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Geological Investigations

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Preliminary Report No. 22

PRELIMINARY REPORT ON THE STRATIGRAPHY AND STRUCTURE OF THE TITALUK ANTICLINE IN THE VICINITY OF MAYBE CREEK, ALASKA

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By

W. P. Brosgé and A. N. Kover

November 1949

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INTRODUCTION

In 1949 U. S. Geological Survey Party No. 1 was assigned to map the Titaluk anticline between the Meade River and the head of Maybe Creek. The party's purpose was to define areas of closure along the axis of the anticline, by structure contours where possible. Earlier field work and photographic studies of the Titaluk anticline 1/ had proven closure on the Maybe Creek dome and had shown probable closure on another structural high just east of the Ikpikpuk River. Party No. 1 spent the summer of 1949 in detailed mapping of structures from the Maybe Creek dome to the Ikpikpuk River and in hasty examination of the few outcrops about 8 miles west of the Ikpikpuk. The The party was comprised of two geologists, two field assistants, a cook, and a mechanic, transported by three weasels and a weasel trailer. Weasels were used not only to move from camp to camp, but also for daily travel in the field, almost to the exclusion of travel by foot. The party left Umiat on June 5 and returned there, with weasels, on August 28.

The area mapped comprises about 175 square miles between parallels 69°15' N. and 69°30' N. and meridians 153°40' W. and 154°50' W. It lies about 150 miles south of Point Barrow and 60 miles west of Umiat. From Umiat the area is easily accessible by weasel along a route that follows the Barrow Trail to the big bend 30 miles west of Umiat and thence along the divides around the head of Prince Creek and Maybe Creek. The distance from Umiat to the Ikpikpuk River along this overland route is 90 miles. Within the area all points can be reached by weasel travel along the ridge crests or across the heads of minor streams, but at the intrenched lower courses of the south-flowing streams and the waters of Maybe Creek and the Ikpikpuk River during late spring flood are virtually impassable to weasels.

Oxbow lakes on the floodplains of Maybe Creek and the Ikpikpuk River, and a mile-long lake about 4 miles north of the Titaluk anticline axis (69°28' N., 154°22' W.) are landing sites for single-engine float or ski planes. The latter lake should also furnish a perennial water supply.

Exposures of rock in place are rare in this area, but the outcrops of most of the sandstones are identified by fairly conspicuous bedding traces marked by sandstone rubble, steep slopes, and the dominance of brush, berries, or moss over grass. For structure contouring, and for the three-point solution of dip and strike problems, the altitudes of sandstone units were measured by plane table and stadia methods, and the thicknesses of the sandstone units and of the intervening stratigraphic intervals were determined by stadia traverse. All altitudes were controlled by a net of fourth-order triangulation and trigonometric levels based on the altitude 672 feet above sea level determined by Ray and Fischer 1/ in 1946 for their Cairn number 9 on the Maybe Creek dome.

1/ Ray, R. G., and Fischer, W. A., Stratigraphy and structure of the area of Maybe Creek, Geol. Investigations, Naval Petroleum Reserve No. 4,

In parts of the area all stadia points were mapped on the plane table, but for the most part only triangulation and traverse stations were so mapped. All points were identified and marked in the field on vertical aerial photographs; the scale of each photograph was computed from the distances between mapped points. The maximum deviation from the normal scale of 1:20,000 was 3 percent.

STRATIGRAPHY

Zones E, F, and G of the Upper Cretaceous part of the Nanushuk Group are exposed in the area north of Maybe Creek. The section is about 800 fet thick. Only nine lithologic units comprising about a third of the total thickness of beds underlying the area are well enough exposed to be identified and mapped. The rest of the section is almost entirely covered; its lithology is conjectural and assumed to be shale. Eight of the mapped units are sandstones that make prominent bedding traces; the ninth is the interval of shale and limestone concretions containing fossils of Faunal Zone 3 in Zone F. Where exposed, this unit is identified by its fauna, but, because, like the rest of the shales, it crops out only in cut banks, only spot locations of Zone 3 can be mapped.

Ray and Fischer in 1946 mapped the bedding traces of the sandstone units in the field and from aerial photos, and numbered the traces (1) to (8) from oldest to youngest. Few changes are made here in their mapping and correlation of the bedding traces, but the small isolated trace called by them number (1) is correlated with their trace number (3). Because the deletion of trace number (1) from their nomenclature does not affect the correlation of the rest of their numbered traces, numbers (2) to (8) are used in this report as used by Ray and Fischer. In addition, an isolated trace above number (8) that was not numbered by Ray and Fischer is numbered (9) in this report.

In some places the correlations shown by this report within the interval from trace (2) to trace (8) differ from those shown by Ray and Fischer. In the vicinity of lat. 69° 20' N., long. 154° 26' W., the correlations of both reports agree, and the traces of sandstone units (4) and (6), key units for correlation, are defined as those mapped in that area.

Traces of the mapped sandstone units are discontinuous, because of breaks in outcrop caused by recent erosion, and because in places the traces themselves are absent even where their horizon is exposed by the present topography. The lithology of most of the sandstones is too variable to be used as a guide in correlating bedding traces. Therefore, the sandstone units of separated sections were correlated by tracing out key units between sections, or by projecting key units across narrow gaps. Sandstones above and below the key units were correlated by matching sequences and thicknesses. The most difficult gaps to bridge are those formed by Anak Creek, Baby Creek, and Banshee Creek. Traces of sandstone (6) were correlated by projection across Anak and Baby Creeks near their southern ends. West of Baby Creek traces of sandstones (6), (7), and (8) are

exposed fairly continuously north to the axis of the anticline, and from there were correlated with the isolated section east of Baby Creek and north of the axis by projection of trace (7) across the head of Baby Creek. Correlation of sections east of Banshee Creek with those to the west is based largely on the continuity of trace (7) along the low divide on the north side of Banshee Creek, where the trace is manifested only as a line of scattered alders on an otherwise grass-covered slope. From Banshee Creek westward to the Ikpikpuk River, key bedding traces can be followed continuously from section to section except for the area on Fry Creek north of the axis. There two isolated traces have been correlated with the trace of unit (3) just south of the axis, but might be either (2) or (4).

Zone G

Rocks of Zone G are found over most of the area, but neither the upper nor the lower boundaries are shown on the map (fig. 1). The youngest beds preserved are those of sandstone unit (9) which crops out between Anak Creek and Baby Creek. There Zone G is at least 250 feet thick. The upper boundary of Zone G is certainly present about 10 miles northeast of the area mapped, where Stefansson 1/has traced the Umiat sandstone of Zone H to the northern flank of the Wolf Creek anticline, and an estimate of the thickness of Zone G may be made there. Stefansson estimated an interval of 1,650 feet between the Umiat sandstone and the top of a calcareous sandstone that he tentatively correlated with the 350-foot basal sandstone of Zone G at Umiat. If this correlation is correct, the 1,650-foot interval at Wolf Creek is represented by an almost equal interval, 1,560 feet, at Umiat, where the lowest 400 feet of this interval is assigned to Zone G. At Wolf Creek Zone G probably includes an almost equal thickness of poorly exposed beds above the basal sandstone. The supposed basal sandstone at Wolf Creek is about 20 feet thick, so the total thickness of Zone G there is probably on the order of 400 to 500 feet.

The supposed basal sandstone of Zone G at Wolf Creek has not been correlated with any of the sandstones in the Maybe Creek area. At Umiat the base of Zone G is drawn at the base of this sandstone and at the top of the 200 feet of Zone F black paper shales that include Faunal Zone 3. In the Maybe Creek area the Zone F shales could be identified only by the presence of Zone 3 fossils. These fossils were found only east of Baby Creek where sandstone unit (6) was the first trace-making unit above the faunal zone. However, the measured thickness from this sandstone down to the faunal zone (240 to 370 feet) includes sandstone units (3), (4), and (5) where they crop out about 4 miles west of Baby Creek. Thus, any one of the sandstones (3), (4), (5), or (6) may be considered the sandstone immediately overlying the shales that contain Faunal Zone 3. For this reason, the lower boundary of Zone G, although certainly present, has not been shown on the geologic map (fig. 1). Because it is a continuous mappable unit, sandstone (6), used by Ray and Fischer 2/ as the approximate base of Zone G, is probably the best choice. Sandstones below it will be described with Zone F.

1/ Stefansson, Karl, Thurrell, R. F., Jr., and Zumberge, J. H., Stratigraphy and structure of the Wolf Creek anticline, Alaska, Geological Investigations, Naval Petroleum Reserve No. 4, Report No. 13, 1948.

2/ Ray, R. G., and Fischer, W. A., op. cit.

The exposed rocks of Zone G include sandstone units (6), (7), (8), and (9); isolated outcrops of tuff; and several thick coal beds underlain by bentonite. The rest of the section is covered, but is interpreted from the gray clay soil, rare shale chips, and narrow streaks of coal dust and chips as mostly clay shales containing very thin and discontinuous coal beds.

Sandstone (6) is 12 to 55 feet of yellow to light-gray, fine- to medium-grained sand, well cemented by calcium carbonate. About 30 percent of the grains are black chert, the rest mostly white quartz. Ironstone is common, and a few plant fragments were found. East of Anak Creek the sandstone contains more feldspar fragments, and the grains are more angular. West of Anak Creek there is almost everywhere at the base a gray, very fine sandstone to siltstone that contains scattered oblate black chert pebbles about 1 inch in diameter. At the mouth of Baby Creek this zone overlies about 25 feet of very limey siltstone that contains a few pelecypods and thin lenses of fine-grained limestone showing cone-in-cone structure. Two miles farther down Maybe Creek the limestone and fossiliferous siltstone is exposed about 100 feet below sandstone (6).

Sandstone (7) is 10 to 58 feet thick and is typically yellow or light gray to salt-and-pepper-colored, medium- to coarse-grained and conglomeratic. Black chert grains make up to 50 percent of the rock. Ironstone is abundant. The conglomerates are not found in all exposures, nor in the same horizon of the unit, but are present locally throughout the area. On the trace about 1 mile southwest of the head of Banshee Creek the float rock grades laterally within 500 feet from medium-grained through coarse-grained sandstone to pebble conglomerate in coarse sand matrix. Two and one half miles northwest of the mouth of Anak Creek the float grades upward from fine to coarse sandstone that contains granules and pebbles. The conglomerate pebbles are commonly subround, prolate, and from a quarter to a half inch in diameter, but may be as much as 2 inches in diameter. Most pebbles are black chert, the rest quartz. The sandstones and probably most of the conglomerates are well-cemented by calcium carbonate, but east of Anak Creek conglomerate pebbles occur in a spongy matrix of limonitic clay.

Just beneath the trace of sandstone (7) there is coal. Sub-bituminous coal beds at least 8½ feet thick and underlain by about 30 feet of bentonite are exposed at two places east of Anak Creek. From Anak Creek to Banshee Creek coal shows only as chips in the soil. West of Banshee Creek no coal was found. Carbonized plant fragments and chips and slabs of silicified wood are common throughout the area.

Sandstone (8) is light gray to salt-and-pepper colored, calcareous, and contains 30 to 50 per cent black chert grains. Grain size ranges from fine to coarse, with some pebbles and granules. Plant fragments and leaf impressions are common. About a mile north - northeast of the mouth of Banshee Creek a bed of sub-bituminous coal 6½ feet thick lies just below the trace. Two and a half miles northeast of the bend of Banshee Creek 11 feet of coal and bentonite are underlain by another 11 feet of bentonite just below the trace. Both coals disappear laterally in 200 feet.

Sandstone (9) is mapped only in a small area 3½ miles east of the mouth

of Baby Creek. Here it consists of about 13 feet of light tan to gray, very fine- to medium-grained probably tuffaceous sandstone with carbonized plant fragments; it lies about 40 feet above sandstone(8). About 1 mile southeast of the head of Baby Creek 12 feet of granule conglomerate overlain by 9 feet of yellow tuff is exposed 43 feet above sandstone (8). The conglomerate grades laterally into sandstone and the trace disappears in a quarter of a mile.

Zone F

Zone F is identified in the area by the diagnostic Faunal Zone 3 fossils. Inoceramus labiatus, Scaphites sp., Borissjakoceras sp., and Natinoceras sp. were found in four cut-bank exposures located on Figure 1. The fossils at the two sites near the head of Baby Creek, and probably those on Anak Creek, were about 240 feet below sandstone (6). The fossils on Maybe Creek were about 370 feet below sandstone (6); this 370-foot interval was determined by stereocomparator measurements controlled by known elevations on Baby Creek and Maybe Creek. The intervals above the fossils, where measured, are largely covered, but all cut-bank exposures of rocks in those intervals in that part of the area show them to be shale. On Maybe Creek and Anak Creek the shales are black and fissile and contain a few lenses of coal about 1 foot long and from a quarter to half an inch thick. In the two exposures at Baby Creek there is little black shale and the rocks range from dark-gray chippy clay shale through silty shale to thin-bedded nodular siltstone. All exposures show interbeds of yellow bentonite less than 2 inches thick, and one bed at the fossil site on the tributary to Baby Creek is 18 inches thick.

Limestone concretions or their fragments are common in all shale exposures. The limestone is dark, dense, and very fine grained, and weathers yellow. In the nonfossiliferous exposures the limestone is in rectangular fragments with much cone-in-cone structure or in disc-shaped concretions a foot thick and 2 or more feet in diameter broken by a polygonal network of calcite-filled joints. Where fossils were found, the concretions are less fractured, and bedding parallel to that of the shale is traced by concentric ridges on their outer surfaces and by color banding on fresh surfaces. The long axes of concretions and fossils lie in the bedding planes. Fossiliferous concretions ranged through an interval of 27 feet on Maybe Creek and probably through 40 feet on Baby Creek. At each of the other sites only two fossiliferous concretions were found.

West of Banshee Creek sandstone units (2), (3), (4), and (5) are present within an interval of about 460 feet below the base of sandstone (6). Although no Zone 3 fossils were found in the interval between any of these sandstones, one or more of the sandstones probably correlate with part of the 240-to 370-foot shale section below sandstone (6) just to the east. Traces of sandstones (4) and (5) are shown on the map to disappear just west of the mouth of Baby Creek, and the trace of sandstone (3) disappears just south of Kay Creek. It is assumed that sandstone (2) is not present in the eastern sections either.

The estimated location of Faunal Zone 3 has been shown on the geologic map (Figure 1) by a dotted line, and on the stratigraphic sections (Figure 2) by a dashed line. If it is projected westward at the 240-foot stratigraphic distance below sandstone (6) that was measured at the westernmost fossil sites, faunal Zone 3 falls within the 100-foot interval between sandstones (3) and (4).

Westward projection of the faunal zone at this level implies the interpretation that the zone is roughly an horizon, and that the greater interval between sandstone(6) and the fossils on Maybe Creek represents an eastward thickening of the overlying shales. Another possible interpretation is that the faunal zone is at least 120 feet thick; its top about 240 feet, and its bottom about 370 feet below sandstone (6). Projected at these levels the faunal zone would include sandstone (3) and lie directly on sandstone (2). The lower boundary of Zone F is not shown on the map. At Umiat Zone F is about 400 feet thick, has a middle sandstone at the base of the black shale, and overlies a conglomeratic sandstone (Ayiyak) at the top of Zone E. Depending on the projected position and thickness assumed for Faunal Zone 3, sandstone (2) might be either the sandstone underlying Zone F or a middle sandstone at the base of the faunal zone. Because the 135 feet of rocks exposed below sandstone (2) includes much coal and bentonite, this sandstone is probably part of Zone E.

Sandstone (2) is mostly gray to salt-and-pepper, fine-to medium-grained, with as much as 50 per cent of black chert grains. Most rocks are noncalcareous, and some quite friable. By its traces the sandstone may be divided into two members, the upper one present only in an area on the anticlinal axis at about long. 154° 34' W., the lower one absent in part of that area. The trace of the lower member has conspicuous bare patches of light-gray, loose sand and clay. Locally sandstones near the base of the unit are cross-bedded and ripple-marked. On Kay Creek the lower member includes a 10-foot conglomerate of chert, quartz, and quartzite pebbles from a quarter of an inch to 2 inches in size, in a matrix of medium-grained, friable sandstone. The conglomerate is present for only about 400 feet along the outcrop, and contains tongues or lenses of sandstone. Immediately above is 5 to 10 feet of red calcareous sandstone with abundant remains of Tellina sp.

Sandstone (3) is gray, medium-grained, and calcareous, with about 30 percent of black chert grains. Three traces are mapped for this sandstone in the area about 2 miles east of the bend of Kay Creek. Elsewhere only one, probably the upper trace, can be followed.

The lithology and thickness of sandstone (4) change sharply going northwest across its outcrop area. South and east of Kay Creek this sandstone is from 35 to 94 feet thick, generally about 60 feet. The rock is dark-gray, fine-to medium-grained, highly calcareous, with about 10 per cent of dark grains, and contains a few wood fragments. Except for an upper 5 or 10 feet of very friable thin-bedded sandstone, it is dense and massive, in beds up to 3 feet thick, and it forms the highest and steepest traces in the area. North and west of Kay Creek sandstone (4) is only 10 to 38 feet thick, gray to yellow, thin-bedded, and locally has torrential cross-bedding. Scattered coal fragments and an 18-inch bed of bentonite are just above the sandstone at one place.

Sandstone (5) makes a trace only about 2 miles north of the mouth of Banshee Creek, and again about 3 miles northwest of the mouth. There it is gray, fine-grained and calcareous and contains a few black chert pebbles like the basal part of sandstone (6).

Thickness and distribution of sandstones

For structure contouring, the stratigraphic intervals between locally

mapped units and the base of sandstone (6) had to be estimated over the whole area. For each sandstone unit, and for each interval between sandstones isopachs based on measured sections were drawn in the simplest pattern that fit the data. The changes in thicknesses shown by the isopach maps are shown in the stratigraphic sections of Figure 2. In these sections sandstones (2), (3), and (4) are abruptly ended, and sandstone (5) is absent. The termination of the sandstones is based on the assumption that where the horizon of a sandstone is present, but there is no sandstone trace, there is no longer sand at that horizon. There is no direct evidence to support this assumption. However, some systematic control of the disappearance of traces is indicated by the fact that mapped points of the disappearance of any one trace can be connected by fairly straight lines of continuous trend. Each of these lines is the boundary between an area in which the trace of a sandstone is present and an area of no trace of that sandstone, and is interpreted as a line separating sand and shale facies and as the zero isopach of the sand.

Isopachs and facies boundaries of two sandstones are parallel to the trend of present structures. Sandstone (2) is exposed only around the structural high just east of the Ikpikpuk. A zero isopach is 2 miles southwest of the Titaluk anticline axis; the line of maximum thickness (about 60 feet) is along the axis. North of the axis the sand thins again to less than 20 feet. Sandstone (6) is mapped for almost the full length of the area. A line of minimum thickness (about 20 feet) is parallel to and 4 to 5 miles southwest of the Titaluk anticline axis. East of Baby Creek the thickness reaches a maximum of about 40 feet on the axis and then diminishes northeastward to about 30 feet. The northern facies boundary of the sandstone crosses the axis near Baby Creek; west of there it is about 3 miles south of, and roughly parallel to the axis.

STRUCTURE

Geologic structure is shown on figure 1 by contours drawn on the horizon of the base of sandstone (6). The oil sand of Umiat Core Test No. 1 about 900 feet below the black paper shale, would be about 1,200 feet below the contoured surface. The only through-going structural axis shown is that of the Titaluk anticline, which plunges generally to the southeast, but has two areas of reversal of plunge that produce closure, one just east of the Ikpikpuk River, and the other east of Baby Creek and including at its eastern end the Maybe Creek dome mapped by Ray and Fischer 1/.

The shape of the structure is roughly that of the topography. The divide between north- and south- flowing streams follows fairly closely along the anticline axis. On the structural high east of Baby Creek the sandstones have been breached and form a rim around a low amphitheater in the thick section of Zone F shales. On the structural high east of the Ikpikpuk the same Zone F section is exposed, but there includes sandstones. The main divide there is directly along the anticline axis, and the highest topographic point of the whole area is close to the highest point on the structure.

The structure contours are based on measured altitudes of the various sandstone units plus or minus their estimated stratigraphic distance from sandstone (6) in each locality. The validity of the relative elevations of contours in widely separated areas therefore depends on the correlation of the mapped units. However local dips indicated by the contours are generally independent of correlation because they are based on points all on the same trace.

The correlation of two isolated traces on Fry Creek near the anticline axis is in doubt. These traces are mapped as those of sandstone (3), but might be of sandstones (2) or (4), so contour altitudes on the axis there might be in error by plus or minus 150 feet. These errors would affect the local rate of eastward plunge of the anticline but not the amount of closure on either of the two structural highs.

Sandstones on the structural high east of Baby Creek are breached, so contours there must be dashed. The highest mapped altitudes of sandstone (6) are shown by 10-foot contours on the Maybe Creek dome and on the higher point just east of Baby Creek. The western closure of dashed contours is controlled by elevations on the traces of sandstone (7) that face each other across Baby Creek and across the anticlinal axis. Unless dips of this sandstone are assumed to steepen sharply in the gap between these traces, the 650-foot contour must close east of Baby Creek.

In the area of westward plunge on the high east of the Ikpikpuk it is possible to follow key beds almost continuously, so that the shape, if not the elevation of the structure relative to eastern areas, cannot be in doubt. The two solid 50-foot contours at the top of the high are drawn from elevations of sandstone (2), and the solid 50- and 10-foot contours of the western closure from sandstone (4). It is because a continuous sequence of sandstones

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1/ Ray, R. G., and Fischer, W. A., op. cit.

(2), (3), (4), (5), and (6) can be traced through this area and southward toward Maybe Creek that sandstone (6), the contoured surface, is defined at its westernmost outcrop. The horizon of sandstone (6) is above the rocks preserved on the high and its position must be projected. The interval from the base of sandstone (4) to the base of sandstone (6) varies by only about 40 feet (about 20%) in areas where both crop out, and the minimum value has been used in projecting sandstone (6) over the structural high.

Earlier maps of the area 1/, 2/ have shown the axis of the Titaluk anticline as intersecting the Ikpikpuk one half to one mile north of the location shown on figure 1. No traces were found north of those shown along the axis here, and the traces mapped do define an axis as shown. It remains possible, however, that the axis drawn west of the high is that of a small fold on the flank of the main fold, like the one plunging southwest 4 miles southeast of the high. The main axis may have a more northerly bearing west of the high, and contours that close around the minor fold may fail to close around the anticline. If the structure contours close normally around the axis mapped at the Ikpikpuk, the amount of closure is at least 370 feet. If the axis shown is only a minor fold axis, the amount of closure is at least 50 feet.

RESERVOIR POSSIBILITIES

Laboratory determinations of porosity and permeability of the eight sandstone units have not been made. All the sandstones are calcareous, and most specimens of their weathered float were estimated in the field to have medium porosity. Locally some rocks, such as the conglomerate and intertongued sandstone in unit (2), are highly porous. The sandstones of unit (4) have very low porosity south of Kay Creek, where they are dark and massive, but have greater porosity to the north where they are yellow and thin-bedded. The change in facies along the horizon of Unit (4), from shale in the southeast through low porosity sandstone to medium porosity sandstone in the northwest, suggests reservoir properties of other sandstones may improve near the axis of the anticline.

1/ Ray, R. G., and Fischer, W. A., op. cit.

2/ 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.