No. 11

PRELIMINARY REPORT ON THE STRATIGRAPHY AND STRUCTURE OF THE AREA OF THE KIGALIK AND AWUNA RIVERS, ALASKA

By

C. L. Whittington and M. L. Troyer

INTRODUCTION

During the summer of 1947, U. S. Geological Survey Party No. 2 made a reconnaissance survey of the area between Awuna River and the divide north of the Kigalik River. The westernmost observations were made along the Awuna anticline to longitude about 157°30' W. and along the Kigalik anticline to longitude about 156°55'W. The easternmost work was done along the Knife Blade Ridge anticline at a longitude of about 154°30'W. Not all of this area was traversed, but a general idea of the area studied may be had by noting the distribution of dip and strike symbols on Figure 1.

Parts of this area had been previously visited by Smith 1/ in 1927 as a part of his traverse from Allakaket to the Arctic Coast. In the period from about July 10 to August 5 his party ascended the Awuna River and Birthday Creek, portaged over the Kigalik-Awuna divide at Birthday Pass, and descended the Kigalik River to its mouth.

Various parties in the field season of 1946 worked in areas not far distant. Webber 2/ began his field work near the headwaters of the Meade River and measured a section across the Kigalik anticline about 25 miles beyond the westernmost observations made on that structure by Party No. 2. Work by Chapman and Thurrell 3/ along the Colville River parallels at a distance of three or four miles work by Party No. 2 in the vicinity of Knife Blade Ridge. The easternmost observations by Party No. 2 in the vicinity of Knife Blade Ridge are about 11 miles west of the area south of Maybe Creek mapped by Ray and Fischer. 4/

Of the 1947 work of other field parties that of Thurrell 5/ along the Colville River is most closely related to this report. His thickness from the base of Zone A to his Trace No. 5 is included in Column 1 of Figure 3. Webber's work 6/ along the Ikpikpuk and Titaluk Rivers is also in a closely related area.

1/ Smith, P. S., and Mertie, J. B., Jr., Geology and mineral resources of northwestern Alaska: U. S. Geol. Survey Bull. 815, p. 14, 1930.

2/ Webber, E. J., Stratigraphy and structure of the area of the Meade and Kuk Rivers and Point Barrow, Alaska: U. S. Geol. Survey Report No. 6, 1947.

3/ Chapman, R. M., and Thurrell, R. F., Jr., Stratigraphy and structure of the area of the Kurupa, Oolamnagavik, Killik, and Colville Rivers: U. S. Geol. Survey Report No. 5, 1947.

4/ Ray, R. G., and Fischer, W. A., Stratigraphy and structure of the area of Maybe Creek: U. S. Geol. Survey Report No. 4, 1947.

5/ Thurrell, R. F., Jr., Preliminary report on the stratigraphy and structure of the area of the Colville River between the Ipnavik and Kurupa Rivers, Alaska: U. S. Geol. Survey, 1947.

6/ Webber, E. J., Preliminary report on the stratigraphy and structure of the area of the Titaluk and upper Ikpikpuk Rivers, Alaska: U. S. Geol. Survey, 1947.

Party No. 2 moved through this area by weasel, the weasels being used extensively on the daily traverses. The party assembled at Umiat late in May and was flown out to a lake about one mile west of the Ikpikpuk River at latitude 69°40'N. where the weasels and initial supplies had been previously cached. Early in June the party moved south into the area in which it was to begin work. For the next several weeks the party worked in the area north of the Kigalik River, moving westward along the divide north of that river. At this time considerable work was done south of the Kigalik River, west of longitude 154°40'W. No closure was detected along the Kigalik anticline. Shortly after the middle of July the party moved southwestward to the vicinity of the Awuna anticline where a westerly plunge had been suggested from the study of aerial photographs. The general route of the party from then on was eastward along the divide between the Awuna and Kigalik Rivers. Due to the need to reach a food cache further east very little data was gathered in the area between Birthday and Section Creeks. It was intended to work this area by one or two spike trips from the camp at the head of Section Creek. However, after constructing a cross-section from data gathered by the party along Section Creek and by Thurrell in the area between the Colville and Awuna Rivers it became apparent that the strata exposed along the axis of the Awuna anticline were stratigraphically below the base of Zone A. It thus appeared that there would be little point in attempting to gather additional data in the area between Birthday and Section Creeks. The party continued eastward, working along the south flank of the Kigalik anticline. On September 1, the party camped about one mile west of the summit of Knife Blade Ridge. Because of unfavorable weather at this time only a small amount of field work was accomplished in the next week. Enough data was gathered to give a general picture of the structure here, but the data on stratigraphy and structure is far from exhaustive. On September 9 the party moved eastward, camping that night about 3 miles northeast of Wolf Creek, and arriving at Umiat on the afternoon of September 10.

Aerial photographs were carried in the field and used to record the points at which observations were made. A considerable amount of data was recorded on the photographs. Approximate elevations were obtained, at first by aneroid barometers, and later by more sensitive airplane altimeters. Plane table and alidade were used in local traverses in the area north of the Kigalik River to obtain dips and strikes by the three-point method. Nearly all other dips and strikes recorded were measured by Brunton compass. Dips of 5° or less in the area south of the Kigalik River should, in general, be considered as dip components with only the approximate strike shown. These low dips were taken on bedding traces* where it was usually impossible to observe an accurate strike with the Brunton.

*The term "bedding trace" is used to indicate surface expressions of bedding, such as rubble horizons of certain rock types, breaks in topography, and changes in vegetation.

STRATIGRAPHY

Knowledge of the stratigraphy of this area is incomplete and derived principally from the study of bedding traces. Outcrops are scarce and usually small. They are confined principally to cut banks along the larger streams. Even here the cut banks are usually largely covered by slumped materials. Small outcrops are occasionally seen also along bedding traces of the type that make breaks in topography.

Very few contacts have been drawn in this area to date. The contact at the base of Zone A along the axis of the Awuna anticline was fairly easy to delineate with the aid of aerial photographs. The contact between Zones A and D, which cover most of the area, has not been delineated. This is due not only to the poor exposures but to poor map quality in the area west of cross-section ABC, which makes it inadvisable at the present time to attempt the construction of additional cross-sections. When better map coverage of the area becomes available and additional cross-sections have been constructed it may be possible to delineate the contact between Zones A and D.

Lower (?) Cretaceous

The dominantly argillaceous section underlying Zone A of the Upper Cretaceous is exposed in cut banks along certain southward flowing tributaries of the Awuna River where they cut across the axis of the Awuna anticline. These outcrops were studied along Quartzite Creek and along Birthday Creek and its west fork. The contact between this argillaceous section and overlying Zone A was traced on aerial photographs from a point just east of Section Creek westward beyond Quartzite Creek to a point about one mile east of Discovery Creek. No outcrops of these argillaceous strata were seen on Section Creek. Certain exposures near the axis of the anticline along Discovery Creek appear from field descriptions to be lithologically similar but have not been shown as Lower (?) Cretaceous on Figure 1.

The rocks of this section have been described in the field as greenish-gray, dark gray, and black silt and clay shales with associated thin interbedded greenish-gray and dark gray very fine-grained sandstones. There appears to be considerable variation in the descriptions of color, and it will be advisable to reexamine all hand specimens taken from this section before coming to any conclusions concerning lithologic uniformity or variation. The thickness of this section is unknown.

In one exposure on Quartzite Creek 350 feet of section was measured. Dips varied from 30 to 90 degrees. In some of the very fine-grained sandstones at this outcrop a small collection of fossils (47AWh174) was made. There were several poorly preserved cephalopods, a fragment of a shell apparently from a Pecten, and a small unidentified pelecypod. The general nature of this collection together with the greenish color common in the section suggests a marine environment.

The age of this section of rocks is as yet uncertain. The steep dips seen in these rocks in many places where they are exposed suggest a nonconformable relationship with the overlying beds of Zone A which have relatively gentle dips. Such a contact, however, was not seen. Also suggesting a Lower Cretaceous age is the apparent resistance of these argillaceous rocks to erosion, similar to the Lower Cretaceous sections described in other parts of northern Alaska.

On the other hand exposures near the contact with the overlying Zone A, appear to be conformable with it, the beds above and below the contact apparently having about the same dip. Also, along the Colville River R. F. Thurrell, Jr., found an argillaceous section underlying Zone A and conformable with it. In addition, the lowest prominent bedding traces of Zone A are not always stratigraphically equivalent. It appears that, at least in certain areas, there is a gradual transition with sandstone being deposited in some areas at the same as shale in others. Thus it might appear that this section was of Upper Cretaceous age older than Zone A.

A third alternative explanation would be to place the contact between Lower and Upper Cretaceous within this argillaceous section. Thus the gently dipping beds underlying the base of Zone A and apparently conformable with it would be of Upper Cretaceous age. And the steeply dipping rocks near the anticlinal axis might be of Lower Cretaceous age.

Upper Cretaceous

Zones A and D.

On the flanks of the Awuna and Kigalik anticlines the rocks above the section referred to as Lower(?) Cretaceous total about 5,000 feet in thickness and are the approximate equivalents of Zones A and D. No sharp contact can be drawn between these two zones. However, there seems to be a transition from a dominantly marine facies to a dominantly nonmarine facies from the base upward to the top of the 5,000-foot section.

The information on this series of rocks was obtained mainly from the study of bedding traces most of which are formed by sandstones. There are, therefore, large thicknesses of section between these sandstone traces on which no information is available. In any one of the stratigraphic columns presented in Figure 3 not more than ten percent of the section is known from recorded evidence. The blank areas are inferred to be largely of argillaceous character.

The sandstone in some of the rubble traces in about the lower 2,000 feet of these sections is quite clean and nearly colorless with little or no calcareous cement. Grain size in general varies from fine to very fine with higher porosity in the fine-grained sands. Porosity in specimens taken from this rubble measures from 15 percent to over 20 percent. These specimens were taken from the freshest appearing rubble and it is thought that weathering has had relatively little effect in increasing the porosity. The most conspicuous of these porous rubble horizons have massive rubble with hardly any sign of bedding. The smallest dimension of many of the rubble blocks is eight to ten inches and the longest dimension two or three feet. The fine-grained sandstone predominates in such rubble. That the porosity exhibited by this rubble is an original condition and not the result of weathering is suggested by the occurrence of petroleum residues in many of these sandstones. The occurrence of these petroleum residues also suggests that Zone A should be productive if its shoreline belt can be found under sufficient cover.

The porous sandstones along the flanks of the Awuna anticline occur below the only known coal-bearing section, but on the south flank of the Kigalik anticline they occur in some places stratigraphically higher than the lowest coal.

The porous sandstone horizons might be thought to be excellent markers for correlation. This is not the case. Even the ones occurring near the base of Zone A on the flanks of the Awuna anticline cannot be correlated from one flank to the other. However, some of them can be traced along the strike for distances of several miles. Some disappear along the strike in a distance of a few hundred feet. A few occur in small patches which cannot be traced more than fifty feet. In other cases porous rubble horizons were traced along the strike into non-porous bedding traces on which small outcrops occur. If the porous sandstones are of the shoestring variety, this type of lateral variation should be expected.

No outcrops corresponding to the porous sandstones have been found. It is believed that the friable nature of these sandstones preclude their forming outcrops unless very active erosion is in progress. It is thought that these sandstones may be present in areas in which there is no surface indication of their presence. In general they have been seen only where the strata dip five degrees or more.

Fossil collections from Zone A were made at four localities (see Figure 1) along the upper Kigalik River. These localities are very probably the ones from which Smith 1/ made collections 24AS67, 68, 69, 72, and 73 in 1924. All these localities are stratigraphically very close to one horizon, and on structural evidence lie about 1,500 feet above the base of Zone A. Assignment of these collections to Faunal Zone 1 is made on the basis of field identification of fragments of Inoceramus n. sp. subround in three of the collections.

Collections from Zone D which are provisionally assigned to Faunal Zone 1 were made in the syncline north of the Awuna anticline along Quartzite Creek and Discovery Creek. The collection from Quartzite Creek (47AWh223) includes fragments identified in the field as Inoceramus n. sp. subround.

On the basis of available evidence it does not seem advisable to try to draw the contact between Zones A and D in this area. However, the evidence gathered from the study of bedding traces suggests that the thickness of Zone A is about 2,000 to 2,500 feet. The base of Zone A is exposed along the Awuna anticline. Along the Kigalik anticline, however, the lowest exposed bedding traces lie about 1,500 feet above the base.

More outcrops have been found in Zone D than in Zone A. These are seen in cut banks along the Awuna River and along the lower Kigalik. Although 100 feet or more of section may be represented in some of these cut-banks, much of the section is usually covered with slumped material, so that usually the maximum section seen is only 20 or 30 feet. Zone D is characterized by the

1/ Op. cit. (Bull. 815), p. 223.

occurrence of sandstones, probably of nonmarine origin; coal; silt shale and silt stone with relatively minor amounts of clay shale; ironstone, often carbonaceous and occasionally carrying tree trunks of considerable size; and minor amounts of sublithographic limestone. The Zone D sandstones are generally gray or reddish in color, fine-grained, and often tightly cemented. Porosities of 15 to 20 percent have been reported from a few samples from this zone, but the porosities are generally five percent or lower. The higher porosities in Zone D seem to be sporadic rather than confined to definite horizons as they are in the porous sandstones of Zone A.

Only a small number of outcrops were seen in Zone A. There are a few along the upper Kigalik River, including one nearly continuous 70-foot sandstone exposure. Others were found on Quartzite Creek and Birthday Creek. In general the remarks made concerning the completeness of exposure in Zone D outcrops apply also to those of Zone A.

Zone E and underlying strata in the vicinity of Knife Blade ridge.

The presence of Zone E in this area is inferred from the occurrence of a white quartz pebble-and granule-conglomerate about 300 feet stratigraphically lower than the black shale which bears fossils of Faunal Zone 3 where it outcrops on September Creek. The stratigraphic equivalents of the 1,700 feet of strata below this conglomerate, shown in Column 5 of Figure 3, are unknown. On the basis of lithology the section below the conglomerate seems to be similar to that of Zones A and D in the area of the Kigalik and Awuna anticlines. However, no faunal evidence indicating the vertical limits of Zone E or of the lower zones was found. It seems probable that at least some of the section below the conglomerate represents Zone E equivalents. Assuming, however, that this conglomerate represents the base of Zone E, the coal-bearing section below it which might be called Zone D is somewhat thinner than that seen in the area to the west. Below the coal-bearing occurs a section in which the presence of coal was not noted. Only the upper part of this section, including two porous sandstone horizons, is represented in Column 5. It is estimated that an additional 500 to 1,000 feet of section is represented along the axis of the Knife Blade Ridge anticline farther west, including other horizons of porous sandstones. Assuming a northwest-southeast trend of the shorelines, this section could be the marine equivalent of the coal-bearing section seen along the Kigalik and Awuna anticlines.

In view of the sparse structural data on which thicknesses in Column 5 are based and of the lack of fossil evidence it seems best not to attempt to correlate this section at this time. At a later data additional cross-sections further west on the north flank of this anticline will be constructed and should give more reliable data on thicknesses. Considerable more data, both structural and lithologic, could have been gathered in the field, if adverse weather had not curtailed the work in this area.

Zone F.

An outcrop exposing a 135-foot section of black "paper" shale bearing Faunal Zone 3 fossils was examined on September Creek (see Figure 3, Column 5). Other outcrops of this shale occur further north on this creek but the outcrop visited is believed to be the most complete exposure. To the east of this exposure the shale can be traced for several miles on aerial photographs by its characteristic soil. The base of Zone F in this area is drawn on the first prominent bedding trace below the black shale exposure. This bedding trace lies about 200 feet stratigraphically lower than the base of the shale exposure.

Zone G.

The first evidence of nonmarine deposits seen above the black shale is an outlier of conglomerate which is considered the base of Zone G. (See Figure 3, Column 5) This outlier caps the highest hill in the vicinity. It is probable that no other strata representing Zone G occur south of Maybe Creek.

Tertiary and/or Quaternary

Post-Cretaceous deposits are limited to fluviatile and lacustrine deposits that are confined to some of the larger valleys. Small gravel terraces lying a few feet above stream level were seen along the Kigalik River in a few places. The gravel consists primarily of pebbles of the more resistant sandstones. No gravel terraces were noted along the Awuna River.

STRUCTURE

Major structures in this area are shown on Figure 1. The general trend of these structures is about N.80°W. Where not traced in the field structural axes have been interpreted from aerial photographs. The bends in structural axes between 156° and 156°30'W. may be due largely to distortions in the base map in this area.

The anticlines have distinct crests. Where an outcrop or bedding trace is present at the axis the position of the crest of the structure can usually be located within about 100 feet, and sometimes within a considerably smaller distance. Dips are low except in the shale section along the axis of the Awuna anticline and for a distance along the axis of the Knife Blade Ridge anticline.

The synclines are quite broad with very gentle dips on the flanks. Usually there is a belt two to four miles wide in which the strata are very nearly horizontal. Under these conditions the axes of the synclinal structures can be located only approximately.

Kigalik Anticline

The Kigalik anticline trends approximately N.80°W. along the Kigalik River from 155°15'W. westward beyond the headwaters of the stream. The trend remains the same at least to 157°W., and appears, from aerial photographs, to continue westward following the same trend at least as far as the area of the headwaters of the Meade River. The location of the axis east of 157°15' is uncertain. The possible relationship of this structure to the Knife Blade Ridge anticline is discussed under the section pertaining to the latter structure.

In the area investigated the Kigalik anticline is assymetrical, dips varying on the south flank from 5° to 20° and on the north flank from 1° to 5°. The steepest dips, 12°-20°, on the south flank appear in the vicinity of the big bend in the Kigalik River (156°20'W.) and decrease both eastward and westward. On the north flank the steepest dips, 4°-5°, appear in the western part of the area and decrease eastward.

The anticline appears to have a very low plunge to the east at some points, but preliminary work does not show if this plunge is continuous. No plunge to the west was noted.

Awuna Anticline

The axis of the Awuna anticline lies approximately four to five miles north of an roughly parallel to the course of the Awuna River from 155°45'W. to 157°35'W.

The anticline is symmetrical with a well defined axial valley along the greater part of the axis. Dips in the shale section in the valley are steep, often being vertical or overturned. Along the high ridges outlining the axial valley dips vary from five to twenty degrees, decreasing away from the axis.

The anticline plunges sharply to the west in the vicinity of Discovery Creek and dies out about 3 miles west of the creek. The structural high is near Quartzite Creek, probably within two to three miles to the east. East of this area there appears to be a slight eastward plunge. From about Section Creek the structure plunges sharply to the east for about 5 miles. On aerial photographs the axis can be traced for about 7 miles east of Section Creek. Beyond this point the location of the structure is unknown.

At about 156°55'W. an anticline appears north of the Awuna anticline and en echelon with it. This structure has been traced westward on aerial photographs beyond 157°30'W. In the vicinity of Discovery Creek the anticline curves to the south. This curve appears to be part of an S-curve, the unnamed structure taking the place of the Awuna anticline west of where the latter structure dies out.

This anticline appears to be relatively symmetrical with low dips on the flanks, at least along the part that was investigated (east of 157°W.).

Knife Blade Ridge Anticline

The Knife Blade Ridge anticline trends approximately N. 80° W. from 154°30'W. to 155°05'W. along Knife Blade Ridge. The axis may bend sharply northward at 155°05'W. It is possible that the structure is a continuation of the Kigalik anticline. A sharp S-curve would be required to join the axes of the two structures. Field data was gathered in the area between these structures, but preliminary study of it does not solve the problem satisfactorily. It is anticipated that a critical study of the field data coupled with available photogrammetric data may solve the problem of the relationship between these structures. The location of the anticline east of 154°30'W. was not determined.

The anticline appears to be relatively symmetrical except for the part extending west for about 3 miles from a small tear fault at about 154°41'W. In this part the north flank is vertical or overturned.

East of the tear fault the anticline plunges steeply to the east for about one mile, and then more gently for at least as far as the structure was traced. No westward plunge was noted.