250-251
section, structural-----	251
Signal Butte, Mont.:	
structure-----	76-77
Smith, C. D. See Taff and Smith.	
Soldier Summit (ozokerite) mine,	
Utah-----	13
South Fork anticline, Mont-----	297-298
Stanton, T. W.:	
on fossils from Montana-----	220
Stebinger, Eugene:	
Anticlines in Blackfeet Indian	
Reservation, Mont--	281-305
Oil and gas in north-central	
Montana-----	49-91
Steele shale (Wyo.)-----	238
oil-----	237
Stillwater Basin. See Upper Still-	
water Basin.	
Structural terraces-----	293, 301-302
Two Medicine Creek, Mont-----	301
Sundance formation (Wyo.)-----	238, 244
oil-----	243
Sweetgrass arch, Mont-----	64-65
Sweetgrass Hills, Mont.:	
oil and gas-----	88-89
section, stratigraphic-----	58, 89
Sweetwater anticline, Wyo-----	249-250

T.		Page.
Taff, J. A., and Smith, C. D.:		
on ozokerite-----	8, 11, 12, 13, 15	
Teapot sandstone member (Wyo.)--	238,	
-----	246-247	
oil-----	247	
Tennessee:		
oil shale-----	316-318, 319	
Pikeville quadrangle, coal---	307-310	
map-----	310	
Tensleep sandstone (Wyo.)-----	238	
oil-----	243	
Tertiary rocks:		
coal-----	203	
Upper Stillwater Basin, Mont--	203-204	
Thermopolis shale (Wyo.)-----	238	
oil-----	237	
Toltec Oil Co.'s (oil) well, Wyo---	242,	
-----	245, 271	
Torchlight sand (Wyo.)-----	238, 246	
oil-----	237, 246	
Town (ozokerite) mine, Utah-----	14-15	
Two Medicine Creek, Mont.:		
anticline-----	299	
structural terrace-----	301	

U.

Uta Basin, Colo., Utah:	
structure-----	189-190
U. S. (ozokerite) prospect, Utah---	12-13
Upper Stillwater Basin, Mont-----	199-200
coal-----	202, 205, 213
analyses-----	209-212
character-----	212
development-----	212-213
Cretaceous rocks-----	201-203
Eagle sandstone-----	201-203
coal-----	202, 207-209
analyses-----	210
Fort Union formation-----	213
coal-----	203, 205-206
geology-----	200-205
igneous rocks-----	204
Linley conglomerate-----	203-204
Livingston formation-----	201-203
coal-----	202, 206-207
map-----	200
map, geologic-----	202
oil-----	213-214
section, stratigraphic-----	201
structure-----	205
Tertiary rocks-----	203-204
Utah, central:	
fossils-----	3
geology-----	2-4
Green River formation-----	3-4
ozokerite-----	1-16
character-----	4-8
map-----	16
origin-----	9-10
production-----	11
tests-----	5-8
uses-----	11
Wasatch formation-----	3

	Page.		Page.
Utah, northeastern	144-146	West Virginia :	
gilsonite	190	oil shale	318, 319
Green River formation (oil shale), analysis	161	White, David :	
distillation	152	work	143
map	In pocket.	White Mountain, Wyo. :	
sections	183-186, in pocket.	Green River formation, section	188-189
views	144, 146	White River, Colo. :	
structure	189-190	Green River formation, sections	172-173, 178-179
		White River formation (Wyo.)	238, 247
		oil	237-238, 247-248
V.		Wilcox group :	
Vicksburg-Jackson area, Miss	93-96	Vicksburg-Jackson area, Miss	116
Catahoula sandstone	97, 105-106	Willow Creek, Mont. :	
sections	105, 106	anticline	300-301
Claiborne group	97, 98, 116	Wilson, W. B. :	
correlation	115-116	work	143
Eutaw formation	117	Winchester, D. E. :	
oil and gas	116, 117	Oil shale in northwestern Colorado, etc	139-198
faults	111-112	work	139-140, 319
geology	97-112	Wind River formation (Wyo.)	238, 247
Jackson formation	97, 98-101	oil	247
sections, stratigraphic	100	Wolf (H. F.) (oil) well, Okla.	137
map	In pocket.	Woodruff, E. G. :	
oil and gas	93-94, 112-120	on Fort Union formation	203
Ripley formation	117	work	139, 140, 142, 147, 166
oil and gas	116, 117	Wreford limestone :	
section, stratigraphic	97	Foraker quadrangle, Okla.	21-22
Selma chalk	117	section	22
structure	108-112	Wyoming, <i>See</i> Wyoming, central ;	
Vicksburg limestone	97, 101-105	Wyoming, northwestern.	
contour map	In pocket.	Wyoming, central	233-236
sections, stratigraphic	100-105	anticlines	248-279
Wilcox group	116	map	278
oil and gas	116	Aspen shale, oil	237
Vicksburg limestone :		Bear River formation, oil	237
Vicksburg-Jackson area, Miss	97, 101-105	Cambrian rocks, oil	242
contour map	In pocket.	Chugwater formation	243-244
sections	100-105	oil	237, 243
Vicksburg monocline, Miss	110-111	Cloverly sandstone, oil	237, 244
oil	114	Cretaceous rocks, oil	237-238
Virgelle, Mont. :		Dakota sandstone	244, 245
structure	82-83	oil	244
Virgelle sandstone member :		Embar formation	243
correlation	291	oil	238, 243
Montana	53, 54, 58-59, 289-291	Frontier formation	246
map	64	oil	237, 246
		geology	242-248
W.		Graneros shale, oil	237
Wallace Creek dome, Wyo	261-262	Kimball sand, oil	237
Wall Creek sandstone (Wyo.)	238, 246, 270	map	278
oil	237, 246, 257	Morrison formation	244
Wamsley Creek anticline, Okla.	37-38	oil	243
Wasatch formation :		Mowry shale	245
Utah	3	oil	237, 238, 245-246
Wyoming	238	Muddy sand, oil	237
oil	237	Niobrara formation, oil	237
Watchorn & Fortuna Oil Co.'s (oil) well, Okla.	129, 134	oil and gas	233-234, 236-279
Western States Oil Co.'s (oil) wells, Wyo	241, 253	history	239-242
West Rosebud Creek, Mont. :		oil-bearing rocks	242-248
coal	206	Peay sand	246
		oil	237, 246
		sections, structural	251, 252, 255-258, 263, 265-267, 271-274, 276

Wyoming, central—Continued.	Page.	Wyoming, central—Continued.	Page.
Shannon sandstone, oil.....	237	Wind River formation.....	247
Steele shale, oil.....	237	oil.....	247
Sundance formation.....	244	Wyoming, southwestern.....	146-147
oil.....	243	Green River formation (oil	
Teapot sandstone member....	246-247	shale).....	152, 161-162,
oil.....	247		168-169, 191
analyses.....	161	map.....	In pocket.
distillation.....	152, 169	sections.....	168-169, 186-189
Tensleep sandstone, oil.....	243	view.....	146
Thermopolis shale, oil.....	237	structure.....	191
Torchlight sand.....	246	Wyoming Central Association's (oil	
oil.....	237, 246	wells, Wyo.....	239, 260
Wall Creek sandstone.....	246, 270		
oil.....	237, 246, 257	Y.	
Wasatch formation, oil.....	237	Yazoo River, Miss.:	
water supply.....	235, 236	section, stratigraphic.....	101-102
White River formation.....	247	Yellow Creek, Colo.:	
oil.....	237-238, 247-248	section, structural.....	190



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