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Report No. 36

STRATIGRAPHY AND STRUCTURE OF THE AREA OF THE UPPER MEADE RIVER, ALASKA

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ABSTRACT

The stratigraphic sequence in the upper Meade River area includes zones B to D of the Nanushuk group (Cretaceous). Zones B and C are not differentiated in mapping and description. South of the Meade River 2,100 feet of zones B-C and 1,500 feet of zone D are exposed. North of the fault zone along the Meade River, the only rocks present, estimated not over 1,000 feet thick, are zone D beds which may be at least in part younger than the zone D rocks south of the Meade River. Sands which barely meet the minimum requirements for potential reservoir beds are present in both zones.

South of the Meade River the Kigalik anticline and the Falcon Creek anticline, both sharp-crested folds, trend east. The intervening synclines are broad with low dips on the flanks. Along the Meade River the major structure is a zone of reverse faults, about three-fourths of a mile wide, which brings rocks of zones B-C on the south opposite rocks of zone D on the north. Minimum displacement in this zone is 1,000 feet at longitude 157°50'W. and 300 feet near the gas-seep lake. North of the fault zone, the Meade River anticline is a rather low fold, so poorly exposed that closure cannot be detected by surface geologic methods.

INTRODUCTION

Geologic studies of structure and stratigraphy in the area of the upper Meade River were made by U. S. Geological Survey Party 2 from July 29 to August 29, 1949. The results of the detailed survey of that part of the Meade River area extending from 69°28'N. to 69°34'N. and from 157°20'W. to 158°10'W. have previously been presented in a preliminary report.1/ That data has now been included in the photogeologic maps of quadrangles H-17 and H-18, which accompany this report as figures 1 and 2. The small amount of additional information obtained in the drainage basin of Shaningarok Creek, lying to the north of the area detailed, is also included in figure 1. The data from a reconnaissance along Falcon Creek extending southward from the west end of the detailed area is presented in the map and cross section of figure 3.

1/ Whittington, C. L., and Keller, S. A., Preliminary reports on the Carbon Creek anticline and on the upper Meade River, Alaska: Geological Investigations, Naval Petroleum Reserve No. 4, Preliminary Report No. 23, pp. 9-16 and fig. 3, 1949.

The upper Meade River area is in the northern part of the Arctic Foothills province. The physiography of the area consists of gently rounded ridges and widely flaring V-shaped valleys. Maximum relief is about 300 feet. The major drainage is the Meade River. Its banks are generally steep, and a discontinuous flood plain is developed about 10 feet above low-water level. The flood plain, in most localities, is only 100 to 200 feet wide, but in the vicinity of abandoned meanders it is considerably more extensive. Locally, these old meanders have been preserved as lakes. For some distance away from the main river secondary streams have steep banks up to 6 feet high and relatively narrow channels.

The first geologic studies in the upper Meade River area were made by E. J. Webber in 1946.1/ Early in 1949 Webber's report and field notes were utilized in photogeologic studies of the upper Meade River area by W. A. English 2/ and W. A. Fischer.3/ A seismograph survey made by Party 45 of the United Geophysical Co., Inc., in 1949 began in the upper Meade River area (see figure 1).4/

STRATIGRAPHY

Nanushuk group (Cretaceous)

The stratigraphic sequence present in the upper Meade River area consists of zones B to D of the Nanushuk group. Diagnostic fossils that have been found in the area are those of faunal zone 1 (zones B and C). No thick shale sequence without sandstone which could be correlated with zone A (Torok formation, Lower Cretaceous) is known to be present. The coal-bearing sequence is assigned to zone D. Pyroclastic deposits (bentonite and tuff) have not been found. Presumably, therefore, zones E through I, which normally contain pyroclastics in outcrop, are absent.

In this area stratigraphic data are scant. Outcrops are few and generally poorly exposed, being limited to the banks of the Meade River and its larger tributaries. However, where the plant covering is not complete in the interstream areas, rubble and residue of weathering of the bedrock gives some evidence, in many places, of the stratigraphic sequence. Rubble from the thicker sandstones forms structure traces which are best developed near the ridge tops. In some places chips of shale occur in the soil. Coal blossoms indicate the existence of coal beds beneath the surface. Because it is highly resistant to weathering, the occurrence in many places of chips and fragments of ironstone serves to overemphasize the importance of this rock. Nevertheless, the over-all picture of the stratigraphy is fragmentary, as much of the sequence is in no way exposed.

1/ Webber, E. J., Stratigraphy and structure of the area of the Meade and Kuk Rivers and Point Barrow, Alaska: Geological Investigations, Naval Petroleum Reserve No. 4, Report No. 6, 1947.

2/ English, W. A., personal communication, 1949.

3/ Fischer, W. A., Interpretation from aerial photographs of geologic structures of the central Colville River area, Alaska: Geological Investigations, Naval Petroleum Reserve No. 4, Report No. 30, 1949.

4/ Palenske, Arnold, Seismograph survey, 1949, Meade River area: United Geophysical Co., Inc., 1949.

Stratigraphic thicknesses were determined by graphic construction as direct measurement of thickness is impossible except in a few scattered outcrops. At the best any such outcrop exposes beds totaling a few tens of feet thick. Only a very small proportion of the stratigraphy of this area is exposed in outcrops.

Significant stratigraphic thicknesses are as follows:

Vicinity of Falcon Creek from axis of Falcon Creek anticline to axis of Sugarlips syncline: 3,000 feet.

Falcon Creek from axis of Sugarlips syncline to axis of Kigalik anticline: 3,600 feet.

Falcon Creek from axis of Kigalik anticline to axis of Pahron syncline: 1,500 feet.

Along meridian 157°50'W. from axis of Pahron syncline northward to the bed approximately equivalent to the highest bed on the axis of Pahron syncline at Falcon Creek: 300 feet. This thickness is determined by the amount of plunge of the Pahron syncline from Falcon Creek to meridian 157°50'W. The dips on which this figure is based were estimated from aerial photographs.

Along meridian 157°50'W. from bed approximately equivalent to highest in Pahron syncline at Falcon Creek to south edge of zone of reverse faults: 700 feet.

North of the zone of reverse faults structural data are so sparse that no reliable estimates of thickness can be made.

Zones B-C (undifferentiated)

In the Meade River area it is possible to differentiate the rocks of zones B and C from those of zone D, but the distinguishing of zone B from zone C is more difficult. Questionable contacts between zone B and zone C are shown in parts of figures 1 and 2, but these contacts are based on criteria whose validity is uncertain. Because of the poor exposures in this area it is not feasible to describe these units separately.

A considerably greater part of the total thickness of these zones is present to the south than along the Meade River. The 2,100 feet exposed on the south flank of the Kigalik anticline probably represents nearly the total thickness of these zones. The section on the north flank of the Falcon Creek anticline is 1,500 feet thick. No zone D rocks are present in the Pahron syncline, so the thicknesses, as given above, between the Kigalik anticline and the Pahron syncline and between the Pahron syncline and the zone of reverse faults, represent the thicknesses of zones B-C at these places.

The rocks of zones B-C consist mainly of alternating shale and sandstone. A few coal beds, as much as 1 foot thick, occur in the upper part. Ironstone is present in limited amounts.

Shale is probably the predominant rock type, but it is exposed in only a few outcrops. Where exposed it is mainly clay shale, light to medium gray, with a greenish cast locally, thinly bedded, noncalcareous, and with a semiconchoidal fracture.

Because of their superior resistance to weathering and erosion, many of the sandstones form structure traces in the interstream areas. Consequently, more data can be obtained on the nature of the sandstones of these zones than on the character of the other rock types. In the lower part of zones B-C the structure traces are persistent and fairly numerous. Upward in the stratigraphic column, however, they are more widely spaced and less persistent, although it is not necessarily true that the sandstones in the upper part of these zones have a lesser lateral extent than those in the lower part. It seems fairly certain, however, that in general they become progressively thinner upward, and thus show less tendency to form structure traces.

In general the sandstones are very fine to fine-grained, poorly sorted, and noncalcareous or slightly calcareous. Where unweathered, these units are light gray. Where weathered they show typical light reddish-yellow surfaces. The poor sorting, absence of glauconite, and the argillaceous content attest to at least a moderately rapid rate of deposition. Porosity in these sands varies from low to medium, and the permeability throughout is low. Porosity and permeability determinations made on several samples in the Fairbanks laboratory of the Geological Survey indicate porosity as high as 15 percent and permeability from 5 to 10 millidarcys. Throughout the area these sandstones are nondistinctive. The monotony of their appearance is offset locally, however, by oscillation ripple marks, worm trails, depositional markings, and shale-pebble inclusions. Carbonaceous material occurs sporadically, increasing to some extent in the beds higher in the stratigraphic section.

In one outcrop cyclic sedimentation is suggested by minor erosional breaks and repetition of rock types in definite sequence. A more pronounced, but still minor, erosional break is present in another outcrop. Minor diastems probably occur throughout the zones B-C sequence in this area. Oscillation ripple marks attest to relatively shallow water deposition. Indications are that the sediments of zones B-C were deposited as near-shore marine units, becoming marginal deposits higher in the stratigraphic sequence.

Zone D

The preponderance of coal seams, clay ironstone, sideritic calcareous claystone, leaf imprints, carbonized wood, and weathered nonmarine sandstone bears witness to the presence of zone D sediments in two separate parts of the upper Meade River area. In one of these places, the Sugarlips syncline, 1,500 feet of zone D rocks occurs. In the other area, between the zone of reverse faults and Shaningarok Creek, the thickness is not known, but probably does not exceed 1,000 feet.

The sandstone units in this zone are predominantly very fine to fine-grained, noncalcareous to slightly calcareous, and are generally highly weathered to a limonitic hue. In addition to this type, a sandstone bed believed to be zone D in age is present within the zone of faulting at several places. This rock is a medium- to coarse-grained sandstone, light gray in color, and distinctive in appearance. On first appraisal, this sandstone appears to be a highly favorable potential reservoir sand; however, an analysis made at the Fairbanks laboratory indicates that although its porosity is 15 percent, the permeability is low.

Other than the rocks discussed above, a minor amount of siltstone is also exposed, and at two localities conglomerate is present. The conglomerate pebbles are predominantly light-gray to black chert, with a lesser amount of white quartz. At one of these places one of the chert pebbles contained crinoid stems. A few pebbles of black argillite also occur at the same locality.

STRUCTURE

Folding

West-trending folds are well defined in the area south of the zone of reverse faults. From south to north these are the Falcon Creek anticline, Sugarlips syncline, Kigalik anticline, and Pahron syncline. The synclines are broad with low dips on the flanks, but the anticlines show sharp crests with moderately steep dips near the axis. Interpretation of aerial photographs suggests faulting on the axis of the Falcon Creek anticline. Both field and photogeologic studies give evidence of faulting along the Kigalik anticline, where structure traces come up to the trace of the axial plane and there disappear instead of curving across it.

North of the zone of reverse faults, folds are poorly defined because of the obscure surface expression of the beds. On the Meade River anticline, which can be followed for about 10 miles, the dips are low. Owing to the poor surface manifestation, it is impossible to determine whether the structure plunges.

Faulting

Along the east-flowing part of the Meade River the most important structural feature is the zone of reverse faulting. Study of the area indicates no clear-cut, single fault line, but a faulted zone extending parallel to the river as a band about three fourths of a mile wide. Within this band a number of faults contribute to the total displacement between the rocks on either side of the fault zone. The best evidence for faulting occurs at the localities described below.

Meade River at longitude 157°46'W.--A 5-foot exposure of very fine-grained sandstone strikes N.40°E., and dips 35°NW. About 100 feet to the north of the first outcrop a 6-foot exposure of similar-appearing sandstone strikes N.60°W. and dips 12°SW. South of the 5-foot outcrop dips estimated from structure traces are 5°SE. This appears discrepant with the measured dips on the two outcrops to the north. In addition, considerable coal is present below the 6-foot exposure of sandstone and to the north. No coal float is present south of this locality.

A fault is therefore postulated immediately south of the 5-foot exposure of sandstone. Lithologic character of rocks south of this postulated fault line suggests sediments of zones B-C; that to the north, zone D. Coupling this postulation with the strong northwest dip described above, which is interpreted as drag, the relative displacement is south side up, north side down.

Meade River at longitude 157°59'W.--At this locality three sandstone traces dip southward about 25°. In the northernmost trace (stratigraphically lowest) Cleoniceras and pelecypods were found. To the north, beyond a small covered interval, the next exposure consists primarily of steep south-dipping (35°-65°) coal beds. The outcrops in the next hundred yards to the north are highly contorted. Sandstone and coal beds have vertical attitudes; in places the less competent beds have been overridden and overturned. Slickensides, calcite-filled fractures, and mullion structure attest to considerable slippage. Farther to the north the beds have a low north dip. A high-angle thrust is postulated between the sandstone containing the fossils (zones B-C) and the coal-bearing section (zone D); relative apparent movement, south side up, north side down.

Falcon Creek at latitude 69°32'N.--In one of the small exposures at this place thin beds of sandstone and coal strike N.60°W. and dip 70° to 90° SW., but 10 feet to the north, thin-bedded sandstone dips southwest about 10°, and 50 feet to the south thin-bedded sandstone and siltstone dip to the southwest about 25°. A sandstone rubble trace 150 feet south of the steep-dipping sandstone and coal appears to have a low south dip. Abrupt variations in dip, plus the magnitudes of these dips in an area of otherwise low-dipping sediments, are suggestive of faulting. The fault probably lies between the exposure of thin-bedded sandstone and siltstone and the low-south-dipping structure trace.

As it is not possible to ascertain the exact relative stratigraphic positions of the units north and south of the fault zone, their displacement cannot be computed. Minimum figures, based on the absence of parts of zones B-C, can be calculated. At longitude 157°50'W. the beds at the south edge of the fault zone are at least 1,000 feet below the top of zones B-C, but at the north edge of the fault zone they are not lower than the base of zone D. The displacement at this locality is therefore not less than 1,000 feet. Eastward from this place to the vicinity of the gas-seep lake, about 700 feet of zones B-C beds progressively disappear against the south edge of the fault zone. On the north side of the fault zone no such loss of section in the zone D beds is known to occur. Therefore the displacement in the vicinity of the gas-seep lake is not less than 300 feet.

The major drainage in the upper Meade River area appears to be controlled by the faulting. It is likely that the 20-mile east-trending part of the Meade River developed along the zone of reverse faults, but that due to meandering it has subsequently moved away from the fault zone in many places. There is evidence for postulating the existence of a similar zone of faulting at one place along Shaningarok Creek, which follows an east-trending course for about 30 miles. This locality is the outcrop on Shaningarok Creek at longitude 157°55'W. in which the beds dip 24° N. The magnitude of this dip is, in this setting, suggestive of contortion or drag along the north side of a fault similar to those inferred to be present along the Meade River.

The course of the Meade River N.25°E. across the eastern part of quadrangle H-17 (fig. 1) shows an even more consistent trend than the east-trending courses referred to above. W. P. Brosge 1/ has noted difficulties in extending photogeologic interpretations across this part of the Meade River. He believes there is some evidence that parallel to this part of the Meade River there is a flexure or fault, west side down, with a displacement of 1,000 feet or more. Brosge has also noted that the course of this part of the Meade River, if projected southward into quadrangle I-17, crosses the Kigalik anticline at the place where its axis makes an abrupt swing. It would thus appear that the structural feature controlling this course of the Meade River is of more than local significance.

Three small cross faults of minor importance are present on the north flank of the Pahron syncline (see fig. 3). The evidence for these faults is offsets in structure traces. The trend of the westernmost fault is easily determined because it cuts two well-defined structure traces which are about half a mile apart. The trend of the other two faults is not as clear because only one of the offset structure traces is very distinctive. A new interpretation of their trend, based on reexamination of aerial photographs, is shown in figure 3; the earlier interpretation is shown in figure 1.

OIL AND GAS POSSIBILITIES

The Pahron gas seep occurs at the lake about a quarter of a mile north of the Meade River at longitude 157°36'W. The main seepage zone, about 50 feet in length, trends N.75°E. approximately 100 feet off the west shore of the lake. Most of the gas is escaping at the extremities of this zone. In addition, two small centers of escape are 50 feet from shore and 50 feet apart, one on either side of the projection of the main zone. When the lake is calm the seepage appears in the form of continuous bubbling at the surface of the water.

1/ Brosge, W. P., personal communication, 1950.

In addition to this seepage, gas was encountered in United Geophysical Co., Inc., shot holes No. 4 and No. 6, along Line 1-49 of the seismograph survey.1/

The analyses cited in connection with the sandstone units in this area, discussed in the section on stratigraphy, although not inspiring, indicate that these sands possess the minimum requirements for reservoir beds. A greater thickness of these sands is present in zones B-C than in zone D.

Should closure be proved on the Meade River anticline, oil possibilities may be considered in the zones B-C beds. Because of poor surface exposure, proving closure is beyond the scope of surface geologic methods.

1/ Palenske, Arnold, Party 45, Report for month of March 1949: United Geophysical Co., Inc., plate 3, 1949.