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Locations of Potential Interest for Fracturing Oil Shale with Nuclear Explosives for In Situ Retorting, Piceance Creek Basin, Rio Blanco County, Colorado*

By

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LOCATIONS OF POTENTIAL INTEREST FOR FRACTURING OIL SHALE WITH NUCLEAR EXPLOSIVES FOR IN SITU RETORTING, PICEANCE CREEK BASIN, RIO BLANCO COUNTY, COLORADO

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ABSTRACT

Analysis of oil assays, structure sections, and isopach maps of the Parachute Creek Member of the Green River Formation indicates that numerous locations in the western part of the Piceance Creek basin could be selected with an oil shale section at least 500 feet thick that contains not less than 20 gallons per ton of shale oil, and has at least 800 feet of overburden.

INTRODUCTION

Since 1958, the U.S. Atomic Energy Commission and the U.S. Bureau of Mines have been cooperating in a research effort to develop an effective method for using nuclear explosives to fracture deeply buried oil shale, to be followed by *in situ* retorting methods to extract the shale oil (Lekas, 1966). At the request of the Commission, the U.S. Geological Survey has undertaken a geological study of the oil shale in the western part of the Piceance Creek basin and, in particular, to describe the subsurface geology of the basin in terms of oil yield, thickness, and areal distribution of the oil shale. This information will be used, in conjunction with other information, to identify a number of locations that might be considered for an underground nuclear explosion experiment, designed to test the overall feasibility of recovering oil from oil shale. This experiment would be part of the AEC's Plowshare Program to develop peaceful applications for nuclear explosions.

Areas of potential interest would have a minimum 500-foot-thick oil shale section defined as containing not less than 20 gallons per ton of shale oil, and a minimum overburden thickness of 800 feet overlying the oil shale section.

BACKGROUND

The Piceance Creek basin is located approximately 25 miles west of the town of Meeker in Rio Blanco County, Colo. The oil shale is in the Green River Formation of middle Eocene age. The Green River Formation has been divided into the Douglas Creek, Garden Gulch, Anvil Points, Parachute Creek, and Evacuation Creek Members. The Parachute Creek Member contains the richest and thickest oil shale beds, and is composed almost entirely of shale and marlstone with varying amounts of kerogen (Donnell, 1961).

The Piceance Creek basin is a large structural downwarp. The basin is asymmetric, generally trending northwest, with very gentle dips on the south and west and steeper dips on the north and east. Two sets of joints are prominent, one set trending northwest and the other northeast. The joint systems control the drainage pattern in the south-central part of the area. High-angle normal faults with small displacements are present in the central part (Donnell, 1961).

The U.S. Bureau of Mines has published assays of oil yields from sections of the Green River oil shale. These assays were made on cuttings and cores from drill holes in the basin (Stanfield and others, 1957, 1960; Belser, 1951). A Bureau of Mines exploratory core hole in sec. 13, T. 1 N., R. 98 W., penetrated approximately 1,600 feet of the Parachute Creek Member.

PROCEDURE

This report restricts itself to the characterization of oil shale within the Parachute Creek Member of the Green River Formation. The oil shale is defined in terms of oil yields based on assays from cuttings and core samples, and on interpretation of inhole geophysical logs. R. D. Carroll (U.S. Geol. Survey, oral commun., 1965) made oil yield determinations from inhole density logs based on specific gravity-oil yield relationship (Smith, 1958). The oil yields are reported as gallons of shale oil yielded per ton of shale. A comparison of the oil yields from cores and cuttings from two drill holes in approximately the same location indicated that for these particular samples the cuttings gave generally lower values than the cores. This is a single comparison and, therefore, may not hold for all locations (Stanfield and others, 1960, p. 12).

An oil shale section, for purposes of this study, is arbitrarily defined as a section containing not less than 20 gallons per ton of shale oil, and is referred to as greater-than-20-gallons-per-ton oil shale. The minimum-500-foot-thick oil shale section stipulation is, therefore, in terms of greater-than-20-gallons-per-ton oil shale.

Figures 1 and 2 are three-dimensional fence diagrams constructed to help determine the oil shale section and to show, as accurately as possible, the actual thickness and oil yield of oil shale in the western half of the Piceance Creek basin. The fence diagrams have been divided into the following class intervals: (1) less-than-15-gallons-per-ton oil shale, (2) 15-20-gallons-per-ton, (3) 20-25-gallons-per-ton, (4) 25-30-gallons-per-ton, and (5) greater-than-30-gallons-per-ton oil shale. In addition, tick marks have been included in the 15-20-gallons-per-ton class interval to show where the upper values (18-20 gallons per ton) occur. Since most of the assayed samples from drill holes used as control points on the fence diagrams are cuttings, the tick marks are to illustrate, only, how the lower boundaries of the oil shale section might vary if oil yields determined from cuttings gave slightly lower values than those determined from cores, as reported by Stanfield and others (1960, p. 12).

A series of characteristic geophysical markers and zones occur on the electrical resistivity inhole logs and can be traced throughout the basin. These are defined here as the A, B, Blue, and Orange markers and Z and Y zones. A third zone characterized by high resistivity on the electric logs has been defined by F. A. Welder (U.S. Geol. Survey, oral commun., 1966) and is referred to as the basal zone. The basal zone thins and disappears toward the edge of the basin. The A, B, Blue, and Orange markers and Z and Y zones are excellent horizons and are useful for showing structure. F. A. Welder picked the markers and zones from the electric logs and they are shown on the fence diagrams (figs. 1, 2, 3, 4). To simplify graphical presentation, the Z and Y zones are shown as markers on the fence diagrams.

Figures 3 and 4, fence diagrams with sea level as the datum plane, show the thickness and distribution of the oil shale section; namely, the oil shale yielding at least 20 gallons of shale oil per ton of rock.

Figure 5 is an isopach map of the western half of the basin, constructed to show the true thickness and distribution of the most continuous, greater-than-20-gallons-per-ton, oil shale section. Oil yields based on assay data and geophysical logs from all available drill holes provided the basis for the map compilation.

Figure 6 is a structural contour map drawn on the top of the greater-than-20-gallons-per-ton oil shale. Figure 7 is a stream-level map depicting the land surface in terms of regional stream gradient. Figure 8, an isopach map of the overburden between the regional stream gradient and the top of the greater-than-20-gallons-per-ton oil shale section, was constructed from figures 6 and 7. The overburden map is valid only for stream level. To calculate the true overburden thickness of a location other than at stream level, it is necessary to determine the difference in elevation in feet between the location at stream gradient (fig. 7) and its topographic elevation, and add this footage difference to the overburden thickness as shown in figure 8. The topographic elevation can be obtained from topographic maps of the area or from survey data.

DISSCUSSION

Reliability of data

There is a general lack of subsurface data in the northwestern part of the Piceance Creek basin. The distance between some of the drill holes used as control points is as great as 6 miles. The majority of available oil yield values used in compiling the cross sections and isopach maps were obtained from cuttings samples which are not regarded by the Bureau of Mines as reliable as core samples. In a few instances the only data available, mainly for the northern part of the basin, were from geophysical logs. The information presented in this report, therefore, should be considered only as a guide to subsurface conditions. A maximum of 70 percent reliability is placed on any interpretation made in this report.

Interpretation of subsurface maps

The area of interest covers the western half of the Piceance Creek basin. The geologic fence diagrams (figs. 1-4) indicate that a thick continuous, greater-than-20-gallons-per-ton, oil shale section exists in the central part of the basin. However, near the edge of the western half of the basin this continuity dies out. On the margins of the western and southern sides of the basin the oil shale thins and breaks up into a series of interfingering rich and lean intervals. To the north, however, the oil shale section thickens in what was probably a subsidiary basin. There is no subsurface information available to indicate the northward extent of this thicker section, but the section presumably thins northward from the existing control points. Figure 5 shows by dashed isopach lines the estimated extent of the interfingered rich and lean oil shale zone. The dashed isopach footages represent the thickest greater-than-20-gallons-per-ton oil shale interval of the interfingered rich and lean zone. /The basal high-resistivity geophysical zone, discussed in the earlier paragraph on geophysical markers and zones, thins to the west and south of the basin. The locations where the zone no longer appears on the resistivity logs have been connected by a line which is shown on the isopach map (fig. 5). This line is called the high-low resistivity break and seems to coincide in general with the start of the interfingered rich and lean oil shale zone (figs. 1, 2).

CONCLUSIONS

Within the western part of the Piceance Creek basin there are numerous locations with a minimum 500-foot-thick oil shale section containing not less than 20 gallons per ton of shale oil and a minimum overburden thickness of 800 feet overlying the oil shale section (figs. 5, 8). Three typical locations are (1) in Duck Creek, sec. 16, T. 1 S., R. 99 W., (2) on the divide between Duck Creek and Corral Gulch, sec. 21, T. 1 S., R. 99 W., and (3) in Corral Gulch, sec. 34, T. 1 S., R. 99 W. Data for these locations are summarized in table 1.

Table 1.--Locations of potential interest

Location	Overburden to top of >20 gal/ton oil shale section, adjusted to topography (feet)	Thickness of >20 gal/ton oil shale section (feet)	Distance to nearest control (miles)	Approximate surface elevation of location (feet)
Duck Cree, sec. 16, T. 1 S., R. 99 W.	800-1,000	600-750	3.5	6,750
Divide between Duck Creek and Corral Gulch, sec. 21, T. 1 S., R. 99 W.	1,200-1,400	550-700	3.5	7,150 (center of section)
Corral Gulch, sec. 34, T. 1 S., R. 99 W.	850-1,050	550-750	2.5	6,650

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