Geology and Oil-Shale Resources of Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah

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GEOLOGICAL SURVEY BULLETIN 1072-O

Prepared in cooperation with the Department of the Navy, Office of Naval Petroleum and Oil Shale Reserves

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By W. B. CASHION

CONTRIBUTIONS TO ECONOMIC GEOLOGY

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GEOLOGY AND OIL-SHALE RESOURCES OF NAVAL OIL-SHALE RESERVE NO. 2, UINTAH and CARBON COUNTIES, UTAH

By W. B. CASHION

ABSTRACT

Naval Oil-Shale Reserve No. 2 occupies an area of about 140 square miles on the south flank of the Uinta Basin in northeastern Utah. The area is characterized by flat-topped uplands and steep-walled canyons, with maximum relief in Desolation Canyon along Green River near the western boundary.

The rocks exposed are mainly sandstone, shale, and marlstone which were deposited near the southern margin of a great inland basin during the Eocene epoch of the Tertiary period. The coarse-grained sediments were deposited in a fluvial environment, and the fine-grained sediments in a lacustrine environment. The fluvial rocks comprise a lower formation, the Wasatch, and an upper formation, the Uinta, which are separated by the lacustrine rocks of the Green River formation.

The Green River formation is about 3,500 feet thick and includes most of the rocks exposed in the area. Three members of the Green River formation were mapped in the area. These are, in ascending order, the Douglas Creek, Parachute Creek, and Evacuation Creek members. The Douglas Creek member is a predominantly sandy unit with some interfingering fine-grained beds. The Parachute Creek member, which contains the principal oil-shale beds of the Green River formation, is composed mainly of marlstone and siltstone. The Evacuation Creek member is composed of marlstone and siltstone with numerous beds of sandstone in the upper 220 feet.

Only the basal part of the Uinta formation is exposed in the reserve. It is predominantly fluvial sandstone and siltstone.

The structure of most of the mapped area is a northward-dipping homocline. This homoclinal structure is broken in the southwestern part of the area by the eastern end of an eastward-plunging anticline and a small syncline. Most of the faulting is restricted to the vicinity of 2 parallel grabens, 12 miles apart, in the northeastern and southwestern parts of the mapped area. The Green River formation is cut by two well-developed vertical joint systems, one trending northeast and the other northwest.

There are two oil-shale zones of possible economic importance in Naval Oil-Shale Reserve No. 2. Both zones attain their maximum thickness and richness in the northeastern part of the area, and both zones decrease in

thickness and richness to the southwest. In an area of about 113 square miles, shale in a continuous sequence 15 feet or more thick that will yield an average of 15 gallons of oil per ton is estimated to contain 3.8 billion barrels of oil. In an area of less than 1 square mile in the northwestern part of the reserve the oil shale is considered potentially strippable.

Several wells drilled a few miles west of Naval Oil-Shale Reserve No. 2 found oil and gas in the Green River-Wasatch contact zone and in a lower zone within the Wasatch formation. Rocks at these horizons in the reserve should be similar lithologically. Production of oil and gas from strata of Mesozoic age elsewhere on the south flank of the Uinta Basin indicates that accumulations of oil and gas may be present in the strata of Mesozoic age underlying Naval Oil-Shale Reserve No. 2.

INTRODUCTION

LOCATION AND PHYSIOGRAPHY OF AREA

Naval Oil-Shale Reserve No. 2 is located in northeastern Utah (fig. 34) and includes about 132 square miles in Uintah County and about 8 square miles in Carbon County. It occupies a portion of the dissected tableland which lies on the south flank of the Uinta Basin, an east-west trending structural basin which extends across norheastern Utah into northwestern Colorado.

The usual access to the area is by an unsurfaced road which joins U.S. Highway 40 about 14 miles west of Vernal, Utah. This route leads southward through Ouray, Utah, and enters the reserve about 50 miles south of U.S. Highway 40. Much of the reserve can be traversed by 4-wheel drive vehicles, but detailed study of the area requires many foot traverses, owing to the steep-walled canyons.

The topography of the mapped area is characterized by flat-topped uplands and steep-walled canyons. Altitudes within the reserve range from about 4,600 feet on Green River at the west boundary to slightly over 7,050 feet near the center of the south boundary. The greatest relief occurs in the spectacular Desolation Canyon of the Green River, where some points along the rim tower more than 2,000 feet above the canyon floor less than a mile away.

Rainfall in the area is scant. During the 12-month period ending July 1, 1955, a precipitation storage station in the reserve received only 9.6 inches of moisture (U.S. Weather Bureau, 1955). This arid climate supports little vegetation. The most common plants are sagebrush and greasewood. A few junipers grow at the higher altitudes.

Although there are many stream valleys within the reserve, there are only two perennial streams, Hill Creek and. Green River. The only notable spring is one which rises in Tabyago

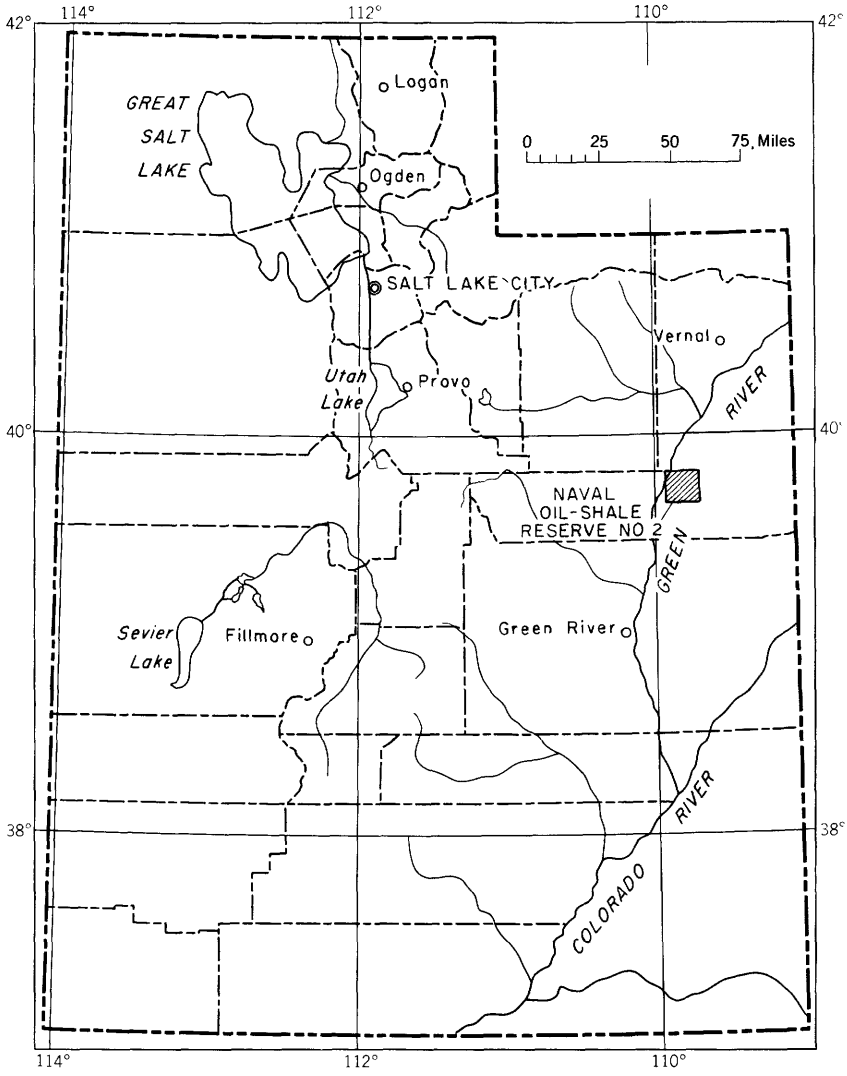

FIGURE 34.—Index map showing location of Naval Oil-Shale Reserve No. 2.

Canyon in sec. 12, T. 12 S., R. 18 E., and flows a short distance before percolating into alluvium. None of the water in the reserve is suitable for drinking.

PREVIOUS WORK

Reconnaissance studies of the oil-shale beds in and around Naval Oil-Shale Reserve No. 2 have been conducted several times during the past 45 years. The first of these studies was made in 1913 by Woodruff and Day (1914). In 1914-17, Winchester made a sur-

vey of the Green River formation in Colorado and in 1918 made a similar survey in Utah (Winchester, 1923). In 1922–25, W. H. Bradley (1931) studied the Green River formation in Colorado and Utah in considerable detail. None of these authors did detailed mapping in the reserve. In 1949 D. C. Duncan and J. R. Donnell made a reconnaissance survey of the reserve and this laid the groundwork for the detailed study which followed.

PURPOSE OF REPORT

The geologic investigation of Naval Oil-Shale Reserve No. 2 was sponsored by the Department of the Navy preliminary to a proposed core-drilling program. The twofold purpose of the investigation was to obtain data on the stratigraphic distribution, continuity, areal extent, oil content, and attitude of the oil-shale beds and on the thickness of over-burden above the oil-shale beds; and to study the oil and gas possibilities of the area.

FIELDWORK

A detailed geologic investigation of Naval Oil-Shale Reserve No. 2 was carried on during the summer and fall of 1953 and 1954 by a field party of the U.S. Geological Survey. Fieldwork was begun in 1953 by L. W. Camp, W. B. Cashion, and C. R. Lewis, assisted by H. J. Hyden, R. G. Miller, P. P. Orkild, and C. T. Sumsion, and completed in 1954 by L. W. Camp, W. B. Cashion, and J. R. Donnell, assisted by E. R. Landis and J. C. Benson. The project was under the general supervision of N. W. Bass and A. D. Zapp.

Geologic contacts were mapped on aerial photographs, and the geologic map (pl. 54) was later compiled on parts of the U.S. Geological Survey topographic maps of the Nutters Hole and Firewater Canyon quadrangles.

Ten detailed stratigraphic sections were measured through the part of the Green River formation containing oil shale. These sections, measured with hand level and 6-foot steel tape, were spaced along the outcrop at intervals of 3 to 5 miles. In each section key beds were identified and estimates made of the potential oil yield of the oil-shale beds. Where possible, the weathered surface rock was chipped away and pieces of the fresh rock examined. In much of the reserve, however, fresh samples could not be obtained from the outcrop because of deep weathering. Oil-yield estimates were based on the color, texture, luster, specific gravity, and weathering characteristics of the rock. The

many key beds identified on the outcrop, and later recognized in cores, enabled the geoloists to accurately predict the depth at which core holes would penetrate the oil-shale zones.

In gathering data for the structure-contour map, altitudes of key beds were determined with planetable and alidade. Distances were measured by stadia or by scaling on the topographic map or aerial photographs. To avoid possible introduction of serious error, the latter method was used only in conjunction with very small vertical angles.

CORE DRILLING

A core-drilling program, under two contracts, was carried out to obtain unweathered samples of the oil shale for assaying. A total of 18 core holes was drilled. Surface study had demonstrated that only the main oil-shale zone (see p. 764) was of possible interest for underground mining, and holes 1 to 11 were planned to evaluate this zone. Only the main oil-shale zone was cored in most of these holes. The second series of holes, numbers 12 to 18, was drilled to evaluate possible strip-mining areas as well as the main oil-shale zone; consequently the cored interval was extended to include a thin upper oil-shale zone. This zone lies above the main oil-shale zone and would, in some localities, be recoverable in opencut mining.

Light, truck-mounted, water-circulating rotary rigs were used by both contractors. In all coring operations, NX-diameter core barrels 10 feet in length were used. The percentage of core recovery was very high, and the only difficulty in drilling was loss of drilling water into the formation in a few of the holes.

All cores were split and logged in detail. One of the halves, except for the obviously barren portions, was crushed and quartered. Samples of the crushed material were assayed for oil yield by the U.S. Bureau of Mines Experiment Station in Laramie, Wyoming.

Lithologic logs of the cores are given in table 3; the results of assays are given in table 4; and the lithologic and assay data for each of the core holes are summarized graphically on plate 55.

STRATIGRAPHY

The sedimentary rocks exposed in and near Naval Oil-Shale Reserve No. 2 were laid down near the southern margin of a great inland basin that existed during the Eocene epoch of the Tertiary period. During the early part of Eocene time, large

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quantities of sand and silt were carried into the area by streams and deposited on flood plains. Near the middle of Eocene time, a great inland lake expanded over the area of the reserve. Rock debris brought into the lake from the south was sorted, with the coarser particles accumulating near the shore and the finer particles accumulating as mud in the deeper parts of the lake to the north. The lake was rich in plant and animal life, and the remains of dead organisms accumulated with the mineral sediment. In late Eocene time, the lake contracted, withdrawing from the area of the reserve, and flood-plain sedimentation was resumed.

The fluvial sediments, those that accumulated on flood plains, have been indurated to form sandstone and siltstone which are characteristically poorly sorted and irregularly bedded. The individual beds are lenticular and many are reddish. The lacustrine sediments, those that accumulated on the lake bottom, have formed marlstone, shale and oil shale which are remarkably well bedded and sorted. They are light to dark gray, and many of the individual finer grained beds can be traced over hundreds of square miles.

The early fluvial sedimentary rocks are generally referred to as the Wasatch formation, the lacustrine sedimentary rocks are referred to as the Green River formation, and the later fluvial beds are called the Uinta formation. The nature of the rock succession indicates that during the expansion and contraction of the lake a great many minor fluctuations occurred. These caused complex interbedding and interfingering of fluvial and lacustrine sediments, especially near the margins of the basin. Under such circumstances, selection of formation boundaries is difficult and somewhat arbitrary.

The base of the Green River formation in this area is the base of a series of oolitic limestone beds that comprise the lowest recognizable lacustrine rocks. By this definition, a considerable amount of interfingered poorly bedded sandstone and reddish siltstone resembling the Wasatch formation is included in the lower part of the Green River formation.

TERTIARY SYSTEM

GREEN RIVER FORMATION

The Green River formation is about 3,500 feet thick and includes most of the rocks exposed in Naval Oil-Shale Reserve No. 2. Approximately the lower two-thirds of the rocks in the formation is shallow-water lake deposits with interfingering fluvial

sediments. These rocks are predominantly sandstone and siltstone. The upper part of the formation consists largely of thin-bedded marlstone and shale. These two lithologic units were referred to by Bradley (1931, p. 15–16) as the "delta facies" and "upper shaly facies," respectively. At the boundary of the two facies is a transitional zone in which the two facies are interbedded and in which the amount of sand and silt increases southward toward the source of the sediment. In the reserve this transitional zone ranges in thickness from about 120 feet to about 180 feet. The important oil-shale beds occur within this transitional zone. The thickest, most persistent, and richest of these oil-shale beds is the Mahogany oil-shale bed. The presence of this bed and of a persistent bed of sandstone, the Horse Bench sandstone bed, near the middle of the "upper shaly facies," make it possible to divide the Green River formation into three members for detailed mapping.

The boundaries of members of the Green River formation in and near the reserve are arbitrary boundaries that separate gross lithologies rather than abrupt changes in lithologic character. Three member names used by Bradley (1931, p. 9–15) in describing the Green River formation in the eastern part of the Uinta Basin are extended into the area of this report. These members are, in ascending order, the Douglas Creek, Parachute Creek, and Evacuation Creek.

The lower and upper boundaries of the Parachute Creek member of this report were selected on the basis of mappability, and they differ somewhat in stratigraphic position from the boundaries as originally determined by Bradley (1931, pl. 8) in the eastern Uinta Basin and more recently by Dane (1955) in the area west of the Green River.

The base of the Parachute Creek member must rise in stratigraphic position southwestward from the eastern part of the Uinta Basin, because sandstone beds of the Douglas Creek appear in progressively higher stratigraphic position. Such sandstone occurs above the base of the Parachute Creek member in the vicinity of Naval Oil-Shale Reserve No. 2, but the base of the member in that area is at the base of the Mahogany oil-shale bed because, by definition (Bradley, 1931, p. 11), the Parachute Creek member contains the principal oil-shale beds of the sequence.

The upper boundary of the Parachute Creek member as determined by Bradley (1931, pl. 8) in the eastern Uinta Basin was found to be poorly suited for mapping and was redetermined by the writer (Cashion, 1956) at a readily mappable color change

about 300 feet stratigraphically higher. Southwestward this color change corresponds closely to the base of the Horse Bench sandstone bed (Cashion, 1956). This horizon is readily traceable as the top of the member westward to and beyond the Green River. In the reserve the upper part of the Parachute Creek member and the lower part of the Evacuation Creek member consist chiefly of gray slope-forming marlstone and contain thin beds of oil shale. The one outstanding break in this stratigraphic sequence is the cliff formed by the brown resistant beds of the Horse Bench sandstone. The upper boundary of the Parachute Creek member as selected by Dane (1955) in the area west of the Green River is more than 150 feet below the base of the Horse Bench sandstone bed.

The contact between the Evacuation Creek member and the overlying Uinta formation is at the base of a massive brown sandstone which is the lowermost unit in a sequence of brown and red cliff-forming sandstone that is interbedded with red and gray shale.

DOUGLAS CREEK MEMBER

The Douglas Creek member of the Green River formation underlies all of the reserve but is exposed only in the deeper canyons, where it forms rugged cliffs and steep slopes. It is composed mainly of brown, gray, and red sandstone and siltstone, green and gray shale, and brown and gray oolitic limestone beds. Numerous beds of marlstone and oil shale occur in the upper 70 feet. The upper 1,220 feet of the Douglas Creek member is exposed in the southwestern part of Naval Oil-Shale Reserve No. 2 (pl. 56); data from nearby wells indicate a total thickness of about 2,500 feet in this area. The member conformably overlies and intertongues with the Wasatch formation and is conformably overlain by the Parachute Creek member of the Green River formation.

PARACHUTE CREEK MEMBER

The Parachute Creek member of the Green River formation underlies about three-fourths of the reserve and is exposed along all major stream valleys. Where it crops out, it weathers to steep slopes and cliffs. The member, which is composed mainly of gray and brown marlstone and siltstone and brown sandstone, contains the principal oil-shale beds of the Green River formation. Its thickness ranges from 380 feet in the southeastern part to 500 feet just northwest of the reserve.

The contact between the Douglas Creek member and the overlying Parachute Creek member is at the base of the Mahogany bed, an extensive oil-shale bed, 5 to 10 feet thick. The contact between the Parachute Creek member and the overlying Evacuation Creek member is at the base of the Horse Bench sandstone bed.

Within the reserve the Parachute Creek member can be divided into 5 persistent units which are, in ascending order, a basal oil-shale zone, 8 to 17 feet thick; a unit of marlstone and siltstone, 30 to 80 feet thick, which contains little organic matter; an upper oil-shale zone, 5 to 15 feet thick; a unit of ledge-forming sandstone and siltstone, 10 to 50 feet thick; and a unit of marlstone and siltstone, 330 to 400 feet thick, containing a few thin beds of oil shale.

In the southwest half of the reserve, lenticular sandstone bodies occur locally in the basal part of the Parachute Creek member (fig. 35). These sandstone bodies range from a few tens of feet to a few hundred feet in width and have a maximum thickness of about 50 feet. The lengths and orientations of these bodies could not be determined by surface study. No evidence of erosion at the base of these sandstone bodies was observed so they probably do not represent channel fills. Stratigraphic discordances, particularly in the main oil-shale zone, are associated with many of these sandstone bodies. Many minor downwarps, probably due to differential compaction, are found in the oil-shale beds below the sandstone lenses. At several localities the main oil-shale bed overlaps itself for a distance of a few hundred feet with no visible evidence of faulting in the intervening strata.

EVACUATION CREEK MEMBER

The Evacuation Creek member of the Green River formation is represented in much of the reserve by only the basal sandstone unit, the Horse Bench sandstone bed. This sandstone bed is a brown resistant ledge-forming unit which caps prominent, sharply defined buttes and mesas in much of the area. The mesa tops are low-angle dip slopes.

The entire Evacuation Creek sequence is present only in the northeast corner of the reserve, where it weathers to gray slopes and minor ledges. A detailed stratigraphic section totaling 540 feet in thickness was measured through the Evacuation Creek member just east of the reserve. The upper 220 feet, which contains many more sandstone beds than does the lower 320 feet,

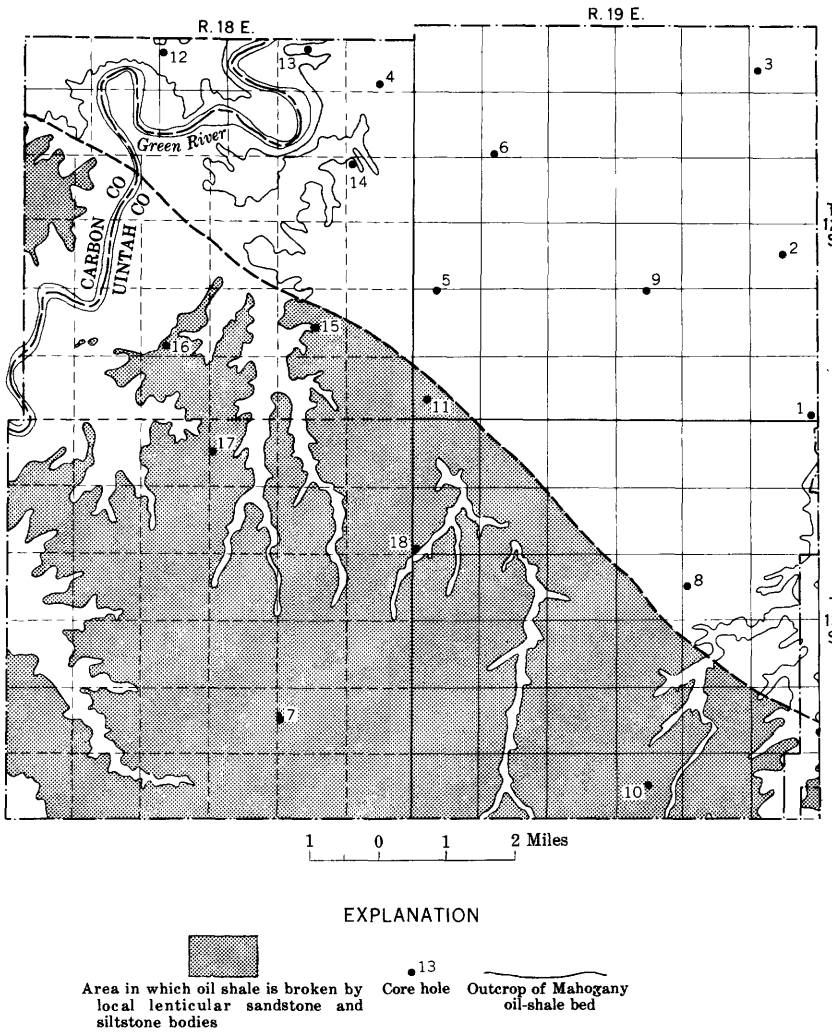

FIGURE 35.—Map showing area in which the continuity of the rich oil-shale beds is broken by local large lenticular bodies of sandstone and siltstone.

is predominantly brown, whereas the lower unit is predominantly light gray and is composed of marlstone. The upper sandy unit is a transition zone between Green River and Uinta lithologies, but it more closely resembles the Green River.

UINTA FORMATION

Only the basal part of the Uinta formation is present in Naval Oil-Shale Reserve No. 2, in a small area at the east edge of sec. 1, T. 12 S., R. 19 E., where it weathers to brown and red cliffs.

The Uinta formation is fluvial in origin and is composed mainly of brown and red sandstone and siltstone. The sandstone beds are massive, poorly sorted, and poorly bedded. The formation conformably overlies and interfingers with the Evacuation Creek member of the Green River formation.

STRUCTURE

Naval Oil-Shale Reserve No. 2 is on the gently dipping south flank of the Uinta Basin. Within the reserve, the rocks dip northward at an inclination of about 125 feet per mile (pl. 54). The only variation in this gentle northward dip is in the southwest part of the area, where an eastward-plunging anticline and an eastward-plunging syncline break the homoclinal structure (pl. 54).

Relatively few faults were observed in the reserve, and the fault pattern is very simple. The faults are essentially vertical and have a northwest trend. Most of the faults are associated with 2 parallel grabens about 12 miles apart. The maximum displacement observed on any of the faults is 50 feet, and surface studies in canyon walls indicate that the displacement decreases downward.

Two well-developed vertical joint systems are present in the Green River formation. One system trends northwest, the other northeast. They are most evident in the Parachute Creek and Evacuation Creek members of the Green River formation, where stream channels have developed along the joints.

ECONOMIC GEOLOGY

OIL SHALE

Oil shale has been defined in various ways (Bradley, 1931, p. 7). For the purposes of this report, however, oil shale is defined as shale or marlstone which, when distilled, will yield approximately 15 or more gallons of oil per ton. This is a useful definition in view of present oil-shale technology.

All beds of oil shale in the Green River formation are magnesian marlstone with a high content of organic matter. The physical and mineralogic characteristics of the oil shale has been described by Bradley (1931, p. 22–32).

The color of the unweathered oil shale ranges from tan through gray to dark gray, depending on the amount of organic matter in the rock. The greater the organic matter present, the darker is the color of the rock. Weathered oil shale rich in or-

ganic matter is blue gray, but oil shale with a small amount of organic matter weathers light gray or brown. Oil-shale beds that are rich in organic matter are much more resistant to erosion than marlstone beds. Because of their color and because they form ledges, oil-shale beds make conspicuous outcrops.

OIL-SHALE ZONES

Two oil-shale zones of possible economic importance occur in Naval Oil-Shale Reserve No. 2. The main oil-shale zone consists of the Mahogany bed and associated oil shale in the basal part of the Parachute Creek member and the uppermost part of the Douglas Creek member. This zone ranges from 20 to 45 feet in thickness in the reserve. In most of the reserve an upper oil-shale zone, generally 5 to 15 feet thick, is present 30 to 80 feet above the main zone. Studies of cores and outcrops show that both zones attain their maximum thickness and richness in the northeastern part of the reserve; to the southwest the main zone decreases in thickness and potential oil yield (pl. 57, fig. 39), and the upper oil-shale zone disappears entirely.

The decrease in thickness and potential oil yield of the oil-shale zones in a southwest direction is apparently due to progressively greater dilution of the organic matter by clastic sediment toward the shore of the ancient lake (see p. 757). This dilution was not uniform and this variation is believed to account for some of the marked irregularities in the thickness and richness of the oil-shale zones (figs. 36–39). It is probable that more extensive core drilling would reveal a more complex pattern of irregularities. In the southwestern part of the reserve there are many abrupt changes in the quality of the main oil-shale zone due to the presence locally of large bodies of sandstone or siltstone (fig. 35).

POTENTIAL RESERVES OF OIL SHALE

As yet oil shale has not been developed commercially on a large scale in the United States; therefore, it is not possible to define accurately potential oil-shale reserves in terms of minimum thickness and minimum potential oil yield. Research in mining and retorting techniques by the U.S. Bureau of Mines at an experimental mine and plant near Rifle, Colo., indicates that a minimum thickness of 25 feet and a minimum oil yield of 25 gallons per ton are necessary for development with present techniques. In Naval Oil-Shale Reserve No. 2, only a relatively small

area, in the northeastern part (fig. 37), is underlain by oil shale that meets these requirements. This area includes 16,757 acres and contains an estimated 1,417 million tons of oil shale with a potential yield of 843 million barrels of oil. What part of this potential supply would be recoverable is not known. The oil shale in this area is more deeply buried than elsewhere in the reserve; the overburden is as much as 950 feet thick.

Inasmuch as continued development in oil-shale technology may considerably broaden the thickness and oil-yield specifications for exploitable oil shale, the resources of Naval Oil-Shale Reserve No. 2 have been appraised for all deposits exceeding 15 feet in thickness and 15 gallons per ton in potential oil yield. The estimates are divided into four categories: (1) shale in and adjacent to the Mahogany oil-shale bed that yields an average of 30 gallons of oil per ton from a continuous sequence 15 feet or more thick (fig. 36, table 1); (2) shale in and adjacent to the Mahogany oil-shale bed that yields an average of 25 gallons of oil per ton from a continuous sequence 15 feet or more thick (fig. 37, table 1); (3) shale in and adjacent to the Mahogany oil-shale bed that yields an average of 15 gallons of oil per ton from a continuous sequence 15 feet or more thick (fig. 38, table 1); and (4) shale in a continuous 25-foot thick sequence which has the highest potential oil yield (fig. 39, table 2). All the estimates are for oil shale in place; no allowances were made for losses in mining or processing.

The thickness maps (figs. 36–39) and the estimates of total potential oil yield (tables 1, 2) are based on the results of assays of core and stratigraphic studies. The oil yields of all core samples were determined by the modified Fischer retort method. The specific gravity of rocks in an oil-shale sequence decreases from 2.74 for marlstone yielding 1 gallon of oil per ton to 1.5 for oil shale yielding 90 gallons of oil per ton (Stanfield and others, 1954, p. 5–6). The specific gravity of each sampled bed was taken into account in estimating tonnage and oil content of the shale.

The estimates are intended only for a general appraisal of the oil-shale resources of the reserve. Mining should be preceded by much more extensive subsurface sampling because, as pointed out previously, unpredictable changes in thickness and grade of the oil shale are probably numerous.

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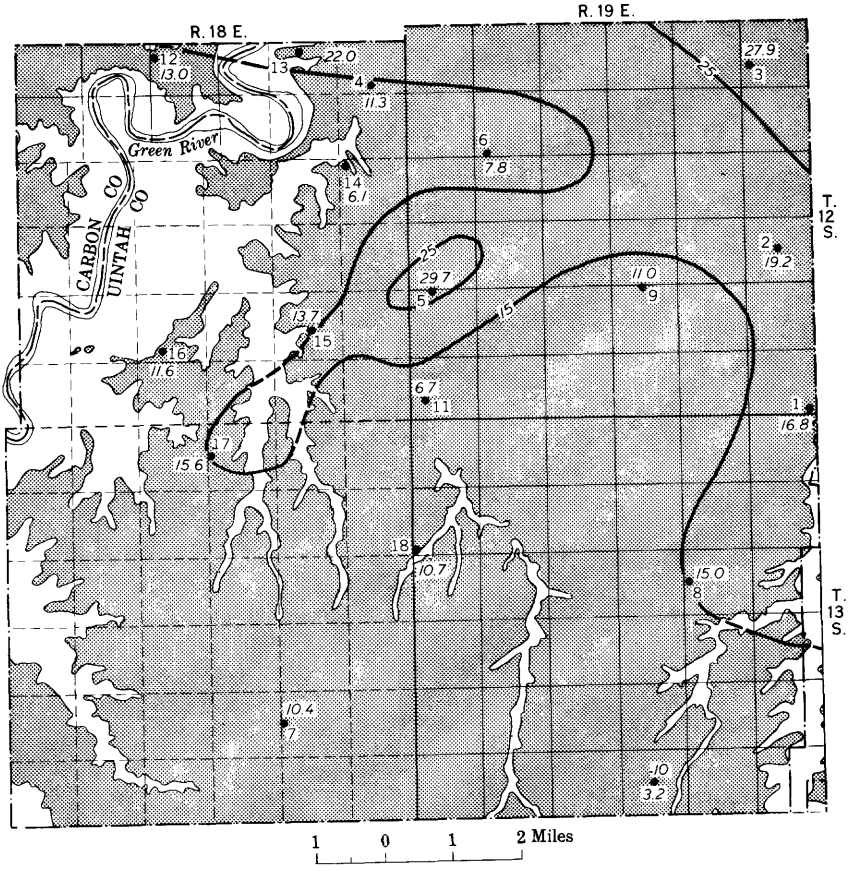

FIGURE 36.—Map showing thickness of oil shale that yields an average of 30 gallons of oil per ton.

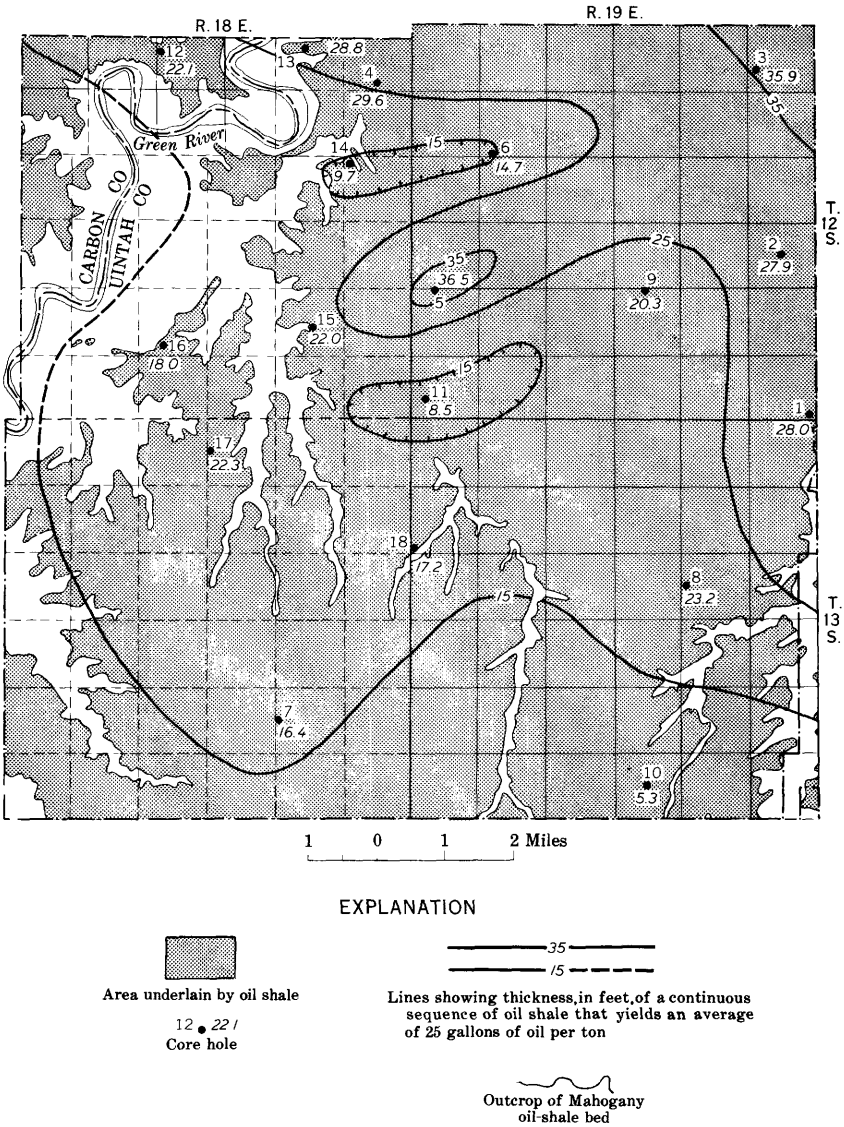

FIGURE 37.—Map showing thickness of oil shale that yields an average of 25 gallons of oil per ton.

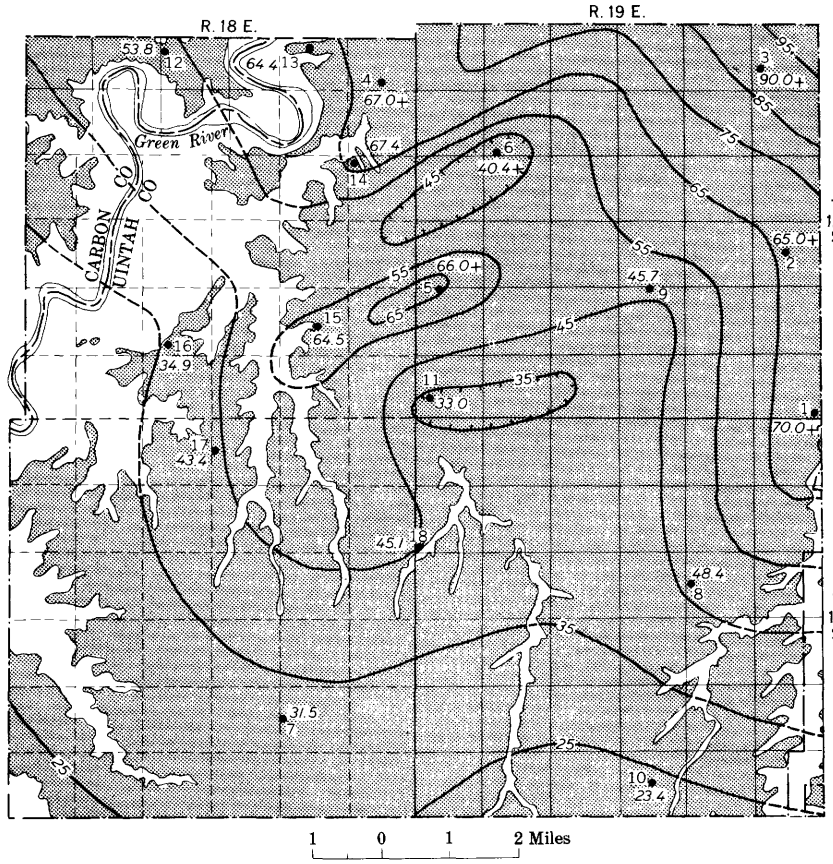

FIGURE 38.—Map showing thickness of oil shale that yields an average of 15 gallons of oil per ton.

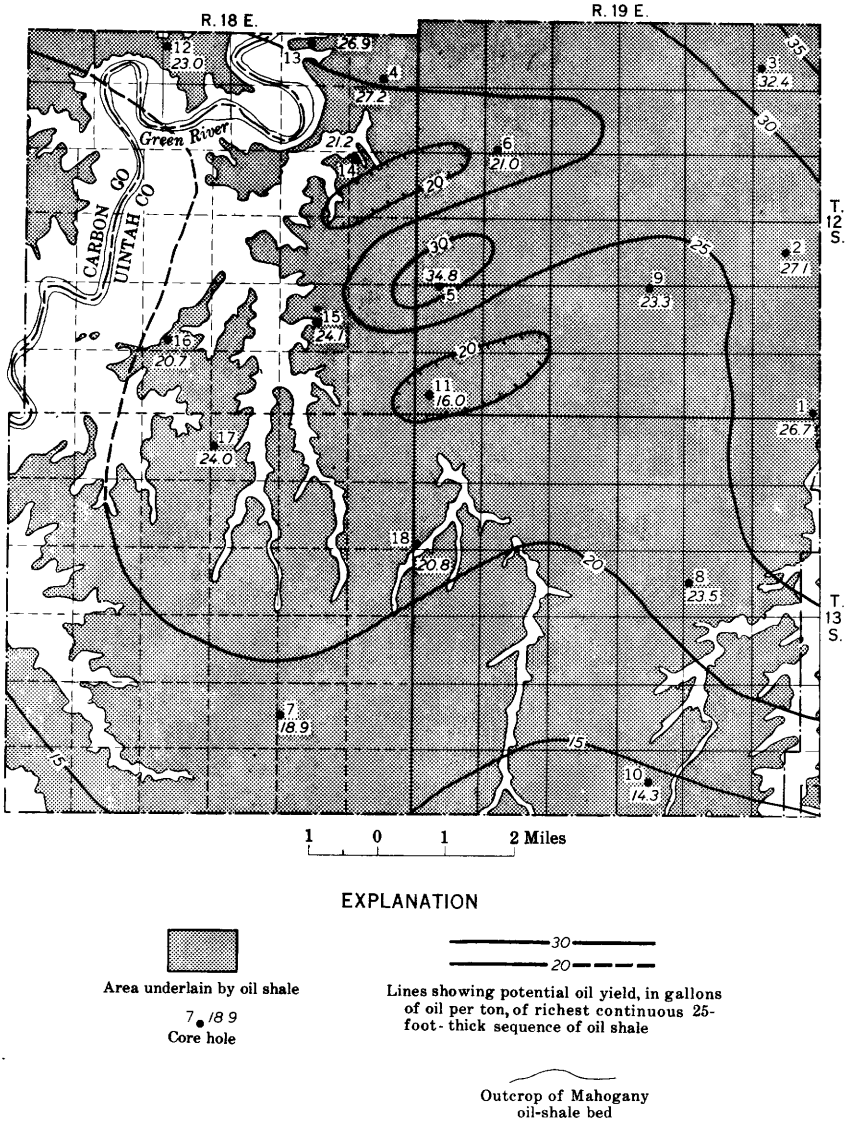

FIGURE 39.—Map showing potential oil yield of richest continuous 25-foot sequence of oil shale.

TABLE 1.—*Estimated tonnage and potential oil yield of a continuous sequence 15-feet or more thick of oil shale in and adjacent to the Mahogany oil-shale bed, Naval Oil-Shale Reserve No. 2, Utah*

[No allowances made for losses in mining or processing]

Location	Acres	Average thickness (feet)	Tonnage		Potential oil yield	
			Average per acre (tons)	Total (millions of tons)	Average per acre (barrels)	Total (millions of barrels)
30 gallons of oil per ton (see fig. 36)						
T. 12 S., R. 18 E....	2,475	18	52,500	130	37,600	93
T. 12 S., R. 19 E....	14,288	20	58,200	832	41,600	594
T. 13 S., R. 18 E....	456	17	49,400	23	35,200	16
T. 13 S., R. 19 E....	2,980	17	49,400	147	35,200	105
Total.....	20,199	.....	.....	1,132	.....	808
25 gallons of oil per ton (see fig. 37)[1]						
T. 12 S., R. 18 E....	7,680	22	64,400	510	39,600	304
T. 12 S., R. 19 E....	21,361	24	72,500	1,549	43,100	921
T. 13 S., R. 18 E....	12,456	18	54,400	678	32,400	404
T. 13 S., R. 19 E....	11,585	19	57,400	665	34,200	396
Total.....	53,082	.....	.....	3,402	.....	2,025
15 gallons of oil per ton (see fig. 38)[2]						
T. 12 S., R. 18 E....	9,870	50	162,000	1,599	57,900	571
T. 12 S., R. 19 E....	22,811	59	191,200	4,361	68,300	1,558
T. 13 S., R. 18 E....	19,096	33	106,900	2,041	38,200	729
T. 13 S., R. 19 E....	20,369	40	129,600	2,640	46,300	943
Total.....	72,146	.....	.....	10,641	.....	3,801

[1] Includes oil shale that yields 30 gallons of oil per ton.
[2] Includes oil shale that yields 30 gallons of oil per ton and oil shale that yields 25 gallons of oil per ton.

TABLE 2.—*Estimated tonnage and potential oil yield of the richest continuous 25-foot-thick sequence of oil-shale in Naval Oil-Shale Reserve No. 2*

[No allowances made for losses in mining or processing]

Location (see fig. 39)	Acres	Average thickness (feet)	Tonnage		Potential oil yield	
			Average per acre (tons)	Total (millions of tons)	Average per acre (barrels)	Total (million) of barrels)
T. 12 S., R. 18 E....	9,870	23	76,500	755	41,800	413
T. 12 S., R. 19 E....	22,811	27	74,500	1,699	47,900	1,093
T. 13 S., R. 18 E....	18,536	19	78,600	1,457	35,500	658
T. 13 S., R. 19 E....	18,332	21	77,500	1,421	38,800	711
Total.....	69,549	.....	.....	5,332	.....	2,875

TABLE 3.—*Lithologic logs of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*

Depth to top of unit (feet)	Thickness (feet)	Description	Depth to top of unit (feet)	Thickness (feet)	Description
Core hole 1; SE¼SE¼ sec. 36, T. 12 S., R. 19 E.; ground elev 5,658 ft					
61.0	5.0	Marlstone, gray and brown; lower half is silty.	87.3	6.0	Marlstone, tan, with chert stringers 2–10mm thick.
66.0	.1	Tuff, yellow-brown.	93.3	6.2	Oil shale, dark-gray.
66.1	4.2	Marlstone, gray.	99.5	1.9	Marlstone, tan.
70.3	.4	Tuff, tan.	101.4	1.9	Oil shale, dark-gray.
70.8	2.7	Marlstone, gray.	103.3	7.0	Marlstone, gray and tan.
73.5	1.8	Oil shale, dark-gray.	110.3	6.2	Oil shale, dark-gray.
75.3	3.9	Marlstone, gray.	116.5	9.9	Marlstone, tan and brown, varved; upper 1.5 feet is silty
79.2	8.1	Oil shale, dark-gray.			
Core hole 2; SE¼NW¼ sec. 24, T. 12 S., R. 19 E.; ground elev 5,546 ft					
268.4	5.0	Oil shale, dark-gray.	294.0	4.1	Marlstone, tan.
273.4	.5	Oil shale, dark-gray, with thin black contorted shiny bedding planes (gilsonite?).	298.1	1.0	Oil shale, dark-gray.
			299.1	7.1	Marlstone, tan.
			306.2	1.6	Oil shale, dark-gray.
			307.8	.9	Marlstone, light-brown.
273.9	.2	Clay, tan, soft.	308.7	2.4	Oil Shale, dark-gray.
274.1	2.1	Oil shale, dark-gray, with detrital material in bedding planes.	311.1	.4	Sandstone, asphaltic, with gilsonite stringers at top and bottom.
276.2	17.8	Oil shale, dark-gray.	311.5	2.5	Oil shale, dark-gray.
			314.0	2.2	Marlstone, light-brown.
Core hole 3; NW¼SW¼ sec. 1, T. 12 S., R. 19 E.; ground elev 5,410 ft					
480.0	5.0	Oil shale, with tuff stringers at top.	516.9	7.9	Oil shale, dark-gray.
			524.8	.1	Tuff, oil-stained.
485.0	5.0	Marlstone, brown.	524.9	4.4	Oil shale, dark-gray.
490.0	6.5	Marlstone, tan.	529.3	11.1	Marlstone, gray and tan.
496.5	.3	Tuff, bleeding oil.	540.4	6.3	Oil shale, dark-gray.
496.8	5.9	Marlstone, tan, with thin tuff stringer at base.	546.7	2.9	Marlstone, tan.
			549.6	1.1	Oil shale, dark-gray.
502.7	1.4	Marlstone, tan.	550.7	.9	Marlstone, tan.
504.1	12.7	Oil shale, with thin tuff stringers.	551.6	.1	Tuff stringers.
			551.7	5.3	Marlstone and limestone in alternating stringers and laminae.
516.8	.1	Tuff, oil-stained, undulatory contacts.			
Core hole 4; SW¼SE¼ sec. 1, T. 12 S., R. 18 E. (unseurveyed); ground elev 5,106 ft					
88.8	2.4	Limestone, tan and gray, with marlstone stringers.	118.5	0.1	Tuff stringer.
			118.6	.6	Oil shale, dark-gray.
91.2	6.4	Marlstone, brownish-gray.	119.2	.3	Sandstone, gray-brown, tuffaceous.
97.6	.3	Tuff, tan.			
97.9	5.1	Marlstone, tan and gray.	119.5	4.2	Oil shale, dark-gray.
103.0	7.9	Oil shale, dark-gray.	123.7	1.1	Oil shale, dark-gray, with tuff stringers.
110.9	1.9	Marlstone, tan.			
112.8	5.7	Oil shale, dark-gray.	124.8	5.6	Oil shale, dark-gray.
			130.4	.4	Marlstone, brown.
Core hole 5; NE¼NW¼ sec. 30, T. 12 S., R. 19 E.; ground elev 5.556 ft					
105.0	6.5	Siltstone, blue-gray, limy.	135.9	4.9	Oil shale, dark-gray.
111.5	3.5	Marlstone, brown, silty.	140.8	.3	Oil shale, dark-gray, with tuff stringers.
115.0	1.8	Marlstone, brown.			
116.8	13.7	Oil shale, dark-gray.	141.1	1.8	Oil shale, dark-gray.
130.5	.1	Tuff, oil-stained.	142.9	2.9	Marlstone, brown.
130.6	.4	Oil shale, with tuff stringer at top.	145.8	3.0	Oil shale, dark-gray.
			148.8	.4	Oil shale with stringers of tuff.
131.0	1.7	Marlstone, brown.			
132.7	1.5	Oil shale, dark-gray.	149.2	.9	Marlstone brown.
134.2	1.7	Marlstone, brown.			

TABLE 3.—*Lithologic logs of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*—Continued

Depth to top of unit (feet)	Thickness (feet)	Description	Depth to top of unit (feet)	Thickness (feet)	Description
Core hole 6; SW¼SW¼ sec. 8, T. 12 S., R. 19 E.; ground elev 5,367 ft					
145.0	0.9	Limestone, tan, sandy.	227.7	0.6	Oil shale, dark gray.
145.9	2.6	Marlstone, tan.	228.3	.1	Oil shale, with tuff stringers.
148.5	4.0	Sandstone, very fine to medium-grained, calcareous, oil stained.	228.4	9.5	Oil Shale, dark-gray.
152.5	35.9	Siltstone, gray and brown, limy; basal part contains beds of marlstone.	237.9	.1	Tuff, tan, contorted contacts.
188.4	5.1	Marlstone, tan.	238.0	2.1	Oil shale, dark-gray.
193.5	.7	Oil shale, dark-gray.	240.1	.5	Tuff, gray.
194.2	4.0	Marlstone, tan, with oil-stained tuff stringers.	240.6	3.9	Oil shale, dark-gray.
198.2	.4	Marlstone, tan.	244.5	3.5	Marlstone, brown.
198.6	4.7	Oil shale, dark-gray, with tuff stringers near center.	248.0	1.4	Oil shale, dark-gray.
203.3	13.0	Marlstone, brown, silty.	249.4	.8	Tuff, gray.
216.3	.4	Tuff, bleeding oil.	250.2	2.3	Marlstone, tan.
216.7	8.7	Marlstone, brown, silty.	252.5	2.3	Oil shale, dark-gray, with tuff stringers.
225.4	2.3	Marlstone, brown.	254.8	7.3	Marlstone, gray and brown, containing several tuff stringers.
			262.1	4.5	Marlstone, tan.
Core hole 7; NW¼SW¼ sec. 26, T. 13 S., R. 18 E. (unsurveyed); ground elev 6,881 ft					
390.0	60.3	Sandstone, fine-to medium-grained, limy, and interbedded blue-gray marlstone.	469.2	0.7	Limestone, tan, with contorted bedding at base.
450.3	2.9	Marlstone, tan.	469.9	1.4	Marlstone, tan, containing contorted tuff bed.
453.2	3.2	Oil shale, dark-gray.	471.3	1.1	Oil shale, dark-gray.
456.4	.9	Lost core.	472.4	.6	Conglomerate, with pebbles of marlstone.
457.3	6.8	Oil shale, dark-gray.	473.0	3.1	Marlstone, tan.
464.1	.1	Tuff, tan.	476.1	.3	Oolite.
464.2	.9	Marlstone, tan.	476.4	2.4	Sandstone, light-gray, fine-grained.
465.1	3.6	Oil shale.			
468.7	.5	Marlstone, tan.			
Core hole 8; SW¼NW¼sec. 14, T. 13 S., R. 19 E.; ground elev 6,247 ft					
130.0	26.0	Siltstone and marlstone, interbedded.	167.8	7.9	Oil shale, dark-gray, with brown contorted tuff stringer at base.
156.0	2.0	Oil shale, dark-gray.	175.7	1.0	Marlstone, brown.
158.0	2.6	Marlstone, dark-brown, with 0.2 in. tuff bed.	176.7	1.5	Oil shale, dark-gray.
160.6	7.2	Oil shale, dark-gray, with tuff bed 0.1 ft thick at base.	178.2	2.7	Marlstone, tan.
			180.9	2.3	Oil shale, dark-gray.
			183.2	.1	Tuff, tan.
			183.3	6.1	Oil shale, dark-gray.
			189.4	2.2	Marlstone, tan.
Core hole 9; NE¼NW¼ sec. 27, T. 12 S., R. 19 E.; ground elev 5,887 ft					
475.0	4.2	Oil shale, dark-gray.	523.0	2.9	Marlstone, tan.
479.2	15.4	Marlstone, brown.	525.9	10.1	Oil shale, dark-gray.
494.6	.3	Tuff, tan.	536.0	2.6	Marlstone, tan.
494.9	15.0	Marlstone, brown.	538.6	2.1	Oil shale, dark-gray, with tuff 0.1 ft thick near middle.
509.9	4.1	Oil shale, dark-gray.			
514.0	1.9	Marlstone, tan.			
515.9	6.9	Oil shale, dark-gray.	540.7	5.4	Marlstone, gray and brown.
522.8	.2	Tuff(?).			

TABLE 3.—*Lithologic logs of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*—Continued

Depth to top of unit (feet)	Thickness (feet)	Description	Depth to top of unit (feet)	Thickness (feet)	Description
Core hole 10; SE¼NW¼ sec. 34, T. 13 S., R. 19 E.; ground elev 6,763 ft					
125.0	23.0	Sandstone, gray, fine-grained, and interbedded gray limy siltstone.	163.4	4.6	Marlstone, brown and gray.
			168.0	2.2	Oil shale, dark-gray.
			170.2	2.5	Marlstone, brown.
148.0	2.9	Marlstone, gray and brown.	172.7	9.9	Sandstone, asphaltic, gray, medium-grained, and interbedded gray, limy siltstone.
150.9	2.0	Oil shale, dark-gray.			
152.9	4.1	Marlstone, brown.			
157.0	6.4	Oil shale, dark-gray.			
Core hole 11; NW¼SW¼ sec. 31, T. 12 S., R. 19 E.; ground elev 5,871 ft					
97.0	14.0	Marlstone, gray and brown.	133.9	1.8	Siltstone, gray, sandy, with oil-shale stringers; bleeding small amount of oil 0.6 ft below top.
111.0	1.4	Lost core.			
112.4	1.2	Marlstone, brown, with some pyrite stringers.	135.7	2.7	Oil shale, dark-brown, with stringers of gray tuff.
113.6	.2	Tuff, yellow-brown.	138.4	.1	Tuff, yellow-brown.
113.8	4.9	Oil shale, dark-gray and brown, with limestone stringers.	138.5	2.5	Oil shale, dark-brown, with stringers of gray tuff.
118.7	7.3	Marlstone, gray and brown.	141.0	3.9	Siltstone, gray, with thin tuff beds.
126.0	.8	Siltstone, gray, limy.			
126.8	5.2	Oil shale, dark-gray and brown.	144.9	1.0	Marlstone, gray and brown.
132.0	1.2	Siltstone, gray, tuffaceous.	145.9	.5	Siltstone, gray, tuffaceous.
133.2	.7	Oil shale, brown, bedding contorted.	146.4	4.1	Marlstone, gray, tuffaceous; silty at base.
Core hole 12; SW¼NW¼ sec. 4, T. 12 S., R. 18 E.; ground elev 5,180 ft					
10.0	9.0	Siltstone, gray, limy, micaceous.	134.8	.1	Tuff, yellow-brown.
			134.9	2.1	Oil shale, brown.
19.0	1.0	Sandstone, gray, fine-grained, limy.	137.0	.1	Tuff, yellow-brown.
			137.1	1.5	Oil shale, brown.
20.0	3.3	Siltstone, gray, limy, micaceous.	138.6	1.0	Marlstone, brown, silty.
			139.6	3.2	Marlstone, gray and brown.
23.3	.3	Tuff, yellow-brown, micaceous.	142.8	.9	Oil shale, dark-gray.
23.6	31.3	Siltstone, gray, limy, micaceous.	143.7	1.8	Marlstone, gray and brown, silty.
54.9	5.9	Marlstone, gray; upper half is silty.	145.5	3.3	Siltstone, gray and brown, cherty.
60.8	.7	Oil shale, dark-gray.	148.8	3.4	Marlstone, gray and brown.
61.5	.9	Marlstone, gray, silty.			
62.4	.1	Tuff, yellow-brown.	152.2	2.1	Oil shale, dark-gray and brown.
62.5	3.0	Marlstone, dark-gray, silty.	154.3	.1	Tuff, yellow-brown.
65.5	.5	Oil shale, dark-gray and brown.	154.4	2.7	Oil shale.
			157.1	5.9	Marlstone, gray and brown.
66.0	.1	Tuff, yellow-brown, oil-stained.	163.0	.1	Tuff, yellow-brown.
66.1	1.3	Oil shale, dark-gray.	163.1	.7	Marlstone, gray and tan, silty.
67.4	.1	Tuff, yellow-brown.			
69.4	7.4	Marlstone, gray and brown.	163.8	4.6	Sandstone, gray, very fine grained.
67.5	1.9	Oil shale, dark-brown.			
76.8	34.4	Siltstone, gray, limy; some fractures filled with solid hydrocarbon.	168.4	3.0	Marlstone, gray and brown.
			171.4	.3	Tuff, yellow-brown, oil-saturated.
111.2	4.3	Marlstone, gray to brown.			
115.5	5.2	Oil shale, dark-gray and brown with thin lenses of pyrite.	171.7	1.1	Marlstone, gray and brown.
			172.8	1.1	Oil shale, dark-gray.
120.7	1.7	Marlstone, brown.	173.9	3.5	Marlstone, gray, micaceous.
122.4	5.4	Oil shale, dark-gray and brown.	177.4	1.6	Oil shale.
			179.0	1.5	Siltstone, gray; bedding shows flow structure.
127.8	.1	Tuff, yellow-brown, oil-stained.			
127.9	3.3	Oil shale, dark-gray and brown.	180.5	1.0	Marlstone, gray and brown, silty.
131.2	2.9	Oil shale, brown, cherty.	181.5	3.4	Siltstone, gray.
134.1	.7	Oil shale, dark-gray and brown.			

TABLE 3.—*Lithologic logs of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*—Continued

Depth to top of unit (feet)	Thickness (feet)	Description	Depth to top of unit (feet)	Thickness (feet)	Description
Core hole 13; NE¼NW¼ sec. 2, T. 12 S., R. 18 E. (unsurveyed); ground elev 5,041 ft					
10.0	54.0	Siltstone, gray and dark-gray, limy. micaceous with a few thin beds of fine-grained sandstone.	106.2	1.7	Marlstone, dark-gray and brown, silty.
			107.9	11.4	Oil shale, dark-gray and brown.
			119.3	.1	Tuff, yellow-brown, irregular bedding.
64.0	3.9	Marlstone, brown and gray.	119.4	3.0	Oil shale, dark-gray and brown.
67,9	1.4	Oil shale, dark gray and brown, in with thin stringers of nahcolite in lower half.	122.4	.3	Siltstone, gray.
			122.7	3.3	Oil shale, dark-gray, cherty.
69.3	3.3	Marlstone, gray, silty, with thin gray, limy siltstone 1.4 ft above base.	126.0	.1	Tuff, yellow-brown.
			126.1	3.3	Oil shale, dark-gray and brown.
			129.4	.1	Tuff, yellow-brown.
72.6	.2	Oil shale, dark-gray, silty.	129.5	.4	Oil shale, dark-gray.
72.8	.2	Tuff, yellow-brown, oil-stained.	129.9	3.0	Marlstone, gray and brown, silty.
73.0	2.6	Oil shale, dark-gray, silty.	132.9	1.3	Oil shale, dark-gray.
75.6	.1	Tuff, yellow-brown, oil-stained.	134.2	.1	Tuff, yellow-brown.
			134.3	.4	Oil shale, dark-gray.
75.7	1.2	Oil shale, brown, silty.	134.7	3.1	Marlstone, gray and brown; upper half is silty.
76.9	5.6	Siltstone, dark-gray, limy, micaceous.			
82.5	3.2	Marlstone, gray-brown, silty.	137.8	3.2	Siltstone, gray and brown, limy.
85.7	3.8	Siltstone, gray, limy.	141.0	1.8	Marlstone, gray and brown, silty.
89.5	1.6	Marlstone, dark-gray, silty.	142.8	2.7	Oil shale, dark-gray.
91.1	3.8	Siltstone, gray, limy, micaceous.	145.5	.1	Tuff, yellow-brown.
			145.6	2.3	Oil shale, dark-gray.
94.9	.3	Tuff, yellow-brown.	147.9	5.4	Marlstone, gray and brown, silty.
95.2	11.0	Siltstone, gray, limy, micaceous.	153.3	1.1	Oil shale, dark-gray.
Core hole 14; NW¼NW¼ sec. 13, T. 12 S., R. 18 E. (unsurveyed); ground elev 5,298 ft					
10.0	1.0	Sandstone, gray, very fine grained, limy.	127.3	3.7	Oil shale, dark-gray.
			131.0	.1	Tuff, yellow-brown.
11.0	2.5	Siltstone, gray, limy.	131.1	.4	Oil shale, dark-gray.
13.5	8.0	Sandstone, gray, fine to coarse-grained, limy; basal 1 ft oil-stained.	131.5	3.0	Marlstone, gray and brown; lower half is silty.
21.5	36.1	Siltstone, gray, limy.	134.5	1.9	Oil shale, dark-gray and brown.
57.6	5.9	Marlstone, gray and brown.	136.4	8.0	Marlstone, gray and brown; lower 2.4 ft is silty.
63.5	.8	Oil shale, dark-gray.			
64.3	4.6	Marlstone, gray and brown; upper half is silty.	144.4	2.6	Oil shale, dark-gray.
			147.0	.1	Tuff, brown.
68.9	2.4	Oil shale, dark-gray and brown, with 2 beds of thin oil-stained tuff.	147.1	3.1	Oil shale, gray and brown.
			150.2	5.0	Marlstone, gray and brown, silty.
71.3	.2	Lost core.	155.2	.6	Marlstone, gray and brown.
71.5	2.0	Oil shale, dark-gray and brown, with several very thin beds of tuff.	155.8	.1	Tuff, yellow-brown, very micaceous.
73.5	6.9	Siltstone, gray, micaceous.	155.9	2.2	Marlstone, gray and brown; lower half is silty.
80.4	2.5	Marlstone, brown, silty.			
82.9	6.6	Siltstone, gray, limy, with thin beds of silty marlstone.	158.1	1.7	Siltstone, gray, limy.
			159.8	1.7	Marlstone, gray and brown.
89.5	.3	Tuff, yellow-brown.	161.5	1.8	Siltstone, dark-gray, limy.
89.8	14.8	Siltstone, gray, limy, with thin beds of silty marlstone.	163.3	.3	Tuff, yellow-brown, oil-stained.
104.6	1.7	Marlstone, gray and brown, silty.	163.6	1.3	Siltstone, dark-gray, limy.
			164.9	.9	Oil shale, dark-gray and brown.
106.3	4.0	Oil shale, dark-gray and brown.	165.8	.1	Tuff, yellow-brown.
110.3	3.7	Marlstone, brown.	165.9	3.7	Marlstone, gray, silty.
114.0	5.2	Oil shale, dark-gray and brown.	169.6	1.4	Oil shale, gray and brown.
			171.0	.9	Siltstone, gray, limy, micaceous.
119.2	.1	Tuff, yellow-brown.			
119.3	4.3	Oil shale, dark-gray and brown.	171.9	.5	Marlstone, gray and brown.
123.6	1.9	Marlstone, brown.	172.4	.1	Tuff, yellow-brown.
125.5	1.7	Oil shale, dark-gray and brown.	172.5	.7	Marlstone, gray and brown.
127.2	.1	Tuff, yellow-brown.	173.2	1.2	Siltstone, gray-green.

TABLE 3.—*Lithologic logs of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*—Continued

Depth to top of unit (feet)	Thickness (feet)	Description	Depth to top of unit (feet)	Thickness (feet)	Description
Core hole 15; NW¼SE¼ sec. 26, T. 12 S., R. 18 E. (unsurveyed); ground elev 5,690 ft					
10.0	20.9	Siltstone, gray, limy, with a few thin beds of very fine grained sandstone.	95.5	0.1	Tuff, yellow-brown.
			95.6	.6	Oil shale, dark-gray and brown.
30.9	1.9	Marlstone, dark-gray and brown.	96.2	.7	Marlstone, gray and brown, silty.
32.8	1.0	Marlstone, gray, silty.	96.9	1.3	Siltstone, gray and brown.
33.8	2.0	Siltstone, gray, limy.	98.2	1.1	Marlstone, gray and brown.
35.8	3.2	Marlstone, gray, silty.			
39.0	1.2	Oil shale, gray and brown, with several very thin stringers of nahcolite.	99.3	2.2	Oil shale, dark-gray and brown.
			101.5	2.1	Marlstone, dark-gray, silty.
40.2	1.4	Marlstone, gray and brown, silty.	103.6	27.7	Siltstone, gray and brown.
41.6	2.4	Siltstone, gray, limy, micaceous.	131.3	.1	Tuff, yellow-brown, oil-stained.
44.0	3.0	Marlstone, gray and brown.	131.4	1.9	Siltstone, gray and brown.
			133.3	.1	Tuff, yellow-brown, oil-stained.
47.0	.1	Tuff, yellow-brown.			
47.1	.7	Marlstone, gray and brown.	133.4	1.6	Siltstone, gray and brown.
			135.0	2.2	Marlstone, gray and brown, silty.
47.8	.5	Oil shale, gray and brown.			
48.3	.1	Tuff, yellow-brown, oil-stained.	137.2	6.4	Oil shale, dark-gray and brown.
48.4	4.3	Oil shale, dark-gray and brown.	143.6	3.3	Marlstone, gray and brown.
52.7	.1	Tuff, yellow-brown.	146.9	2.5	Siltstone, gray, limy.
52.8	1.2	Oil shale, brown.	149.4	.6	Marlstone, brown.
54.0	8.0	Siltstone, gray, micaceous.	150.0	.9	Oil shale, dark-gray and brown.
62.0	1.3	Marlstone, brown, silty.			
63.3	3.6	Siltstone, gray, micaceous.	150.9	1.5	Marlstone, gray, silty.
66.9	1.3	Marlstone, gray and brown.	152.4	1.0	Siltstone, gray, limy.
			153.4	.4	Tuff, yellow-brown.
68.2	4.0	Oil shale, dark-gray and brown.	153.8	2.6	Marlstone, gray and brown; upper half is silty.
72.2	3.8	Marlstone, brown, cherty.			
76.0	7.7	Oil shale, dark-gray and brown.	156.4	2.7	Siltstone, gray, micaceous.
			159.1	.3	Tuff, yellow-brown, oil-stained.
83.7	.1	Tuff, yellow-brown.			
83.8	3.8	Oil shale, dark-gray and brown.	159.4	2.0	Siltstone.
			161.4	.9	Oil shale, dark-gray and brown.
87.6	2.9	Marlstone, gray and brown.	162.3	3.1	Marlstone, gray and brown.
90.5	.9	Oil shale, dark-gray.			
91.4	.1	Tuff, yellow-brown.	165.4	1.2	Oil shale, gray and brown.
91.5	1.0	Oil shale, dark-gray.	166.6	2.5	Tuff, gray with inclusions of siltstone.
92.5	2.5	Marlstone, gray and brown.	169.1	4.4	Siltstone, gray, tuffaceous.
95.0	.5	Oil shale, dark-gray and brown.			
Core hole 16; SE¼SW¼ sec. 28, T. 12 S., R. 18 E. (unsurveyed); ground elev 5,890 ft					
10.0	14.4	Siltstone, gray, limy.	47.5	5.1	Marlstone, gray and brown, silty.
24.4	1.2	Marlstone, brown, silty.			
25.6	1.8	Siltstone, gray, limy.	52.6	.1	Tuff, yellow-brown.
27.4	.9	Marlstone, gray and brown, silty.	52.7	1.8	Siltstone, gray, limy.
			54.5	1.6	Sandstone, brown, fine-grained, oil-stained.
28.3	.1	Tuff, yellow-brown.			
28.4	1.1	Oil shale, dark-gray and brown.	56.1	1.9	Siltstone, gray, limy.
			58.0	2.6	Sandstone, brown, fine-grained, oil-stained.
29.5	3.6	Siltstone, gray and brown, limy.	60.6	1.0	Siltstone, gray, limy.
33.1	2.7	Marlstone, gray and brown.	61.6	2.5	Sandstone, brown, fine-grained, oil-stained.
35.8	.1	Tuff, yellow-brown.	64.1	.3	Siltstone, gray, limy.
35.9	3.9	Oil shale, dark-gray and brown.	64.4	7.0	Sandstone, brown, fine-grained, oil-stained.
39.8	.1	Tuff, yellow-brown.	71.4	9.5	Siltstone, gray, limy.
39.9	1.6	Marlstone, gray and brown.	80.9	4.0	Sandstone, gray, fine-grained.
41.5	6.0	Siltstone, gray, limy.	84.9	4.1	Siltstone, gray, micaceous.

TABLE 3.—*Lithologic logs of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*—Continued

Depth to top of unit (feet)	Thickness (feet)	Description	Depth to top of unit (feet)	Thickness (feet)	Description
Core hole 16; SE¼SW¼ sec. 28, T. 12 S., R. 18 E. (unsurveyed); ground elev 5,890 ft—Continued					
89.0	3.8	Marlstone, gray and brown, silty.	109.9	0.8	Marlstone, brown.
92.8	2.2	Siltstone, gray, limy.	110.7	1.0	Oil shale, dark-gray and brown.
95.0	5.4	Marlstone, gray and brown, silty.	111.7	.1	Tuff, yellow-brown.
100.4	2.0	Oil shale, dark-gray and brown.	111.8	3.9	Oil shale, dark-gray and brown.
102.4	.9	Siltstone, gray, with thin stringers of oil shale.	115.7	.1	Tuff, yellow-brown.
103.3	1.1	Oil shale, dark-gray and brown.	115.8	3.4	Oil shale, dark-gray and brown.
104.4	.1	Tuff, yellow-brown.	119.2	.1	Tuff, yellow-brown.
104.5	.8	Oil shale, dark-gray and brown.	119.3	1.0	Oil shale, dark-gray.
105.3	2.9	Marlstone, brown.	120.3	.3	Siltstone, gray, micaceous.
108.2	.1	Tuff, yellow-brown.	120.6	.2	Oil shale, dark-gray.
108.3	1.5	Marlstone, brown.	120.8	.1	Tuff, yellow-brown.
109.8	.1	Tuff, yellow-brown.	120.9	1.7	Siltstone, gray, micaceous.
			122.6	.3	Oil shale, dark-gray.
			122.9	11.6	Siltstone, gray, micaceous.
Core hole 17; SW¼NW¼ sec. 3, T. 13 S., R. 18 E. (unsurveyed); ground elev 6,090 ft					
10.0	19.0	Siltstone, gray, micaceous.	123.8	7.3	Oil shale, dark-gray and brown.
29.0	1.9	Marlstone, gray and brown.	131.1	.1	Tuff, yellow-brown, oil-stained.
30.9	.1	Tuff, yellow-brown, oil-stained.	131.2	1.3	Oil shale, dark-gray and brown.
31.0	5.0	Oil shale, dark-gray and brown.	132.5	1.6	Marlstone, gray and brown.
36.0	.1	Tuff, yellow-brown.	134.1	.9	Oil shale, dark-gray and brown.
36.1	1.4	Marlstone.	135.0	2.5	Marlstone, gray and brown.
37.5	4.5	Siltstone, gray, micaceous.	137.5	.9	Oil shale, dark-gray.
42.0	1.2	Marlstone, gray and brown, silty.	138.4	.1	Tuff, yellow-brown.
43.2	.1	Tuff, yellow-brown.	138.5	.9	Oil shale, dark-gray.
43.3	1.9	Marlstone, gray and brown, silty.	139.4	2.4	Marlstone, brown.
45.2	4.2	Siltstone, gray, micaceous.	141.8	.3	Oil shale, dark-gray and brown.
49.4	1.5	Marlstone, brown.	142.1	.1	Tuff, yellow-brown.
50.9	1.0	Siltstone, gray, limy.	142.2	.5	Oil shale, dark-gray and brown.
51.9	4.0	Sandstone, dark-gray, micaceous, oil-stained.	142.7	2.3	Marlstone, gray and brown, silty.
55.9	1.1	Siltstone, gray, limy.	145.0	.8	Oil shale, dark-gray.
57.0	8.2	Sandstone, gray and brown, fine-grained.	145.8	.1	Tuff, yellow-brown.
65.2	51.2	Siltstone, gray, limy.	145.9	.2	Oil shale, dark-gray.
116.4	.9	Marlstone, gray and brown.	146.1	3.0	Marlstone, gray and brown, silty.
117.3	4.1	Oil shale, dark-gray and brown.	149.1	2.1	Siltstone, brown, limy.
121.4	2.4	Marlstone, brown.			
Core hole 18; SW¼SW¼ sec. 7, T. 13 S., R. 19 E.; ground elev 6,275 ft					
10.0	5.0	Marlstone, gray, silty.	55.0	4.0	Sandstone, gray and brown, fine to medium-grained.
15.0	6.1	Marlstone, gray and brown.	59.0	2.5	Marlstone, gray and brown, silty.
21.1	2.2	Oil shale, dark-gray and brown.	61.5	2.0	Sandstone, gray and brown, very fine grained.
23.3	7.3	Marlstone, gray and brown, silty.	63.5	1.5	Siltstone, gray, limy.
30.6	2.0	Siltstone, brown.	65.0	7.0	Sandstone, gray and brown, very fine to medium-grained.
32.6	12.4	Sandstone, gray and brown, very fine grained, with several thin beds of siltstone.	72.0	30.4	Siltstone, gray, with a few thin beds of limestone.
45.0	2.3	Marlstone, gray and brown, silty.	102.4	2.8	Marlstone, gray and brown, silty.
47.3	5.7	Sandstone, gray and brown, fine to medium-grained.	105.2	1.6	Oil shale, dark-gray.
53.0	2.0	Siltstone, gray.			

TABLE 3.—*Lithologic logs of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*—Continued

Depth to top of unit (feet)	Thickness (feet)	Description	Depth to top of unit (feet)	Thickness (feet)	Description
Core hole 18; SW¼SW¼ sec. 7, T. 13 S., R. 19 E.; ground elev 6,275 ft—Continued					
106.8	3.9	Marlstone, gray and brown.	129.4	1.0	Marlstone, gray and brown.
110.7	6.2	Oil shale, dark-gray and brown.	130.4	2.4	Siltstone, gray.
116.9	.1	Tuff, yellow-brown.	132.8	.9	Marlstone, gray and brown.
117.0	1.5	Oil shale, dark-gray and brown.	133.7	.1	Tuff, yellow-brown.
118.5	1.5	Marlstone, gray and brown.	133.8	1.0	Marlstone, gray and brown.
120.0	.6	Oil shale, dark-gray.	134.8	2.3	Marlstone, brown.
120.6	1.6	Marlstone, gray and brown.	137.1	1.3	Oil shale, brown.
122.2	.8	Oil shale, dark-gray.	138.4	2.7	Marlstone, gray and brown, silty.
123.0	.1	Tuff, yellow-brown.	141.1	1.5	Siltstone, gray.
123.1	.8	Oil shale, dark-gray.	142.6	.6	Marlstone, gray and brown.
123.9	2.2	Marlstone, gray and brown.	143.2	1.0	Oil shale, dark-gray and brown.
126.1	.5	Oil shale, dark-gray.	144.2	1.5	Marlstone, gray, silty.
126.6	.5	Marlstone, gray and brown.	145.7	.8	Siltstone, gray, limy.
127.1	2.3	Siltstone, gray and brown, stringers of oil shale and tuff.			

TABLE 4.—*Assays of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*

[Samples are air dried; (*) indicates estimated oil yield (too low to measure accurately). Assays by U.S. Bur. Mines Petroleum and Oil-Shale Experiment Station]

Depth (feet)		Yield of product						Specific gravity of oil at 60°/60°F.	U.S. Bur. Mines sample No.
		Gallons per ton		Weight percent					
From—	To—	Oil	Water	Oil	Water	Spent shale	Gas loss		
Core hole 1, SE¼SE¼ sec. 36, T. 12 S., R. 19 E.									
65.0	71.3	*1.8	1.4	0.7	0.6	98.3	0.4	.....	SBR55–1784
72.3	73.5	7.5	3.6	2.8	1.5	94.9	.8	0.903	SBR54–1642
73.5	75.3	34.1	4.3	13.0	1.8	82.7	2.5	.914	1643
75.3	79.2	14.3	3.7	5.4	1.5	91.7	1.4	.906	1644
79.2	86.4	49.8	3.4	18.9	1.4	76.4	3.3	.907	1645
86.4	87.3	18.8	3.6	7.2	1.5	89.4	1.9	.925	1646
87.3	93.3	14.7	1.0	5.7	.8	92.2	1.3	.921	1647
93.3	99.5	23.6	3.1	8.8	1.3	89.1	.8	.895	1648
99.5	101.4	5.5	1.8	2.1	.8	97.0	.1	.899	1649
101.4	103.3	21.7	3.8	8.3	1.6	88.9	1.2	.914	1650
103.3	105.9	6.1	3.8	2.3	1.6	95.4	.7	.909	1651
105.9	110.3	*3.9	2.3	1.5	1.0	97.2	.3	.....	SBR55–1785
110.3	111.1	18.4	6.7	6.9	2.8	89.2	1.1	.897	SBR54–1652
111.1	116.5	21.4	3.4	8.0	1.4	89.3	1.3	.894	1653
116.5	119.0	10.3	4.4	3.9	1.8	93.5	.8	.905	1654
119.0	123.0	*4.2	1.3	1.6	.6	97.4	.4	.....	SBR55–1786
123.0	125.6	11.5	4.0	4.4	1.6	93.0	1.0	.917	SBR54–1655
Core hole 2, SE¼NW¼ sec. 24, T. 12 S., R. 19 E.									
268.4	270.8	17.7	2.0	6.7	0.8	90.8	1.7	0.904	SBR54–1690
270.8	274.0	30.8	2.2	11.7	.9	85.0	2.4	.911	1691
274.0	280.6	43.4	2.4	16.4	1.0	79.3	3.3	.906	1692
280.6	281.9	16.1	1.7	6.1	.7	91.5	1.7	.914	1693
281.9	284.2	22.4	2.2	8.6	.9	88.8	1.7	.919	1694
284.2	287.3	15.8	1.2	6.0	.5	91.9	1.6	.913	1695
287.3	289.1	39.2	3.0	14.7	1.3	81.7	2.3	.901	1696
289.1	291.7	17.2	2.3	6.3	1.0	91.3	1.4	.880	1697

TABLE 4.—*Assays of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*—Continued

Depth (feet)		Yield of product						Specific gravity of oil at 60°/60°F.	U.S. Bur. Mines sample No.
		Gallons per ton		Weight percent					
From—	To—	Oil	Water	Oil	Water	Spent shale	Gas loss		
Core hole 2, SE¼NW¼ sec. 24, T. 12 S., R. 19 E.—Continued									
291.7	294.0	20.5	3.1	7.7	1.3	89.6	1.4	0.903	SBR54–1698
294.0	296.6	6.2	2.9	2.4	1.2	95.4	1.0	.909	1699
296.6	298.1	13.4	4.1	5.1	1.7	91.7	1.5	.919	1700
298.1	299.1	22.0	3.1	8.4	1.3	88.5	1.8	.921	1701
299.1	301.4	6.6	3.1	2.5	1.3	95.6	.6	.915	1702
301.4	303.0	5.6	.7	2.1	.3	97.0	.6	.900	1703
303.0	306.2	*5.2	1.9	2.1	.8	96.6	.5	.....	SBR55–1787
306.2	307.8	26.4	4.8	10.0	2.0	86.4	1.6	.904	SBR54–1704
307.8	308.7	9.6	5.8	3.6	2.4	93.0	1.4	.905	1705
308.7	314.0	21.4	2.6	8.0	1.1	89.2	1.7	.899	1706
314.0	316.2	11.8	3.0	4.5	1.2	93.1	1.2	.909	1707
Core hole 3, NW¼SW¼ sec. 1, T. 12 S., R. 19 E.									
480.0	485.0	23.8	2.4	9.0	1.0	88.5	1.5	0.904	SBR55–1788
485.0	490.0	10.4	1.9	4.0	.8	94.1	1.1	.921	1789
490.0	498.0	6.5	1.4	2.5	.6	96.4	.5	.911	1790
498.0	502.0	*4.9	1.7	2.0	.7	96.6	.7	.....	1791
502.0	503.6	9.4	2.4	3.6	1.0	94.6	.8	.909	SBR54–1549
503.6	504.1	14.5	1.9	5.6	.8	92.6	1.0	.918	1550
504.1	506.4	30.7	3.4	11.7	1.4	84.5	2.4	.916	1551
506.4	509.0	18.9	2.2	7.2	.9	90.2	1.7	.907	1552
509.0	511.0	31.5	2.4	12.1	1.0	84.4	2.5	.918	1553
511.0	513.6	59.6	3.1	22.4	1.3	72.0	4.3	.902	1554
513.6	514.3	30.4	1.9	11.5	.8	84.9	2.8	.906	1555
514.3	518.1	49.5	2.6	18.6	1.1	76.4	3.9	.900	1556
518.1	519.0	44.5	2.6	16.9	1.1	78.8	3.2	.911	1557
519.0	519.5	16.3	2.3	6.2	1.0	90.9	1.9	.918	1558
519.5	524.0	20.7	1.8	7.9	.7	89.3	2.1	.914	1559
524.0	526.0	41.2	3.1	15.5	1.3	80.2	3.0	.900	1560
526.0	528.3	17.8	2.4	6.5	1.0	90.9	1.6	.880	1561
528.3	529.3	35.7	3.4	13.4	1.4	82.8	2.4	.899	1562
529.3	530.9	13.4	2.5	5.1	1.0	92.4	1.5	.909	1563
530.9	533.0	8.2	3.2	3.1	1.4	94.5	1.0	.913	1564
533.0	536.0	12.8	4.3	4.9	1.8	91.8	1.5	.916	1565
536.0	537.9	6.8	3.6	2.6	1.5	94.8	1.1	.916	1566
537.9	540.4	*4.7	2.4	1.9	1.0	96.4	.7	.....	1567
540.4	546.7	25.7	4.2	9.6	1.8	86.5	2.1	.899	1568
546.7	549.6	11.2	3.8	4.3	1.6	92.8	1.3	.910	1569
549.6	550.7	16.4	2.9	6.3	1.2	91.0	1.5	.920	SBR55–1792
550.7	552.6	7.9	1.6	3.0	.7	95.4	.9	.924	1793
552.6	553.7	8.9	2.4	3.4	1.0	94.7	.9	.923	1794
553.7	557.0	*3.5	.8	1.4	.4	97.6	.6	.923	1795
Core hole 4, SW¼SE¼ sec. 1, T. 12 S., R. 18 E. (unsurveyed)									
90.8	103.0	*4.1	2.9	1.6	1.1	96.8	0.5	.....	SBR54–1665
103.0	108.5	31.9	2.8	12.2	1.1	84.4	2.3	0.912	1666
108.5	110.9	20.6	3.2	7.7	1.4	89.2	1.7	.901	1668
110.9	112.8	13.4	3.4	5.1	1.4	92.0	1.5	.907	1669
112.8	118.5	38.2	3.4	14.4	1.4	81.5	2.7	.905	1670
118.5	119.7	35.1	3.2	13.4	1.3	82.6	2.7	.913	1671
119.9	121.1	17.4	1.8	6.6	.8	91.0	1.6	.915	1672
121.1	122.8	26.2	1.7	10.0	.7	87.5	1.8	.918	1673
122.8	125.7	16.3	1.0	6.2	.4	92.1	1.3	.909	1674
125.7	127.0	39.6	3.4	14.8	1.4	81.6	2.2	.897	1675
127.0	129.1	16.6	2.3	6.1	.9	91.8	1.2	.875	1676
129.1	130.4	30.8	3.8	11.5	1.6	85.2	1.7	.892	1677
130.4	131.0	12.0	3.4	4.5	1.4	92.8	1.3	.903	1678

TABLE 4.—*Assays of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*—Continued

Depth (feet)		Yield of product						Specific gravity of oil at 60°/60°F.	U.S. Bur. Mines sample No.
		Gallons per ton		Weight percent					
From—	To—	Oil	Water	Oil	Water	Spent shale	Gas loss		
Core hole 5, NE¼NW¼ sec. 30, T. 12 S., R. 19 E.									
105.0	116.8	*1.1	3.6	0.4	1.6	97.5	0.5	.....	SBR55–1796
116.8	118.1	34.7	3.1	13.4	1.3	82.8	2.5	0.923	SBR54–1615
118.1	123.3	15.7	3.2	6.0	1.3	92.1	.6	.912	1616
123.3	130.4	41.9	4.6	15.9	1.9	79.5	2.7	.910	1617
130.4	131.0	46.0	4.8	17.5	2.0	77.8	2.7	.913	1618
131.0	132.7	14.6	4.1	5.6	1.7	91.4	1.3	.927	1619
132.7	134.2	22.6	3.8	8.7	1.6	88.3	1.4	.924	1620
134.2	135.9	14.2	2.8	5.4	1.2	92.5	.9	.919	1621
135.9	139.0	33.9	5.0	12.8	2.1	83.1	2.0	.902	1622
139.0	141.0	15.4	3.1	5.7	1.3	92.1	.9	.881	1623
141.0	142.9	30.4	4.7	11.4	2.0	84.2	2.4	.898	1624
142.9	143.9	9.8	3.4	3.7	1.4	93.8	1.1	.908	1625
143.9	145.8	5.4	3.0	2.0	1.3	95.8	.9	.902	1626
145.8	148.2	24.9	4.8	9.5	2.0	86.7	1.8	.917	1627
148.2	150.0	13.4	2.9	5.1	1.2	92.2	1.5	.913	1628
Core hole 6, SW¼SW¼ sec. 8, T. 12 S., R. 19 E.									
185.0	189.0	*2.4	2.6	0.9	1.1	97.6	0.4	.....	SBR55–1797
189.0	193.5	10.3	7.3	3.9	3.1	92.3	.7	0.910	SBR54–1570
193.5	194.2	34.4	7.0	13.1	2.9	81.4	2.6	.916	1571
194.2	198.6	10.9	5.2	4.2	2.1	92.9	.8	.913	1572
198.6	201.0	25.3	4.4	9.6	1.9	87.0	1.5	.911	1573
201.0	203.3	30.7	4.1	11.5	1.7	85.1	1.7	.899	1574
203.3	221.2	6.8	3.4	2.6	1.4	95.4	.6	.918	1575
221.2	227.8	*4.0	4.1	1.6	1.7	96.2	.5	.....	1576
227.8	229.0	33.9	4.8	13.0	2.0	83.0	2.0	.918	1577
229.0	232.7	18.1	3.8	6.9	1.6	90.1	1.4	.908	1578
232.7	235.0	15.7	4.7	6.0	1.9	91.0	1.1	.912	1579
235.0	240.1	37.5	4.8	14.2	2.0	81.3	2.5	.908	1580
240.5	241.5	17.3	4.8	6.7	2.0	90.0	1.3	.924	1581
241.5	243.8	14.5	4.1	5.5	1.7	91.6	1.2	.919	1582
243.8	244.5	26.2	4.1	10.1	1.7	86.7	1.5	.919	1583
244.5	248.0	14.0	2.2	5.4	.9	92.5	1.2	.923	1584
248.0	249.4	34.2	3.8	13.0	1.6	83.0	2.4	.907	1585
249.4	250.8	11.4	1.4	4.2	.6	94.3	.9	.879	SBR55–1798
250.8	251.5	9.6	2.9	3.6	1.2	94.1	1.1	.893	SBR54–1586
251.5	252.5	6.1	2.6	2.3	1.1	95.5	1.1	.892	1587
252.5	254.8	16.1	3.8	6.1	1.6	90.8	1.5	.902	1588
254.8	262.0	5.8	4.1	2.2	1.7	95.1	1.0	.910	1589
262.0	263.0	*3.6	.5	1.4	.2	97.6	.8	.....	1590
Core hole 7, NW¼SW¼ sec. 26, T. 13 S., R. 18 E. (unsurveyed)									
444.5	450.3	*1.7	4.8	0.7	2.0	97.0	0.3	.....	SBR55–1799
450.3	453.2	*4.7	4.8	1.8	2.0	95.8	.4	.....	SBR54–1656
453.2	456.4	18.0	4.9	6.8	2.1	90.0	1.1	0.911	1657
457.3	464.2	35.0	4.6	13.2	1.9	82.8	2.1	.905	1658
464.2	465.1	10.3	4.3	3.9	1.8	93.6	.7	.911	1659
465.1	467.5	24.7	5.3	9.4	2.2	87.2	1.2	.908	1660
467.5	468.7	21.4	5.5	8.1	2.3	88.6	1.0	.905	1661
468.7	469.2	*2.9	5.4	1.2	2.2	96.2	.4	.....	1662
469.2	470.0	*3.0	.6	1.2	.3	98.2	.3	.....	SBR55–1800
470.0	471.3	12.5	3.1	4.7	1.3	93.3	.7	.894	SBR54–1663
471.3	472.4	15.6	3.4	6.0	1.4	91.6	1.0	.921	1664
473.0	475.1	8.6	2.9	3.2	1.2	94.8	.8	.886	1667
475.1	476.4	6.4	1.3	2.4	.5	96.5	.6	.897	SBR55–1801

TABLE 4.—*Assays of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*—Continued

Depth (feet)		Yield of product						Specific gravity of oil at 60°/60°F.	U.S. Bur. Mines sample No.
		Gallons per ton		Weight percent					
From—	To—	Oil	Water	Oil	Water	Spent shale	Gas loss		
Core hole 8, SW¼NW¼ sec. 14, T. 13 S., R. 19 E.									
149.1	154.0	*1.9	2.9	0.7	1.2	97.6	0.5	.....	SBR55–1802
154.0	156.0	7.0	3.6	2.6	1.5	94.9	1.0	0.903	1803
156.0	158.0	29.9	3.0	11.5	1.2	85.0	2.3	.919	SBR54–1629
158.0	160.6	14.9	2.6	5.7	1.1	91.9	1.3	.908	1630
160.6	161.8	32.1	3.0	12.2	1.3	84.1	2.4	.912	1631
161.8	162.8	27.9	1.9	10.6	.8	87.0	1.6	.907	1632
162.8	167.8	52.3	3.6	19.8	1.5	75.5	3.2	.905	1633
167.8	172.0	15.2	2.0	5.8	.9	92.1	1.2	.920	1634
172.0	173.1	35.2	4.4	13.2	1.9	83.2	1.7	.900	1635
173.1	175.7	15.6	2.9	5.8	1.2	92.2	.8	.888	1636
175.7	176.7	10.4	.8	4.0	.3	95.2	.5	.909	SBR55–1805
176.7	178.2	20.0	3.7	7.7	1.6	89.5	1.2	.920	SBR54–1637
178.2	180.3	5.6	4.1	2.1	1.7	95.8	.4	.914	1638
180.9	182.7	17.9	3.5	6.7	1.5	90.8	1.0	.905	1639
182.7	189.4	15.3	1.1	5.8	.4	92.8	1.0	.902	1640
189.4	191.6	5.4	1.4	2.1	.6	96.6	.7	.917	1641
Core hole 9, NE¼NW¼ sec. 27, T. 12 S., R. 19 E.									
475.0	478.2	26.1	3.8	9.9	1.6	86.6	1.9	0.908	SBR54–1591
478.2	479.2	17.0	1.8	6.4	.7	91.7	1.2	.899	1592
479.2	484.3	6.7	2.6	2.6	1.1	95.7	.6	.913	1593
484.3	486.2	5.3	2.6	2.0	1.1	96.3	.6	.920	1594
486.2	487.5	12.1	2.6	4.6	1.1	92.8	1.5	.915	1595
487.5	488.9	5.4	1.1	2.1	.4	96.8	.7	.916	1596
488.9	493.9	*3.5	.7	1.4	.3	97.9	.4	.....	1597
493.9	503.4	*1.8	3.1	.7	1.3	97.5	.5	.....	1598
503.4	509.9	*4.0	3.1	1.6	1.3	96.6	.5	.....	1599
509.9	510.8	29.1	3.4	11.1	1.4	85.7	1.8	.916	1600
510.8	512.5	18.5	3.4	7.0	1.4	89.9	1.7	.911	1601
512.5	514.0	17.4	2.3	6.5	1.0	91.1	1.4	.900	1602
514.0	515.9	7.0	2.0	2.6	.9	96.2	.3	.891	SBR55–1806
515.9	518.5	34.2	2.9	13.0	1.2	83.3	2.5	.908	SBR54–1603
518.5	520.4	56.8	4.1	21.4	1.7	72.3	4.6	.905	1604
520.4	521.6	37.9	2.6	14.3	1.1	81.9	2.7	.904	1605
521.6	522.8	36.1	3.8	13.8	1.6	81.6	3.0	.918	1606
522.8	523.0	5.2	2.0	2.0	.8	96.9	.3	.912	SBR55–1807
523.0	525.9	14.2	3.1	5.5	1.3	91.5	1.7	.923	SBR54–1607
525.9	528.7	19.0	1.8	7.3	.7	90.8	1.2	.921	1608
528.7	529.7	19.2	1.6	7.3	.6	91.0	1.1	.910	1609
529.7	531.6	32.7	3.1	12.3	1.3	84.4	2.0	.903	1610
531.6	536.0	15.5	3.1	5.8	1.3	91.9	1.0	.892	1611
536.0	538.6	5.7	2.4	2.2	1.0	96.5	.3	.903	1612
538.6	540.7	27.4	3.8	10.5	1.6	85.9	2.0	.921	1613
540.7	543.0	5.6	4.1	2.1	1.7	95.8	.4	.916	1614
Core hole 10, SE¼NW¼ sec. 34, T. 13 S., R. 19 E.									
148.0	149.3	*4.2	5.3	1.7	2.2	95.4	0.7	.....	SBR54–1679
149.3	150.9	14.1	2.9	5.4	1.2	92.6	.8	0.914	1680
150.9	152.9	16.8	4.2	6.3	1.8	90.6	1.3	.904	1681
152.9	157.0	10.9	4.4	4.1	1.9	93.1	.9	.905	1682
157.0	159.5	33.6	4.3	12.7	1.8	83.4	2.1	.905	1683
159.5	163.4	18.2	3.2	6.9	1.4	90.6	1.1	.912	1684
163.4	164.3	9.5	2.3	3.5	1.0	94.8	.7	.893	1685
164.3	166.8	14.6	2.0	5.6	.8	92.6	1.0	.911	1686
166.8	168.0	*3.3	2.2	1.3	.9	97.5	.3	.....	1687
168.0	170.2	16.2	1.0	6.1	.4	92.4	1.1	.904	1688
170.2	172.2	9.4	.6	3.6	.2	95.3	.9	.908	1689

TABLE 4.—*Assays of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*—Continued

Depth (feet)		Yield of product						Specific gravity of oil at 60°/60°F.	U.S. Bur. Mines sample No.
		Gallons per ton		Weight percent					
From—	To—	Oil	Water	Oil	Water	Spent shale	Gas loss		
Core hole 11, NW¼SW¼ sec. 31, T. 12 S., R. 19 E.									
97.4	98.6	7.8	5.0	3.0	2.1	94.1	0.8	0.906	SBR54–1708
98.6	101.6	*2.0	2.4	.8	1.0	98.0	.2	.....	SBR55–1808
101.6	104.7	9.1	6.1	3.5	2.5	93.1	.9	.908	SBR54–1709
104.7	109.0	6.6	2.9	2.5	1.2	95.7	.6	.910	1710
109.0	111.0	*4.9	6.0	1.9	2.5	94.9	.7	.....	1711
111.2	113.4	11.5	5.2	4.4	2.1	92.6	.9	.914	1712
113.8	118.7	20.8	3.8	7.9	1.6	89.0	1.5	.905	1713
118.7	126.0	*4.5	3.6	1.8	1.5	95.9	.8	.....	1714
126.8	129.9	48.7	4.1	18.3	1.7	77.0	3.0	.903	1715
129.9	132.0	26.4	2.9	10.1	1.2	87.0	1.7	.912	1716
132.0	133.2	*3.4	2.9	1.4	1.2	97.3	.1	.....	SBR55–1809
133.2	133.9	16.0	3.1	6.1	1.3	91.3	1.3	.917	SBR54–1717
133.9	135.7	7.4	1.4	2.8	.6	94.2	2.4	.905	SBR55–1810
135.7	141.0	20.4	2.8	7.8	1.2	89.6	1.4	.918	SBR54–1718
141.0	144.9	*3.6	1.2	1.4	.5	97.8	.3	.....	SBR55–1811
144.9	145.9	6.5	4.3	2.5	1.8	95.1	.6	.913	SBR54–1719
145.9	146.4	*1.2	1.2	.5	.5	98.8	.2	.....	SBR55–1812
146.4	148.1	*4.3	4.4	1.7	1.9	95.8	.6	.....	SBR54–1720
Core hole 12, SW¼NW¼ sec. 4, T. 12 S., R. 18 E.									
54.75	57.25	8.0	4.2	3.0	1.8	94.6	0.6	0.905	SBR55–445
57.25	60.8	6.4	5.3	2.4	2.2	94.8	.6	.909	446
60.8	61.5	33.9	4.8	12.9	2.0	83.1	2.0	.911	447
61.5	62.4	11.2	3.2	4.3	1.3	94.0	.4	.915	448
62.4	63.7	9.5	3.4	3.6	1.4	93.9	1.1	.912	449
63.7	65.5	7.3	4.1	2.8	1.7	94.8	.7	.912	450
65.5	68.3	22.3	1.9	8.5	.8	89.3	1.4	.914	451
68.3	69.4	19.2	2.0	7.2	.9	90.7	1.2	.902	452
69.4	76.8	7.2	2.2	2.7	.9	95.6	.8	.917	453
76.8	84.7	*2.8	.2	1.1	.1	98.3	.5	.....	454
84.7	91.2	*2.7	1.2	1.1	.5	98.0	.4	.....	455
91.2	91.3	88.2	2.9	33.5	1.2	59.9	5.4	.909	456
91.3	111.2	*2.1	3.7	.8	1.6	97.5	.1	.....	457
111.2	112.1	*4.8	2.3	1.9	1.0	96.6	.5	.....	458
112.1	113.2	7.6	3.0	2.9	1.3	95.6	.2	.916	459
113.2	115.5	13.8	1.3	5.3	.5	93.8	.4	.917	460
115.5	117.5	24.7	1.9	9.4	.8	88.2	1.6	.915	461
117.5	119.2	16.6	1.9	6.3	.8	91.8	1.1	.903	462
119.3	120.7	20.6	1.7	7.8	.7	90.4	1.1	.906	463
120.7	122.4	12.6	1.4	4.8	.6	92.6	2.0	.913	464
122.4	123.7	47.2	3.0	18.0	1.2	77.3	3.5	.911	465
123.7	124.3	53.9	2.6	20.4	1.1	74.3	4.2	.907	466
124.3	124.9	31.1	1.6	11.7	.6	85.5	2.2	.900	467
124.9	125.8	54.5	3.4	20.7	1.4	74.1	3.8	.911	468
125.8	127.2	31.8	3.2	12.0	1.4	84.0	2.6	.909	469
127.2	127.8	33.8	2.9	12.9	1.2	83.4	2.5	.910	470
127.9	130.2	16.5	1.9	6.3	.8	91.2	1.7	.922	471
130.2	131.2	38.0	2.4	14.7	1.0	81.9	2.4	.924	472
131.2	134.1	15.6	1.2	6.0	.5	92.1	1.4	.920	473
134.1	134.5	46.1	2.7	17.6	1.1	78.3	3.0	.913	474
134.5	135.6	35.0	3.6	13.3	1.5	82.9	2.3	.906	475
135.6	138.6	19.6	2.6	7.3	1.1	90.0	1.6	.889	476
138.6	139.6	10.2	2.9	3.9	1.2	93.8	1.1	.909	477
139.6	140.9	*3.2	3.1	1.3	1.3	96.6	.8	.....	478
140.9	142.8	6.4	4.1	2.5	1.7	94.9	.9	.925	479
142.8	143.3	15.5	3.6	5.9	1.5	91.0	1.6	.919	480
143.3	143.7	37.6	3.6	14.5	1.5	81.3	2.7	.924	481
143.7	145.5	7.3	3.1	2.8	1.3	95.0	.9	.915	482
145.5	148.8	*3.3	1.8	1.3	.8	97.2	.7	.....	483
148.8	152.2	8.0	5.5	3.0	2.3	93.5	1.2	.904	484
152.2	153.5	29.4	4.0	11.0	1.7	85.2	2.1	.898	485
153.5	155.6	22.3	2.5	8.4	1.1	88.9	1.6	.902	486
155.6	156.3	29.8	3.5	11.1	1.5	85.2	2.2	.896	487
156.3	157.1	18.0	2.4	6.7	1.0	90.9	1.4	.894	488
157.1	161.2	9.1	3.1	3.5	1.3	94.0	1.2	.913	489
161.2	163.1	9.9	2.6	3.8	1.1	93.9	1.2	.922	490
163.1	163.8	*4.9	1.9	2.0	.8	96.7	.5	.....	491
168.4	169.7	10.9	1.9	4.1	.8	94.3	.8	.899	492
169.7	172.8	*3.0	3.1	1.2	1.3	97.0	.5	.....	493

TABLE 4.—*Assays of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*—Continued

Depth (feet)		Yield of product						Specific gravity of oil at 60°/60°F.	U.S. Bur. Mines sample No.
		Gallons per ton		Weight percent					
From—	To—	Oil	Water	Oil	Water	Spent shale	Gas loss		
Core hole 12, SW¼NW¼ sec. 4, T. 12 S., R. 18 E.—Continued									
172.8	173.9	20.6	2.6	7.9	1.1	89.2	1.8	0.917	SBR55-494
173.9	177.4	5.6	2.5	2.1	1.1	95.9	.9	.907	495
177.4	179.0	20.8	2.4	8.0	1.0	89.8	1.2	.920	496
179.0	180.5	*3.7	5.2	1.5	2.1	95.9	.5	.....	497
180.5	181.1	10.4	3.4	4.0	1.4	93.5	1.1	.916	498
181.1	181.5	*3.0	3.8	1.2	1.6	96.5	.7	.....	499
Core hole 13, NE¼NW¼ sec. 2, T. 12 S., R. 18 E. (unsurveyed)									
52.0	64.0	*1.5	4.0	0.6	1.6	97.3	0.5	.....	SBR55-500
64.0	65.2	12.2	5.0	4.6	2.1	92.0	1.3	0.904	501
65.2	67.9	7.6	6.5	2.9	2.7	93.5	.9	.906	502
67.9	68.4	44.3	5.0	16.8	2.1	78.0	3.1	.907	503
68.4	69.3	15.3	2.9	5.9	1.2	91.4	1.5	.920	504
69.3	70.7	12.8	3.4	4.9	1.4	93.4	.3	.919	505
70.7	72.6	12.2	3.8	4.7	1.6	93.2	.5	.915	506
72.6	75.8	26.0	3.1	9.9	1.3	86.8	2.0	.911	507
75.8	76.9	19.5	1.9	7.4	.8	90.1	1.7	.904	508
76.9	82.5	7.7	2.4	3.0	1.0	94.9	1.1	919	509
82.5	85.7	10.1	2.4	3.9	1.0	93.9	1.2	.923	510
85.7	89.5	*4.0	.5	1.6	.2	97.6	.6	.....	511
89.5	91.1	*4.4	1.2	1.8	.5	96.9	.8	.....	512
91.1	106.2	*2.6	2.8	1.0	1.2	97.1	.7	.....	513
106.2	107.9	8.9	2.3	3.4	.9	94.7	1.0	.904	514
107.9	109.0	35.3	2.6	13.5	1.1	82.7	2.7	.917	515
109.0	110.3	21.4	2.8	8.1	1.2	88.9	1.8	.908	516
110.3	111.5	18.5	2.2	7.0	.9	90.3	1.8	.903	517
111.5	113.2	38.3	2.5	14.5	1.0	81.3	3.2	.907	518
113.2	114.8	35.0	2.2	13.2	.9	82.8	3.1	.906	519
114.8	116.2	58.8	2.4	22.2	1.0	73.6	3.2	.903	520
116.2	117.9	62.2	2.4	23.5	1.0	71.9	3.6	.905	521
117.9	118.4	38.6	1.4	14.5	.6	82.8	2.1	.900	522
118.4	119.5	48.2	2.5	18.2	1.0	78.1	2.7	.902	523
119.5	121.0	19.0	1.6	7.3	.7	91.1	.9	.920	524
121.0	122.4	26.2	1.9	10.1	.8	87.8	1.3	.920	525
122.4	122.7	*5.1	1.6	2.0	.7	96.9	.4	.....	526
122.7	125.1	14.7	.8	5.6	.4	93.7	.3	.919	527
125.1	126.7	38.2	2.4	14.4	1.0	82.1	2.5	.903	528
126.7	129.0	16.1	2.0	6.0	.8	92.1	1.1	.887	529
129.0	129.9	27.4	3.4	10.3	1.4	86.9	1.4	.895	530
129.9	131.2	11.9	2.5	4.5	1.1	93.4	1.0	.911	531
131.2	132.9	*4.7	3.4	1.9	1.4	96.0	.7	.....	532
132.9	134.7	19.8	3.0	7.6	1.2	89.8	1.4	.914	533
134.7	136.7	7.4	3.1	2.8	1.3	95.0	.9	.916	534
136.7	137.8	6.8	2.9	2.6	1.2	95.3	.9	.921	535
137.8	141.0	*2.2	1.8	.9	.7	97.5	.9	.....	536
141.0	142.8	6.7	5.0	2.6	2.1	95.3	.0	.920	537
142.8	144.1	36.6	3.8	13.7	1.6	82.7	2.0	.899	538
144.1	147.9	25.9	2.4	9.7	1.0	87.8	1.5	.897	539
147.9	152.6	11.1	2.4	4.2	1.0	94.3	.5	.910	540
152.6	153.3	8.3	1.6	3.2	.6	96.0	.2	.917	541
153.3	154.4	23.0	2.9	8.9	1.2	88.7	1.2	.925	542
Core hole 14, NW¼NW¼ sec. 13, T. 12 S., R. 18 E. (unsurveyed)									
51.7	57.6	*1.4	2.9	0.6	1.2	98.1	0.1	.....	SBR55-543
57.6	63.5	7.3	4.3	2.8	1.8	95.0	.4	0.902	544
63.5	64.3	35.3	5.0	13.3	2.1	81.9	2.7	.905	545
64.3	66.8	11.1	3.4	4.2	1.4	93.1	1.3	.911	546
66.8	68.9	7.6	4.6	2.9	1.9	94.1	1.1	.912	547
68.9	71.3	20.1	3.1	7.7	1.3	89.5	1.5	.912	548
71.5	72.4	33.6	2.5	12.7	1.0	84.3	2.0	.902	549
72.4	73.5	17.3	2.0	6.5	.8	91.2	1.5	.900	550
73.5	80.4	6.0	2.3	2.3	.9	96.0	.8	.920	551
80.4	82.9	9.7	1.4	3.7	.6	95.4	.3	.922	552
82.9	89.1	*2.2	1.0	.9	.4	98.7	.0	.....	553
89.1	104.6	2.0	2.6	.8	1.1	97.5	.6	.....	554
104.6	106.3	8.5	2.4	3.2	1.0	95.0	.8	.907	555
106.3	107.5	34.8	2.9	13.4	1.2	83.2	2.2	.920	1813

TABLE 4.—*Assays of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*—Continued

Depth (feet)		Yield of product						Specific gravity of oil at 60°/60°F.	U.S. Bur. Mines sample No.
		Gallons per ton		Weight percent					
From—	To—	Oil	Water	Oil	Water	Spent shale	Gas loss		
Core hole 14, NW¼NW¼ sec. 13, T. 12 S., R. 18 E. (unsurveyed)—Continued									
107.5	110.3	18.1	2.8	6.9	1.1	90.8	1.2	0.907	SBR55–1814
110.3	114.0	12.8	2.9	4.9	1.2	92.9	1.0	.911	1815
114.0	116.9	29.2	3.6	11.1	1.5	85.3	2.1	.911	1816
116.9	119.2	40.6	3.5	15.3	1.5	80.4	2.8	.904	1817
119.2	122.2	14.7	2.5	5.6	1.1	92.0	1.3	.917	1818
122.2	123.6	21.0	2.9	8.0	1.2	89.3	1.5	.918	1819
123.6	125.5	13.0	2.2	5.0	.9	93.1	1.0	.921	1820
125.5	126.3	16.7	1.1	6.3	.5	92.1	1.1	.909	1821
126.3	128.1	35.5	2.9	13.4	1.2	83.0	2.4	.906	1822
128.1	130.8	14.5	2.0	5.3	.9	92.7	1.1	.881	1823
130.8	131.5	33.0	4.2	12.4	1.8	83.6	2.2	.903	1824
131.5	132.5	11.3	2.4	4.3	1.0	93.8	.9	.915	568
132.5	134.5	*4.3	1.9	1.7	.8	96.6	.9	.....	569
134.5	136.4	19.9	2.4	7.6	1.0	89.6	1.8	.922	570
136.4	138.5	5.7	2.9	2.2	1.2	95.7	.9	.913	571
138.5	142.0	*3.0	1.4	1.2	.6	97.3	.9	.....	572
142.0	144.4	7.1	4.3	2.7	1.8	94.4	1.1	.910	573
144.4	147.4	22.7	2.9	8.5	1.2	88.4	1.9	.900	574
147.4	150.2	21.1	2.6	8.0	1.1	88.9	2.0	.903	575
150.2	155.2	8.8	2.4	3.3	1.0	94.6	1.1	.912	576
155.2	157.0	11.8	2.5	4.5	1.1	93.4	1.0	.924	577
157.0	158.1	*4.3	.8	1.7	.4	97.5	.4	.....	578
159.8	161.5	10.4	1.6	3.9	.7	94.7	.7	.904	579
161.5	164.9	*2.6	2.9	1.0	1.2	97.3	.5	.....	580
164.9	165.8	23.0	2.0	8.9	.8	88.7	1.6	.921	581
165.8	169.6	6.8	2.0	2.6	.8	95.9	.7	.914	582
169.7	171.0	20.4	2.0	7.9	.8	88.3	3.0	.922	583
171.9	173.2	6.7	1.8	2.6	.7	96.1	.6	.923	584
Core hole 15, NW¼SE¼ sec. 26, T. 12 S., R. 18 E. (unsurveyed)									
29.9	30.9	*0.8	3.4	0.3	1.4	97.7	0.6	.....	SBR55–620
30.9	32.8	6.9	5.3	2.6	2.2	94.0	1.2	0.899	621
32.8	33.8	*1.9	4.1	.7	1.7	96.7	.9	.....	622
33.8	35.8	*1.5	3.4	.6	1.4	97.9	.1	.....	623
35.8	39.0	*2.9	6.5	1.2	2.7	96.1	.0	.....	624
39.0	40.2	26.3	5.8	10.0	2.4	85.8	1.8	.906	625
40.2	41.6	8.6	3.1	3.3	1.3	95.1	.3	.906	626
41.6	44.0	6.9	2.9	2.6	1.2	96.0	.2	.906	627
44.0	47.8	*4.9	4.6	1.9	1.9	95.8	.4	.....	628
47.8	49.3	20.5	3.0	7.8	1.3	90.1	.8	.916	629
49.3	51.6	19.3	3.1	7.4	1.3	90.3	1.0	.912	630
51.6	52.9	35.0	2.6	13.2	1.1	83.9	1.8	.904	631
52.9	54.0	14.9	2.3	5.6	1.0	92.7	.7	.905	632
54.0	62.0	*3.8	2.6	1.5	1.1	97.0	.4	.....	633
62.0	63.3	8.9	2.4	3.4	1.0	94.9	.7	.922	634
63.3	66.9	*3.4	2.9	1.3	1.2	97.3	.2	.....	635
66.9	68.2	8.1	2.4	3.1	1.0	95.2	.7	.911	636
68.2	69.2	28.5	2.6	11.0	1.1	86.2	1.7	.922	637
69.2	72.2	16.4	3.4	6.2	1.4	91.2	1.2	.910	638
72.2	76.0	11.2	2.6	4.3	1.1	94.0	.6	.913	639
76.0	77.8	32.3	3.1	12.3	1.3	84.6	1.8	.911	640
77.8	78.6	30.2	1.7	11.5	.7	86.2	1.6	.908	641
78.6	80.6	59.3	2.9	22.4	1.2	72.8	3.6	.906	642
80.6	82.6	44.7	2.2	16.9	.9	79.5	2.7	.904	643
82.6	83.7	48.1	2.6	18.3	1.1	77.9	2.7	.910	644
83.7	86.2	14.7	1.7	5.7	.7	92.6	1.0	.922	645
86.2	87.6	21.1	1.4	8.2	.6	89.8	1.4	.927	646
87.6	90.5	13.0	.7	5.0	.3	93.6	1.1	.921	647
90.5	92.5	32.4	2.4	12.3	1.0	84.4	2.3	.908	648
92.5	95.0	10.6	2.2	3.9	.9	94.0	1.2	.889	649
95.0	96.2	23.6	2.2	8.9	0.9	88.5	1.7	.902	650
96.2	96.9	9.2	.5	3.5	.2	95.3	1.0	.915	651
96.9	98.2	*5.5	.2	2.2	.1	97.2	.5	.....	652
98.2	99.3	6.4	.6	2.4	.3	96.4	.9	.908	653
99.3	101.5	23.7	1.7	9.2	.7	89.4	.7	.924	654

TABLE 4.—*Assays of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*—Continued

Depth (feet)		Yield of product						Specific gravity of oil at 60°/60°F.	U.S. Bur. Mines sample No.
		Gallons per ton		Weight percent					
From—	To—	Oil	Water	Oil	Water	Spent shale	Gas loss		
Core hole 15, NW¼SE¼ sec. 26, T. 12 S., R. 18 E. (unsurveyed)—Continued									
101.5	103.6	5.6	2.8	2.1	1.2	96.3	0.4	0.921	SBR55–655
135.0	137.2	*3.5	3.4	1.4	1.4	97.0	.2	.....	656
137.2	141.1	21.6	1.2	8.1	.5	90.3	1.1	.899	657
141.1	143.6	20.0	1.7	7.5	.7	90.8	1.0	.894	658
143.6	146.9	8.4	2.5	3.2	1.0	95.1	.7	.905	659
146.9	149.4	*3.6	1.0	1.4	.4	97.9	.3	.....	660
149.4	150.0	8.0	2.9	3.1	1.2	95.4	.3	.919	661
150.0	150.9	22.9	3.1	8.9	1.3	88.3	1.5	.927	662
150.9	152.4	7.0	1.6	2.7	.6	96.4	.3	.914	663
152.4	153.4	*4.0	.6	1.6	.2	98.0	.2	.....	664
153.8	155.4	7.8	1.3	2.9	.6	96.0	.5	.895	665
155.4	156.4	9.8	1.2	3.7	.5	95.4	.4	.895	666
156.4	161.4	*2.1	2.9	.9	1.2	97.8	.1	.....	667
161.4	162.3	31.3	2.2	12.0	.9	85.5	1.6	.918	668
162.3	165.4	5.9	2.5	2.2	1.1	96.0	.7	.912	669
165.4	166.6	20.9	2.4	8.1	1.0	89.6	1.3	.923	670
Core hole 16, SE¼SW¼ sec. 28, T. 12 S., R. 18 E. (unsurveyed)									
23.9	24.4	*0.7	2.6	0.3	1.1	98.3	0.3	.....	SBR55–585
24.4	25.6	*5.0	4.8	2.0	2.0	95.7	.3	.....	586
25.6	27.4	*1.5	3.4	.6	1.4	97.7	.3	.....	587
27.4	28.3	*4.5	7.2	1.8	3.0	94.3	.9	.....	588
28.3	29.5	21.2	4.8	8.1	2.0	88.1	1.8	0.910	589
29.5	33.1	5.8	3.4	2.2	1.4	95.4	1.0	.913	590
33.1	35.9	6.7	4.8	2.6	2.0	94.9	.5	.913	591
35.9	36.8	20.2	3.5	7.8	1.4	89.6	1.2	.921	592
36.8	37.7	16.6	2.0	6.4	.8	91.7	1.1	.919	593
37.7	39.5	22.6	3.6	8.5	1.5	88.8	1.2	.904	594
39.5	40.8	12.5	2.2	4.7	.9	93.8	.6	.904	595
40.8	47.5	*2.5	3.2	1.0	1.3	97.6	.1	.....	596
47.5	49.3	*3.5	3.1	1.4	1.3	97.2	.1	.....	597
49.3	52.6	*4.7	2.8	1.9	1.1	96.8	.2	.....	598
52.6	54.5	*1.3	1.4	.5	.6	98.5	.4	.....	599
85.5	89.0	*1.5	2.9	.6	1.2	98.0	.2	.....	600
89.0	92.8	*3.8	3.1	1.5	1.3	96.8	.4	.....	601
92.8	95.0	*1.2	3.1	.5	1.3	97.9	.3	.....	602
95.0	100.4	5.5	2.0	2.1	.8	96.5	.6	.904	603
100.4	102.4	23.4	1.1	9.0	.5	89.0	1.5	.922	604
102.4	103.3	9.3	1.7	3.5	.7	95.3	.5	.906	605
103.3	105.3	29.7	2.0	11.3	.9	85.5	2.3	.914	606
105.3	108.5	13.0	1.9	5.0	.8	93.5	.7	.914	607
108.5	110.7	8.4	2.4	3.2	1.0	95.2	.6	.907	608
110.7	113.1	30.6	3.4	11.7	1.4	85.5	1.4	.919	609
113.1	115.4	22.4	2.3	8.5	1.0	89.1	1.4	.914	610
115.4	116.1	38.4	2.8	14.5	1.2	82.1	2.2	.904	611
116.1	117.1	40.4	2.6	15.3	1.1	81.2	2.4	.907	612
117.1	117.8	63.2	2.8	23.9	1.1	71.0	4.0	.904	613
117.8	118.4	56.2	3.2	21.3	1.4	73.5	3.8	.910	614
118.4	119.6	18.4	1.3	7.0	.5	91.4	1.1	.905	615
119.6	120.3	51.1	3.6	19.4	1.5	75.5	3.6	.911	616
120.6	120.8	45.9	1.9	17.6	.8	78.6	3.0	.920	617
120.9	122.6	*5.2	2.6	2.1	1.1	96.2	.6	.....	618
122.6	122.9	19.2	1.8	7.4	.8	89.8	2.0	.921	619
Core hole 17, SW¼NW¼ sec. 3, T. 13 S., R. 18 E. (unsurveyed)									
30.0	31.1	6.8	5.5	2.6	2.3	94.3	0.8	0.914	SBR55–671
31.1	31.9	14.8	2.5	5.7	1.0	92.4	.9	.920	672
31.9	33.3	16.9	3.0	6.5	1.2	91.0	1.3	.918	673
33.3	35.3	18.0	3.4	6.8	1.4	90.5	1.3	.907	674
35.3	36.0	29.9	3.4	11.3	1.4	85.3	2.0	.905	675
36.0	37.5	11.0	1.9	4.1	.8	94.2	.9	.901	676
37.5	42.0	*2.5	2.6	1.0	1.1	97.4	.5	.....	677
42.0	45.2	*2.9	1.8	1.2	.7	97.7	.4	.....	678

TABLE 4.—*Assays of cores from holes 1–18, Naval Oil-Shale Reserve No. 2, Uintah and Carbon Counties, Utah*—Continued

Depth (feet)		Yield of product						Specific gravity of oil at 60°/60°F.	U.S. Bur. Mines sample No.
		Gallons per ton		Weight percent					
From—	To—	Oil	Water	Oil	Water	Spent shale	Gas loss		
Core hole 17, SW¼NW¼ sec. 3, T. 13 S., R. 18 E. (unsurveyed)—Continued									
45.2	49.4	*0.9	2.4	0.3	1.0	98.6	0.1	.....	SBR55–679
49.4	50.9	7.4	1.7	2.9	.7	95.7	.7	0.927	680
50.9	51.9	*2.0	.1	.8	.1	98.6	.5	.....	681
72.2	74.0	.0	2.4	.0	1.0	98.6	.4	.....	682
78.7	81.1	.0	1.8	.0	.8	99.2	.0	.....	683
85.1	97.7	.0	4.7	.0	2.0	97.8	.2	.....	684
103.7	114.0	*1.2	5.0	.5	2.1	97.2	.2	.....	685
114.0	116.4	*2.5	4.8	1.0	2.0	95.7	1.3	.....	686
116.4	117.3	8.6	1.4	3.3	.6	94.9	1.2	.916	687
117.3	118.2	16.7	2.0	6.4	.9	91.1	1.6	.921	688
118.2	119.7	25.6	3.4	9.8	1.4	86.8	2.0	.919	689
119.7	121.4	14.7	3.1	5.6	1.3	91.9	1.2	.908	690
121.4	123.8	8.7	1.9	3.3	.8	94.8	1.1	.905	691
123.8	125.5	31.9	2.9	12.2	1.2	84.3	2.3	.915	692
125.5	127.5	39.2	2.4	14.9	1.0	80.8	3.3	.910	693
127.5	129.5	57.8	3.4	21.9	1.4	72.1	4.6	.909	694
129.5	131.1	44.2	2.4	16.8	1.0	79.7	2.5	.909	695
131.1	132.5	16.5	1.8	6.4	.7	91.6	1.3	.920	696
132.5	134.1	12.2	1.3	4.7	.5	93.7	1.1	.916	697
134.1	135.0	34.9	2.6	13.4	1.1	83.4	2.1	.919	698
135.0	137.5	12.7	.7	4.9	.3	93.9	.9	.919	699
137.5	139.4	34.4	2.9	13.0	1.2	84.0	1.8	.906	700
139.4	140.0	13.2	1.9	4.9	.8	93.5	.8	.887	701
140.0	141.8	11.8	1.6	4.4	.6	94.3	.7	.883	702
141.8	142.7	27.0	3.1	10.2	1.3	86.8	1.7	.905	703
142.7	145.0	6.5	1.4	2.5	.6	96.4	.5	.915	704
145.0	146.1	20.1	3.1	7.8	1.3	89.4	1.5	.923	705
146.1	146.6	10.1	2.3	3.9	1.0	94.2	.9	.921	706
146.6	149.1	*3.7	2.9	1.5	1.2	96.8	.5	.....	707
149.1	150.2	7.1	1.6	2.7	.6	96.0	.7	.903	708
Core hole 18, SW¼SW¼ sec. 7, T. 13 S., R. 19 E.									
10.0	15.0	*0.9	3.6	0.4	1.5	97.4	0.7	.....	SBR55–709
15.0	18.4	*2.9	6.2	1.2	2.6	95.3	.9	.....	710
18.4	19.4	13.3	2.4	5.1	1.0	92.6	1.3	0.916	711
19.4	21.1	*4.2	5.9	1.7	2.4	94.6	1.3	.....	712
21.1	23.3	20.4	1.9	7.6	.8	90.0	1.6	.899	713
23.3	30.6	*1.4	2.6	.6	1.1	97.4	.9	.....	714
45.0	47.3	.0	6.5	.0	2.7	96.7	.6	.....	715
59.0	61.5	.0	4.6	.0	1.9	97.5	.6	.....	716
102.4	105.2	*4.8	4.3	1.9	1.8	95.3	1.0	.....	717
105.2	106.8	23.3	3.4	8.9	1.4	87.7	2.0	.916	718
106.8	108.2	13.9	2.4	5.2	1.0	92.6	1.2	.902	719
108.2	110.7	9.6	2.3	3.6	1.0	94.3	1.1	.905	720
110.7	111.9	29.6	3.1	11.3	1.3	85.4	2.0	.914	721
111.9	112.7	21.6	2.2	8.2	.9	89.2	1.7	.908	722
112.7	115.1	59.6	3.1	22.5	1.3	72.3	3.9	.906	723
115.1	116.9	40.9	3.1	15.5	1.3	80.4	2.8	.910	724
116.9	118.5	16.4	2.6	6.3	1.1	91.2	1.4	.918	725
118.5	120.0	13.6	2.0	5.2	.8	92.9	1.1	.913	726
120.0	120.6	27.1	2.6	10.4	1.1	87.1	1.4	.917	727
120.6	122.2	12.7	1.6	4.8	.7	93.8	.7	.909	728
122.2	123.9	30.8	3.5	11.7	1.4	85.2	1.7	.905	729
123.9	126.1	12.7	1.8	4.7	.7	93.8	.8	.883	730
126.1	126.6	28.5	3.5	10.7	1.5	86.2	1.6	.908	731
126.6	127.1	10.0	2.3	3.8	1.0	94.6	.6	.904	732
127.1	129.4	*6.7	1.8	2.7	.8	96.1	.4	.....	733
129.4	130.4	13.7	2.0	5.2	.9	93.3	.6	.915	734
130.4	132.8	*4.2	2.0	1.7	.8	96.8	.7	.....	735
132.8	134.8	16.9	2.6	6.3	1.1	91.3	1.3	.895	736
134.8	137.1	13.3	2.3	5.0	1.0	93.2	.8	.899	737
137.1	138.4	17.1	2.5	6.4	1.0	91.4	1.2	.892	738
138.4	141.1	6.6	3.1	2.5	1.3	95.6	.6	.907	739
142.6	143.2	5.4	4.3	2.1	1.8	95.0	1.1	.911	1188
143.2	144.2	19.8	4.0	7.6	1.7	89.4	1.3	.925	1189
144.2	145.7	5.2	2.5	2.0	1.1	96.4	.5	.919	1190

STRIP-MINING POSSIBILITIES

Strip mining of oil shale has never been undertaken on a commercial scale in the United States. Thus it was necessary to use arbitrary specifications in designating areas which might be considered for strip mining. In this report, a deposit is considered potentially strippable if the overburden is less than 4 times the thickness of oil-shale beds which have an average yield of 25 gallons of oil per ton. Only one area, in the northeast part of T. 12 S., R. 18 E. (fig. 40), meets this specification. In this area

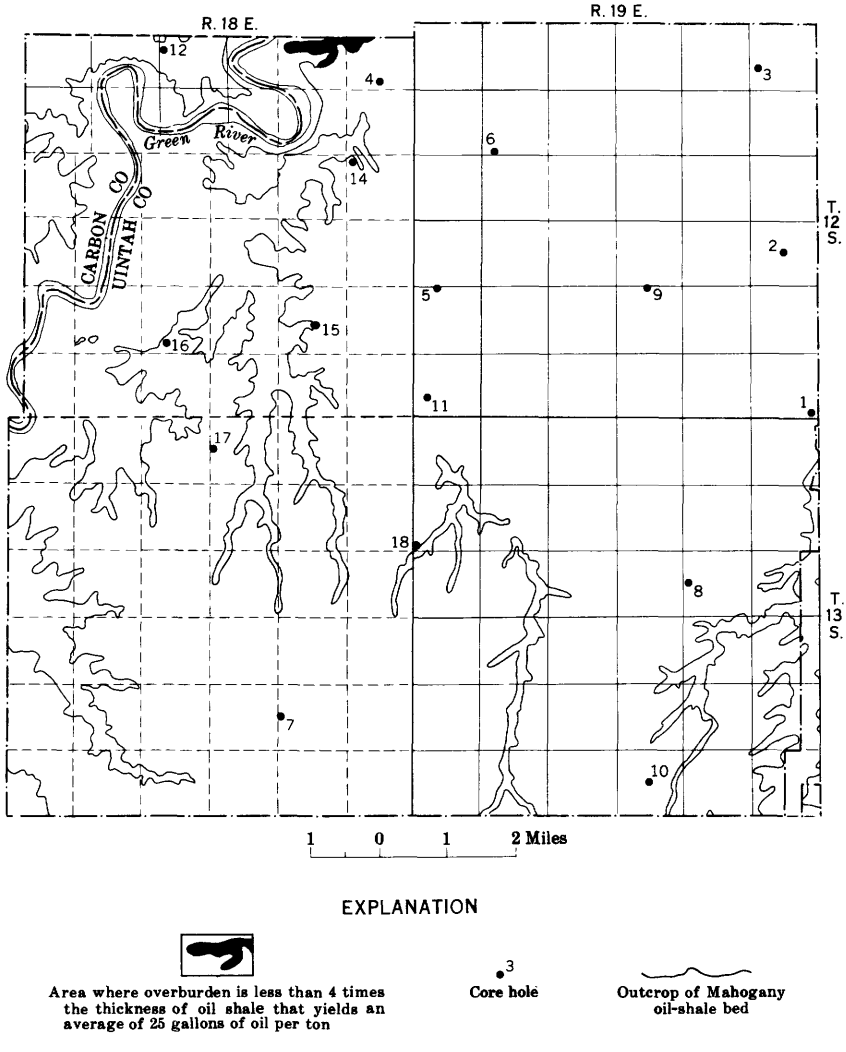

FIGURE 40.—Map showing area which may be suitable for strip mining.

the shale, which yields an average of 25 gallons of oil per ton, totals 18.5 million tons and has a potential oil yield of about 11 million barrels. The overburden is about 110 feet.

The main oil-shale zone is under thin to moderately thick overburden in a number of areas of similar or larger size in the reserve, especially in T. 12 S., R. 18 E., but the potential oil yield is less. Should it become economically feasible to exploit shale averaging 20 gallons per ton, a large tonnage would be recoverable by stripping.

OIL AND GAS POSSIBILITIES

The variety and abundance of surface occurrences of hydrocarbons, such as tar sands and veins of solid hydrocarbons, long ago drew attention to the oil and gas possibilities of the rocks of Tertiary age of the Uinta Basin. However, the first commercial oil discovery was not made until 1949, when oil was found in northern Uintah County in the basal part of the Green River formation; this well was the first well in the Roosevelt field (fig. 41). Since 1949 exploration has proceeded steadily, with moderate success.

WASATCH AND GREEN RIVER FORMATIONS

All the oil fields shown in figure 41 produce from the uppermost part of the Wasatch formation or the basal part of the Green River formation, with the exception of the Duchesne County field, where a zone in the middle part of the Green River formation is productive. Most of the exploratory wells have been drilled on structural anomalies discovered by geological or geophysical mapping. However, development drilling of the fields has thus far failed to demonstrate the presence of structural closures, and it appears likely that the oil is localized by stratigraphic traps.

Most of the exploration and discoveries have been in the deeper northern part of the basin, where the Green River formation is thicker. Recently, however, exploration in the southern part of the basin has increased. In 1952 the Cities Service Oil Co. drilled the Peters Point Unit No. 1 (well 1, figs. 41, 42) in the center of the SW¼SW¼ sec. 6, T. 13 S., R. 17 E., to a total depth of 8,310 feet. Shows of oil and gas were found in strata of the basal Green River formation and uppermost strata of the Wasatch formation between 2,804 and 2,900 feet. Gas was found in sandstone in the Wasatch formation between 4,625 and 4,653 feet, but tests did not indicate a commercial potential, and the well was

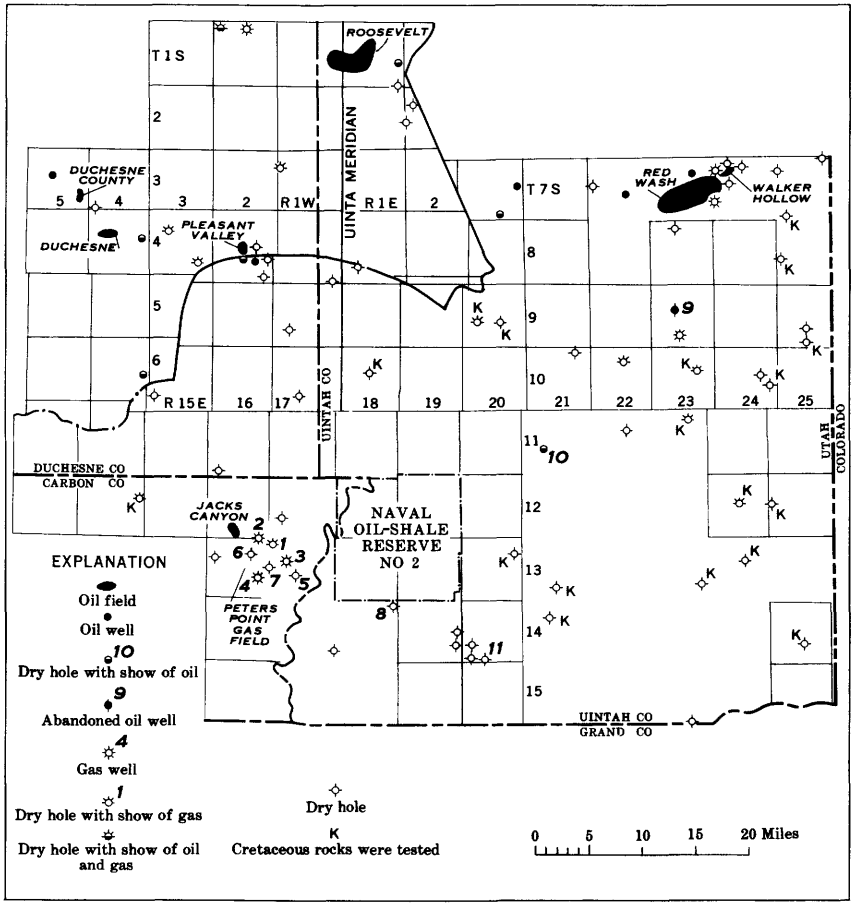

FIGURE 41.—Map showing location of Naval Oil-Shale Reserve No. 2 and oil and gas fields and dry holes in parts of Uintah, Duchesne, and Carbon Counties, Utah.

plugged and abandoned. In 1953, the El Paso Natural Gas Co. drilled the Peters Point Unit No. 2 (well 2, figs. 41, 42), SW¼-NE ¼SW¼ sec. 36, T. 12 S., R. 16 E., to a total depth of 4,984 feet. Gas in commercial quantities was found in sandstone in a zone between 2,745 and 3,232 feet, in the basal part of the Green River formation and the uppermost part of the Wasatch formation. Initial tests showed a potential of 2.1 million cubic feet of gas per day. The well is considered to be the discovery well of the Peters Point gas field. Traces of high-pour-point oil were also found in the well between 2,675 and 2,716 feet.

Five development wells have subsequently been drilled by El Paso Natural Gas Co. in the Peters Point gas field; 2 were successful and 3 were dry holes. In the Unit No. 3 (well 3, figs. 41,

42) gas was found in sandstone beds in the Wasatch formation between 4,710 and 4,795 feet. A test of the zone produced 648 thousand cubic feet of gas per day. The productive zone in this well appears to be the same as the 4,625- to 4,653-foot zone in the Unit No. 1 well. The Unit No. 3 well had a good show of gas in a zone between 2,808 and 2,878 feet. This zone correlates with the productive zone in the Peters Point Unit No. 2 and the Peters Point Unit No. 4. In the Unit No. 4 (well 4, figs. 41, 42) gas was found in commercial quantities in sandstone beds between 3,102 and 3,127 feet in the basal Green River and uppermost Wasatch, a zone correlative with the productive zone in the Unit No. 2 well. In Unit No. 5 and 7 wells (wells 5 and 7, figs. 41, 42) and No. 6 (well 6, fig. 41) no shows of oil or gas were found. The gas wells have been shut in pending construction of pipelines.

In 1954, the El Paso Natural Gas Co. discovered oil in a zone that is in the basal part of the Green River formation and the uppermost part of the Wasatch formation. The well, the Jacks Canyon Unit No. 3, is in the SE¼SE¼SW¼ sec. 28, T. 12 S., R. 16 E., a few miles northwest of the Peters Point gas field (fig. 41). Initial production was 72 barrels of 28° API gravity oil per day, pumping, from sandstone beds between 2,860 and 2,984 feet. One development well, Unit No. 4X, in the center of NW¼SE¼ sec. 33, T. 12 S., R. 16 E., drilled in 1955, had an initial flowing potential of 1.35 million cubic feet of gas and 48 barrels of oil per day.

Developments in the Peters Point and Jacks Canyon fields are of particular importance to the oil and gas possibilities of Naval Oil-Shale Reserve No. 2. The Peters Point field is associated with an eastward-plunging anticlinal nose which dies out in the southwestern part of the reserve (fig. 42). However, the distribution of the gas does not indicate that the accumulations are structurally controlled. Peters Point Unit No. 6 (well 6, fig. 41) is structurally higher than other wells in the field but was not productive; on the other hand, Unit No. 4, though drilled near the axis of a syncline (fig. 42), was completed as a gas well. Therefore, the lower structural position of Naval Oil-Shale Reserve No. 2 does not appear to be a strongly adverse factor.

The Peters Point field has two productive zones. The higher zone is in the basal part of the Green River formation and the uppermost part of the Wasatch formation. The zone is gas bearing in Peters Point Unit No. 2 and 4 wells and is oil bearing in the Jacks Canyon field. The interval between the top of the Mahogany oil-shale bed and the top of this producing zone is 2,619

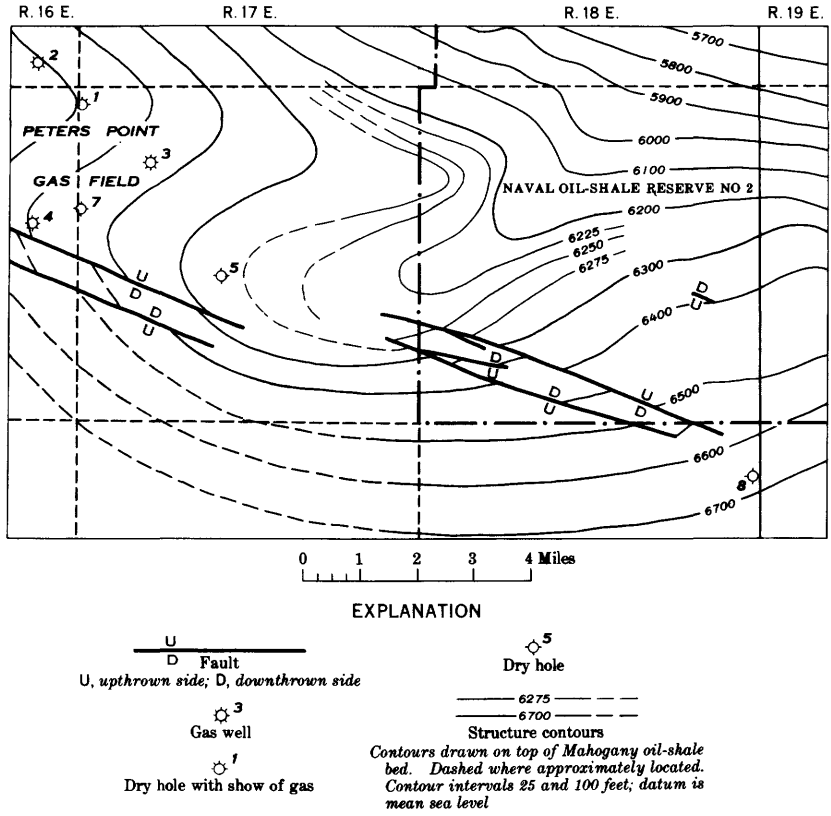

FIGURE 42.—Structure-contour map showing structural relation between the southwest part of Naval Oil-Shale Reserve No. 2 and the Peters Point gas field.

feet in the No. 2 well, 2,610 feet in the No. 4 well, and 2,730 feet in the Jacks Canyon discovery well. Between these wells and the reserve, four wells have failed to produce from this zone, although the No. 1 well had shows of oil and gas and the No. 3 well had shows of gas. In the No. 5, the well nearest the reserve, sandstone beds were not present in the zone.

The lower of the two zones produced gas in the Peters Point Unit No. 3 and contained considerable, though not commercial, quantities of gas in Unit No. 1. No. 5 well, nearer the reserve, was not drilled deep enough to test the lower zone; consequently there is no evidence as to the eastward extent of this gas accumulation. The initial potential of the zone in the single commercial well was only 648 thousand cubic feet per day. The interval between the top of the Mahogany oil-shale bed and the top of the gas-bearing zone is 4,510 feet in No. 1 well and 4,460 feet in No. 3.

In 1953, the El Paso Natural Gas Co. drilled the Firewater Canyon Unit No. 1 well in the center of the SE¼SE¼ sec. 1, T. 14 S., R. 18 E. (well 8, figs. 41, 42) to a total depth of 5,513 feet without finding shows of oil or gas. Several thick, porous sandstone beds were penetrated, some of them water bearing, but sandstone beds were not present in the zones that are productive in the Peters Point field.

To summarize, exploration in the area west of Naval Oil-Shale Reserve No. 2 has demonstrated that the Green River-Wasatch contact zone and a lower zone within the Wasatch formation are favorable for the occurrence of oil or gas. The accumulations appear to be stratigraphically controlled. Stratigraphic conditions in the correlative strata underlying the reserve, especially the southwestern part, should be similar.

MESAVERDE GROUP

Relatively little drilling exploration has been done in the pre-Tertiary rocks of the Uinta Basin. The Measverde group has been penetrated in several tests (fig. 41), and the basal sandstone beds of the Mesaverde are believed to have good possibilities for the discovery of oil or gas. In 1953, the Continental Oil Co. completed the No. 1 Chapita well, SE¼SE¼NW¼ sec. 16, T. 9 S., R. 23 E (well 9, fig. 41). Thirty barrels of 48° API gravity oil was produced from a sandstone zone in the lower part of the Mesaverde group, between 8,275 and 8,301 feet. The well was later abandoned. The Peters Point Unit No. 1 (well 1, figs. 41, 42) found a good show of gas in the 8,234- to 8,300-foot interval in the lower part of the Mesaverde group. This interval is 8,119-8,185 feet below the top of the Mahogany oil-shale bed. In 1951 and 1952, the Carter Oil Co. drilled the No. 1 Willow Creek, in the center of the NE¼SW¼ sec. 21, T. 11 S., R. 21 E. (well 10, fig. 41). This well found good shows of oil in a zone between 8,180 and 8,198 feet in the lower part of the Mesaverde group. This zone is approximately 6,700 feet below the Mahogany oil-shale bed.

ROCKS OLDER THAN THE MESAVERDE GROUP

The rocks older than the Mesaverde group in the central part of the Uinta Basin are virtually unexplored. A recent test, completed in 1956, was the first to penetrate the older rocks in the vicinity of Naval Oil-Shale Reserve No. 2. This was the Carter Oil Co. No. 1 Minton-State, center of the NE¼SE¼ sec. 32, T. 14 S., R. 20 E. (well 11, fig. 41), which was abandoned at a

depth of 12,897 feet after reportedly reaching Precambrian granite. Strata of Paleozoic age are absent or very thin in this well, indicating that the ancient Uncompahgre uplift extended northwestward at least this far into the area of the present Uinta Basin and may underlie all or part of the reserve. This ancient positive feature has been traced by surface study across southwestern Colorado and into eastern Grand County, Utah. It appeared as a landmass in the early part of the Pennsylvanian period of the Paleozoic era, and parts of it remained emergent well into the Mesozoic era. During this period the landmass was stripped of its cover of pre-Pennsylvanian and earliest Pennsylvanian strata and the Precambrian core was deeply eroded. The landmass was progressively buried during the Mesozoic era by encroaching sediments. The oil and gas possibilities near the truncated edges of pre-Pennsylvanian and earliest Pennsylvanian strata buried beneath overlapping younger strata have long intrigued petroleum geoloists, but little actual drilling exploration has been done and none has been successful. In eastern Grand County, Utah, and western Mesa County, Colo., about 35 miles southeast of the reserve, numerous folds are present in the rocks of Mesozoic age that overlapped the northern part of the Uncompahgre mass, and exploration for natural gas in this area has been notably successful in recent years. Commercial accumulations have been found in the Dakota sandstone of Cretaceous age and the Morrison formation and the Entrada sandstone of Jurassic age.

REFERENCES

Bradley, W. H., 1931, Origin and microfossils of the oil shale of the Green River formation of Colorado and Utah: U.S. Geol. Survey Prof. Paper 168.

Cashion, W. B., and Brown, J. H., Jr., 1956, Geology of the Bonanza-Dragon oil-shale area, Uintah County, Utah, and Rio Blanco County, Colorado: U.S. Geol. Survey Oil and Gas Inv. Map OM–153.

Dane, C. H., 1955, Stratigraphic and facies relationships of the upper part of the Green River formation and the lower part of the Uinta formation in Duchesne, Uintah, and Wasatch Counties, Utah: U.S. Geol. Survey Oil and Gas Inv. Chart OC–52.

Duncan, D. C., and Denson, N. M., 1949, Geology of Naval Oil-Shale Reserves 1 and 3, Garfield County, Colorado: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 94.

Stanfield, K. E., Rose, C. K., McAuley, W. S., and Tesch, W. J., Jr., 1954, Oil yields of sections of Green River oil shale in Colorado, Utah, and Wyoming, 1945–52: U.S. Bur. Mines Rept. Inv. 5081.

U.S. Weather Bureau, 1955, Climatology data, Utah: Dept. Commerce, v. 57, No. 7, p. 88.

Winchester, D. E., 1923, Oil shale of the Rocky Mountain region: U.S. Geol. Survey Bull. 729.

Woodruff, E. G., and Day, D. T., 1914, Oil shale of northwestern Colorado and northeastern Utah: U.S. Geol. Survey Bull. 581-A.

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