

(200)
N2299p
no. 7

✓ U.S. Geological Survey.

PRELIMINARY REPORT ON STRATIGRAPHY AND STRUCTURE
OF THE AREA OF THE TOPAGORUK, MEADE, AND
KUK RIVERS AND POINT BARROW, ALASKA.

BY

Edward J. Webber

INTRODUCTION

As part of the program of exploration in Naval Petroleum Reserve No. 4, a Geological Survey party was assigned to investigate the geology of the general area of the Meade River during the field season of 1946. A geologic traverse by boat was made down the Meade River, from the headwaters, along the west shore of Admiralty Bay and the south shore of Elson Lagoon to Point Barrow, along the Arctic coast southwest of Point Barrow to Peard Bay, up the Kukroak River for about 10 miles, along the coast to Wainwright, and 25 miles up the Kuk River. Aerial reconnaissance flights were made along the Esoktok and Nigisaktovik Rivers and the upper part of Topagoruk River. No outcroppings were seen along these rivers and plans for boat traverses were abandoned.

The objectives of the geological investigation were twofold: (1) to locate structural axes, with particular attention to areas favorable to the accumulation of petroleum, (2) to determine the stratigraphic relationship of rocks exposed in the area to the known sequence of Upper Cretaceous formations north of the Brooks Range.

This report contains a preliminary description of the structure and stratigraphy and is based largely on field work. Interpretations of field data are

tentative, incomplete, and subject to later revision. Fossils are so sparse that correlation and interpretation of Upper Cretaceous stratigraphy and structure on a faunal basis are for the most part impossible in this area. Upper Cretaceous rocks in the Meade River area are believed to be largely within Formation D. It is hoped that heavy mineral analysis of sandstones will show intraformational zones of heavy minerals that may serve as guides to interpretation of both stratigraphy and structure in the Arctic coastal plain part of the area where exposures are sparse and poor. This will have to be based on determination of mineral zones in Formation D in the headwaters area of the Meade, where the structure and stratigraphic succession are better known (pl. 1, A), and in the valleys of the Colville, Kurupa, Columagavik, and Killik Rivers where this part of the Upper Cretaceous sequence is well exposed. A completed report on results of field and laboratory studies, to be submitted April 1, 1947, will incorporate heavy mineral and other studies upon which depend the enlargement, corroboration, and possible modification of the present analysis.

Most of the area traversed lies within the Arctic coastal plain (fig. 1), where a blanket of unconsolidated sediments covers the bedrock. So far as known, outcrops here are limited to banks of streams and to sea cliffs along the Arctic coast (pl. 1, B, and pl. 2, A). Exposures are likewise limited to the banks of streams in that part of the traverse that lies within the Arctic Plateau province, with the exception of the headwaters area of the Meade. Outcrops and structural traces believed indicative of the attitude of the underlying rocks (topographic features, lines of vegetation, and lines of rubble) were not seen in the inter-stream areas. Only limited data can be obtained at the many localities along the streams where only piles of rock rubble are found. Along parts of the traverse



A. Typical exposure along stream bank in headwaters of Meade River. Gastropod and pelecypod fossils were collected from the lower part of sandstone bed.



B. Dense calcareous sandstone exposed in bed of Meade River about 10 miles south of coal mine. Beds dip in south-southeast direction (toward lower right in photograph).

the distance between outcrops was 5 to 10 miles, and the exposed stratigraphic thickness was rarely more than 15 or 20 feet (pl. 1, B). Consequently, interpolation of data between exposures is hazardous.

UPPER CRETACEOUS

Stratigraphy

Rocks of Upper Cretaceous age form the bedrock throughout the area. Sandstone, siltstone, and shale comprise the bulk of the stratigraphic section. Coal, lignite, conglomeratic sandstone, impure limestone, and bentonite occur as interbeds. The entire section is characterized by thickening and thinning of beds, lateral lithologic change and repetition of rock types. In general, the rocks are well indurated. The sandstones are typically greenish-gray and weather to yellow-brown. The predominant grain size is fine, but some are very fine- or medium-grained; a few are coarse grained. Most of the sandstone beds are cross-bedded, ripple-marked and poorly size-sorted. Many contain abundant carbonized plant remains and ironstone nodules, and some are calcareous. Several specimens of megafossils were found at two localities near the headwaters of the Meade River. The sedimentary section is indicative of deltaic deposition under terrestrial and brackish water conditions.

Meade River south of latitude 39°42' N. and north from latitude 39°48' N.

to coal mine. -- Clay shale, claystone, and mudstone comprise as much as two-thirds of the total thickness exposed, at least in the southern of the two areas. These rocks crop out at only a few places, but their relative abundance is indicated at one large continuous exposure in the headwaters of the Meade River (pl. 2, B). Most of the beds are calcareous and a few are believed to contain small amounts of bentonitic material. A few beds contain ironstone nodules and locally are carbonaceous.



A. Horizontal bed of sandstone exposed at base of Skull Cliff along Arctic coast. Oil seep indicated by arrow. Tertiary (?) and Quaternary deposits overlie the sandstone bed.



B. Exposure of interbedded sandstone and shale in headwaters of Meade River believed correlative with Formation D.

The sandstones are greenish-gray to light neutral gray and are predominantly fine-grained. Carbonized plant remains (pl. 3, A) and ironstone nodules, many of them calcareous, are abundant. Some of the sandstone beds contain calcareous cement. The proportion of calcareous sandstones to non-calcareous sandstones is smaller than the similar proportion for shales. Megafossils were found in sandstone at two localities in the headwaters of the Meade River (pl. 1, A). These consist of a few specimens of poorly preserved gastropods and pelecypods. Thin beds of conglomeratic sandstone were seen at a few places. The conglomeratic material is of pebble size and consists of rounded black and green chert, water-worn ironstone nodules, quartz, and shale. Beds of siltstone comprise a very small part of the section. A few beds of impure limestone, as much as five feet thick, were seen. Locally, these contain ironstone nodules and plant remains, attesting the environment in which the limestones were deposited. Numerous beds of coal and lignite, as much as seven feet thick, are interbedded in the section.

Thin beds of bituminous material, usually less than a half foot thick, overlie many of the coal and lignite beds. This bituminous material contains cardboard-thin lenses of a cannel-like coal, and thin layers of carbonized plant remains. Thin slivers may be ignited readily by a match flame and burn with a petroliferous odor, whereas the coal and carbonaceous material from the same specimen cannot be ignited by a match. Although similar to the coal when fresh, the bituminous material exhibits strikingly different physical characteristics when weathered; then, it is dark brown to black, soft, almost as light in weight as wood, and can be split into paper-thin sheets. Its greater resistance to weathering, compared with other rocks, is shown by its abundance in numerous large and small pieces on the bars, although it comprises but a very small fraction of the total stratigraphic

thickness. Except for its content of coal and carbonaceous material, it is similar to the oil shale found as interbeds in Triassic rocks in 1945 by the Chandler River party of the Geological Survey. The occurrence of this bituminous material as float along the Meade River is mentioned in Geological Survey Bulletin 815 (p. 284). Float, composed solely of this material, picked up along bars was used as fuel several times in the camp wood stove, where it burned with a smoke-laden, crackling flame, and gave a more intense heat than any of the coal. It burned out, however, much sooner than coal and left the entire original fragment whitened and brittle.

Meade River between 39°42' and 39°48' north latitude. -- Shale and nearly an equal aggregate thickness of sandstone and siltstone constitute the stratigraphic section. The sandstones and siltstones are greenish-gray to light neutral gray and weather yellow-brown to dirty orange. The predominant grain size of the sandstones is fine. Some of the sandstones and siltstones contain ironstone nodules and a few carbonized plant remains. Calcareous and ferruginous material are present in some, probably as cement. The distribution of rubble of a very fine- to fine-grained sandstone at one locality suggests a bed as much as 35 feet thick. Only one bed of coal was found. Most of the shales are carbonaceous.

Meade River from coal mine to mouth. -- Sandstone, siltstone, shale, coal, and bituminous material comprise the section and are similar in lithologic character and relative abundance to the rocks of the area south of the coal mine. The sandstones are distinctly denser, however, and more indurated. Beds of dense, impure limestone, as much as six feet thick, appear to comprise a sizable part of the section (p. 3, B). These contain ironstone nodules and carbonized plant remains.



A. Carbonized remains of wood in sandstone. Orientation of fragment, three feet long, is normal to the bedding.



B. Rubble of dense impure limestone from bed about six feet thick overlying thin-bedded sandstone near Meade River coal mine.

Elastic blue clay having a greasy feel and possibly bentonitic is exposed along some of the sluffed outbanks near the Meade River coal mine. Its stratigraphic position is unknown, but at a few localities the clay sluffs in such a manner as to suggest that it is interbedded in the Upper Cretaceous sequence. On the other hand, it may be the same blue clay described under the heading of Tertiary (?) deposits.

Esoktek River and upper part of Topagoruk River. -- The Esoktek River and upper part of Topagoruk River were covered only by aerial reconnaissance. No outcrops were seen. Rock rubble was observed along the stream banks, however, at a few localities in the headwaters area where these streams lie within the Arctic Plateaus. This weathered rubble appeared yellow-brown and, presumably, was sandstone. Within the Arctic coastal plain only unconsolidated sediments were observed along the stream banks (pl. 4, A). Inasmuch as outcrops were not seen, plans to traverse these rivers by boat were abandoned.

Niglanktivik River. -- The northern half of this stream was covered by aerial reconnaissance. No bedrock was seen. It is believed that this river flows on or near bedrock, however, as small piles of rock rubble along the banks are numerous. Landings were made about four miles above the mouth and about 15 miles above the mouth in order to collect samples. At the two localities inspected the rocks are similar to those along the Meade River and probably represent an equivalent part of the Upper Cretaceous section. Abundant coal float on sand bars was observed from the air for about eight miles upstream from a point near the mouth of the river. Minor amounts of coal float were also seen in the vicinity of the junction of Enelachiak Creek. Inasmuch as outcrops were not seen, a plan to traverse this stream by boat was abandoned.

Mouth of the Meade River to Point Barrow. -- No outcrops of bedrock were seen along the west shore of Admiralty Bay and south shore of Elson Lagoon. At one place along the south shore of Elson Lagoon, about eight miles east of the village of Barrow, the beach sands contain numerous subangular fragments of sandstone, as much as four inches in diameter, which weather yellow-brown. The sandstone contains carbonized plant remains and ironstone nodules. Bedrock probably is not far distant because such material was not seen along the Arctic coast between Barrow and the Kuk River unless in proximity to outcrops.

Point Barrow to and including Kuk River. -- Interbedded sandstone, siltstone, and shale comprise the stratigraphic section. The sandstones are light to dark neutral gray and greenish-gray. Along the coast, where they are constantly beaten by the salt-water spray, they weather to a dirty gray, but along the streams back from the coast they weather to both dirty gray and yellow-brown. The grain size is predominantly fine to very fine. Most of the sandstones are silty and contain carbonized plant remains and locally ironstone nodules. Interbeds of conglomeratic sandstone, containing rounded, black and green chert pebbles, are found in the sandstone beds. Shales constitute a very small part of the section studied. A thin bed of shale was the only calcareous rock seen. The coal beds are as much as 14.5 feet thick (pl. 4, B). Several thin beds of bentonite and slightly altered volcanic ash less than 0.4 feet thick are interbedded in the section.

This section appears to be different in several respects from that exposed along the Meade River. The differences are as follows: (1) beds of bituminous material were found overlying coal beds only along the Meade, (2) limestones were observed only along the Meade, (3) none of the coal beds seen along the Meade River were half as thick as one exposed along the Kuk River, (4) beds of pure bentonite



A. Aerial view of unconsolidated sands on Topagoruk River, showing flat, escarpment-broken, surface of Arctic coastal plain.



B. Part of flat-lying coal bed 14.5 feet thick, exposed on Kuk River. Bottom of bed not shown.



C. Flat-lying Tertiary (?) beds at Skull Cliff. Beds are conformable with underlying Upper Cretaceous rocks shown at bottom and with overlying Quaternary deposits above light-colored bed of bentonite.

and volcanic ash were found only along the Arctic coast and along the Kuk River, and (5) most of the sandstones seen along the Arctic coast and the Kuk River were silty, whereas fewer silty sandstones were found along the Meade River.

Correlation and thickness of Upper Cretaceous section. -- Only the lower part of the Upper Cretaceous sequence, rock units lower than Formation E, seems to be exposed throughout the area traversed. The section exposed in the northernmost anticline recognized is believed on the basis of its lithologic character, to be equivalent to Formation C. Throughout the rest of the area the rocks are believed, on the basis of their lithology, to be equivalent to Formation D. The rocks exposed in the headwaters of the Meade River are those most definitely correlated with Formation D. The rocks in the vicinity of the coal mine are similar to those in the headwaters. On the other hand, a preliminary structural profile along the Meade River suggests that the section exposed in the vicinity of the coal mine is at least as low as the lower part of Formation D and possibly may be as low as Formation B.

Preliminary compilation and interpretation of structural data have been made to permit a preliminary estimate of the thickness of the exposed section in the area traversed. The figures of thickness here given are purely tentative and may undergo considerable revision. The total thickness of the exposed Upper Cretaceous is at present believed to be about 5,700 feet. Formation D may be about 3,700 feet thick in the area of the Meade River south of latitude $69^{\circ}42'$ N., where the top and bottom are believed recognized. The rocks believed correlative with Formation C are possibly about 2,000 feet thick. The thickness of section from the vicinity of the coal mine which may possibly be added to the total thickness is probably less than 2,000 feet.

Structure

The structural data are shown on the accompanying map (fig. 1). South of about latitude 69°55' N. the strata are in gentle open folds. To the north they are horizontal or nearly so.

Three anticlines are recognized near the headwaters of the Meade. They trend east-west, and their axes are about 10 miles apart. Most of the dips measured on the limbs are less than five degrees; a few as much as 15 degrees or more were measured. The steepest dips are near the crests on the two southernmost anticlines. The dips on the southern flanks generally are steeper than those on the northern flanks. A plunge of $1\frac{1}{2}$ degrees to the east was measured on a bed at the axis of the southernmost anticline. A plunge to the west on the middle anticline is indicated by structural data measured from outcrops along the banks of the Meade River. Structural traces were not discernible on available aerial photographs that show the interstream areas or on the ground, except locally. Aerial reconnaissance along the middle anticline later disclosed other structural traces not seen from the ground. Some of these suggest an eastward plunge about four miles east of the Meade River. Structural data obtained in the area 6 to 18 miles north of the axis of the northernmost anticline suggest the presence of other folds, but here dip readings are few, questionable, and not adequate to delineate the structural axes.

In the Arctic coastal plain bedrock is believed to be nearer the surface west of the Meade River than it is to the east. Between the Meade and Kuk Rivers, the Avalik River (Geological Survey Bulletin 815, Plate II) and Nigisaktovik River flow on or near bedrock, whereas east of the Meade River the Esoktok and Topageruk Rivers flow on or near bedrock only in their headwaters

which are within the Arctic Plateaus. That this bedrock "high" may possibly reflect the regional structure to some extent is suggested by very gentle dips to the northwest in the vicinity of the Kuk River and Peard Bay, mostly horizontal attitudes between Point Barrow and Peard Bay, and gentle dips to the southeast at the Meade River coal mine and for about 25 miles south (fig. 1, pl. 1, B, and 2, A).

POST-UPPER CRETACEOUS SEDIMENTS

Tertiary (?) deposits

At Skull Cliff (fig. 1) flat-lying silty sandstones and mud shales, 8 feet thick and tentatively believed to be of Tertiary age, overlie Upper Cretaceous rocks (pl. 4, C). These were also seen at several other localities between Skull Cliff and Peard Bay but are poorly exposed. The sandstone is greenish gray and very fine grained. The Tertiary (?) deposits are only slightly consolidated in which respect they differ markedly from Upper Cretaceous rocks immediately beneath them. One of the beds of sandstone contains nearly round, well-indurated sandstone nodules 0.5 to 1.5 feet in diameter composed of a cemented form the same material as the enclosing rock. Both the upper and lower contacts of the section of Tertiary (?) deposits are marked by a bed of bentonite and altered volcanic ash less than 0.4 feet thick. These pyroclastic deposits are conformable with the overlying and underlying beds and are questionably included in the Tertiary (?) section.

At numerous places along the Kuk River and the middle and lower parts of the Meade River a stiff blue clay, having a greasy feel, was seen in thicknesses of less than a foot to as much as about six feet. This clay overlies Upper Cretaceous

rocks and underlies unconsolidated sands. This blue clay was not seen at Skull Cliff. At several sluffed sea cliffs to the southwest along the Arctic coast, however, it was found together with rubble from Tertiary (?) deposits. Relationships suggest that it possibly underlies the Tertiary beds. Similar clay is described as occurring on the Inaru River by James Gilluly (Geological Survey Bull. 815, p. 241). At several localities along the Meade River it appears to grade downward into the Upper Cretaceous bedrock. The blue clay is believed to represent a post-Upper Cretaceous soil, possibly of Tertiary age, formed by long-continued weathering at or near sea level. Although it was not everywhere seen to overlie the Upper Cretaceous rocks, its presence may be considered an indication of the presence of Upper Cretaceous bedrock within about six feet.

Quaternary deposits

Throughout the Arctic coastal plain bedrock is overlain by a cover of unconsolidated sediments, except locally along some of the stream courses where this cover has been removed (pl. 1, B). About eight miles north of the approximate boundary between the Arctic Plateaus and the Arctic coastal plain a thickness of 55 feet of unconsolidated sediments was measured, but neither the top nor the bottom contact were seen (pl. 5, A). It is possible that they may be as much as 30 feet thicker at that place. East of the Meade River these deposits probably thicken, as described under the heading of Structure. The thickness of unconsolidated deposits has been greatly modified by erosion and other agencies at many places. Unconsolidated sand is their principal constituent. Locally, clay, silt, coaly debris, and chert pebbles are admixed with the sand. Beds of peat as much as six feet thick overlie the sands at many localities. Shells similar to those of species now living in the Arctic Ocean are found at many places in these deposits.

The surface of the Arctic coastal plain is almost flat. In the southern part, however, unconnected escarpments formed in the unconsolidated sands have gentle to almost perpendicular faces as much as about 60 feet high (pl. 4, A). The ground is permanently frozen below a depth of about two feet. The small creeks are usually as deep or deeper than they are wide; their underwater profile is generally that of a "U". The Topagoruk, Meade, Esoktok, and Nigisaktovik Rivers have gentle banks and channel profiles at many places. Deep ponded river stretches are separated by braided areas and riffles where the water is a few inches to a few feet in depth. Below the mouth of the Nigisaktovik, however, the Meade River has only a few shallow braided areas of riffles, and there are none for about 20 miles above its mouth.

The part of the Meade River that lies within the Arctic Plateaus contains no thick or widespread unconsolidated deposits. Fluvial deposits, probably not more than 30 feet thick, are found in the valley of the Meade River. These are composed of sand and minor amounts of plant debris, clay, and silt. Some mammalian remains are found in these deposits.

The surface of the Arctic Plateaus in the Meade River area is gently rolling, and the maximum relief is several hundred feet. In the headwaters of the Meade River, however, the hill slopes are as much as 15 to 20 degrees and the maximum relief as much as 1,500 feet. The small creeks generally are not more than a few feet deep and have gentle banks, although many are incised for short distances above where they empty into the Meade River. The banks of the Meade are steep in most places, especially in the eastward-flowing part near the headwaters. The river is mostly less than three or four feet deep.

A report on permafrost investigations in the Meade River area by W. L. Barksdale of the Geological Survey is to be available sometime during the winter of 1946-47. It will contain additional information pertinent to exploration by seismograph and building of air strips, camp sites, and roads.

SEEPAGES AND OCCURRENCES OF PETROLIFEROUS MATERIAL

At the base of Skull Cliff a light petroleum drips very slowly from an area a few inches across in a deeply weathered bed of Upper Cretaceous sandstone (pl. 2, A). The thickness of sandstone exposed is eight feet; the lower contact was not seen. The sandstone is greenish-gray and medium- to coarse-grained. It contains carbonized plant remains. Any indications of petroliferous staining or impregnation of the sandstone have been removed by the sea water, inasmuch as the seep is between high and low tide levels. There are scattered outcrops of sandstone along the coast from near the Sina shelter cabin to near Peard Bay (pl. 5, B), a distance of about 25 miles; these probably represent the same bed as the one exposed at Skull Cliff. At these outcrops, however, the sandstone is fine- to very fine-grained and silty. Another oil seep has been reported about $1\frac{1}{2}$ miles northeast of the Sina shelter cabin near the head of one of the gullies emptying into the ocean. This latter seep is said to be readily visible in the wintertime.

Gas bubbling from the bed of a lake near the headwaters of the Meade River is coal gas, according to an analysis made for the U. S. Navy.

Bituminous material having characteristics of oil shale is found in thin, numerous beds along the Meade River, as described in the section on Stratigraphy. The beds range in thickness from less than 0.1 to as much as 1.2 feet. They overlie beds of coal or lignite.



A. Unconsolidated Quaternary deposits on Meade River in Arctic coastal plain about eight miles north of the Arctic Plateaus. Deposits here measured 55 feet thick.



B. Exposure of flat-lying bed of sandstone near Peard Bay, believed correlative with sandstone bed at Skull Cliff shown in Plate 2, A.

Natives have reported "lakes of oil" in the vicinity of Wainwright. Investigation at Wainwright and geological investigations along the Kuk River indicate that these reports probably refer to the deposits of peat that have a strong organic odor. Material that may be pitch is said to have been found near the head of the Ivisauruk River and also between the Ivisauruk and Kaolak Rivers. A greasy mud, which does not freeze in wintertime, is reported as occurring on the Avalik and Kaolak Rivers. Descriptions suggest that it may possibly be bentonite.