United States

Department of the Interior

U.S. Geological Survey

Washington

Geological Investigations

Naval Petroleum Reserve No. 4

Alaska

Report No. 30

INTERPRETATION FROM AERIAL PHOTOGRAPHS OF GEOLOGIC STRUCTURES OF THE CENTRAL COLVILLE RIVER AREA, ALASKA

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By

William A. Fischer

April 1949

(R.30)

CONTENTS

ILLUSTRATIONS

(R.30)

INTERPRETATION FROM AERIAL PHOTOGRAPHS OF GEOLOGIC STRUCTURES OF THE CENTRAL COLVILLE RIVER AREA, ALASKA

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INTRODUCTION

Location, extent, and physiographic character

The area discussed in this report lies between 153° and 158° west longitude and between 69° 15' and 69° 45' north latitude. It encompasses approximately 4,300 square miles. The terrain is in large part gently rolling with a maximum local relief of approximately 500 feet. Three major northward-flowing streams, Meade, Titaluk, and Ikpikpuk, traverse the area.

Selection of area

This particular area was selected for photo investigation for the following reasons:

(1). It is an area that may contain structures and sedimentary facies favorable to the accumulation of oil, and it lies within the boundaries of Naval Petroleum Reserve No. 4.

(2). It is essentially the continuation of an area previously worked by similar methods.

(3). It is an area that will be visited by a field party this summer. The photogrammetric studies will provide valuable information to the party, some of which is unobtainable by even the most careful field investigations. In addition, the findings of the field party will provide an excellent check on the photogrammetric methods and results, and will thus aid in the comprehensive interpretations to be based on both field and photogrammetric studies at the end of the field season.

Parts of the area lying east of the Ikpikpuk River have been previously studied and reported upon, but the area has been restudied and some changes in interpretations have been made. For this reason, and also in order to clarify the whole regional picture, the structure of the east Ikpikpuk area is again discussed here.

(R.30)

Procedures

1. Instruments used.--Two height finding instruments were available for quantitative dip measurement, KEK Stereoscopic Plotter and a Fairchild Stereocomparagraph. Mechanical deficiencies at first encountered with the KEK Plotter have been rectified, and the instrument is now in excellent working condition.

2. Methods.--All dip measurements were taken by the three point method, utilizing one of the above instruments for determining relative elevations. These photo dips, together with all available information from field studies, were plotted on suitable base maps before any regional interpretations were made. Every precaution was taken to prevent the formation of a pattern in the operator's mind or on the photos until all measurements had been completed.

3. Limitations.--Photo interpretation methods in this region are greatly impeded by the unconsolidated mantle along the northern margin of the region and by the relative uniformity of weathering characteristics of the different rock types.

The photo interpreter is much better able to recognize the more obscure indications of structure than the field geologist, and hence is better able to evaluable the overall structural pattern, particularly in regard to such factors as drainage control.

4. Relative accuracy.--It will be noted on the accompanying illustration that many of the dips are shown without quantitative figures. Some of these were determined merely by stereoscopic observation of the dipping beds. In the majority of such cases the limitations imposed by vague or straight bedding traces made it impossible to be sure that measured dips were not merely directional components rather than true dips. For this reason it was not felt wise to include their numerical evaluation.

Where the amount of dip has been shown, the probable error is believed to be about one degree. Dips shown without definite angles should display a strike correct within 10 degrees.

Nomenclature

The apparent interconnection of many of the major folds and the discovery of new folds has presented a problem in nomenclature. The following revisions of existing names and additions of new names are presented in order to clarify the nomenclature: (1) The Meade River, Titaluk, Ikpikpuk, Maybe Creek Dome anticlines are referred to in their entirety as the Titaluk anticline, and sections of this structure are designated by the names previously used.
(2) The elongate structure, the east end of which has been called the Wolf Creek anticline, is referred to in its entirety as the Wolf Creek anticline.
(3) The Maybe Creek anticline is renamed the Weasel Creek anticline.
(4) The anticlinal structure extending generally along the divide north of the Kigalik River is called the Cache Ridge anticline.

Aims and purposes

The aims and purposes of the photo study and of this report are two-fold. First, to provide a reasonable interpretation of the structure of the area together with all available stratigraphic and physiographic data. Second, for the benefit of the field parties the following additional information has been or will be provided to expedite their movements:

(1). The location and general configuration of every bedding trace within the area that is suitable for dip determinations.

(2). The location of all visible dangers to stream travel, and the location of the most favorable stream crossing spots for weasels.

(3). A proposed location for every station of the primary triangulation net. These locations would insure proper defilade and base line distance.

(4). A selection of small streams that might provide additional geologic information and hence might justify additional study by boat or on foot.

(5). A proposed route of travel for main party movements.

(6). The map locations of unusual or unidentifiable features that should be examined on the ground. Ground identification of these features will aid in future photo studies.

General

1. Maps.--The accuracy and detail of the recent maps of this area have been greatly improved. Position shifts of considerable magnitude over locations shown on earlier maps have resulted in alignment of structural axes that formerly seemed offset.

2. Photography.--The photography taken in the reserve last season is of the highest quality, far superior in every respect to any other coverage provided in this area in past seasons.

STRATIGRAPHY

With the exception of the Gubik remnants along the northern margin of the area, all rock exposed at the surface is probably Cretaceous in age. Some Tertiary deposits may be concealed beneath the Gubik mantle, but it is extremely unlikely that any Tertiary is present south of the axis of the Wolf Creek anticline. There is a general and consistent plunge of the Cretaceous to the north and east. Rocks of Lower Cretaceous age are confined to the headwater area of the Meade River. Zones D and E extend north and east from this point to the Ikpikpuk River. Near the Ikpikpuk and extending along Maybe Creek are occasional exposures of Zone F. In the vicinity of the Maybe Creek Dome and the Wolf Creek anticline Zone G is present. Along the north limb of the Wolf Creek anticline Zone G and approximately one half of Zone H are exposed.

(R.30)

FAULTS

No major faults have been mapped within this area except for the Kigalik fault and the Knife Blade Ridge tear fault mapped by Whittington 1/ in 1947. The photos show some evidences of disturbance along the Cache Ridge anticline, but there is probably no significant displacement. There are two other areas of possible faulting--one at the extreme southeastern corner of the area (Figure 1) and the other at the extreme southwestern corner near the head of the Meade River. South of the Meade River near the 158° meridian there are erratic dips of high magnitude. These were observed on the photos, and some were also recorded in the field. Some characteristic fault lineations are visible in the photos, but these do not extend for any considerable distance. Topographic variations in this area are duplicated in many other areas where the structures are well exposed and no faults are known. Hence, changes in topography in this area cannot be taken as evidence of faulting. The failure of the competent beds along the south limb of the Meade River anticline has probably resulted in a very sharp downwarp, which may be locally ruptured. Both disappear east of 157°50'.

Another example of erratic dips of high magnitude occurs near the headwaters of Maybe Creek in the extreme southeastern corner of the area. Here the bedding traces are definitely offset. This may represent a fault, but the nature and location of the possible fault cannot be determined from the photos or in the field. These steep dips occur at approximately the E-F contact, which is the same stratigraphic position at which Detterman 2/ finds steep dips near Nimuluk Creek, approximately 15 miles to the southeast.

STRUCTURAL PATTERN

The major folds within the area are similar in general characteristics and in direction to those previously mapped in other portions of the reserve. The folds trend approximately N. 75° W. The tendency of the structures to merge and diverge that has been noted further to the west continues into this area.

The northern limits of the mapped area are covered by a relatively thin mantle of Gubik sediments, obscuring all but occasional indications of structure. While the probable fold axes have been traced through this area, their exact location is open to some question. Surface field work would probably produce little additional information. Hence, precise mapping of these partially buried structures will require subsurface studies. The approximate southward extent of the Gubik formation coincides on the illustration (Figure 1) with the boundary of the foothills province.

1/ Whittington, C. L., and Troyer, M. L., Stratigraphy and structure of the area of the Kigalik and Awuna Rivers, Alaska: Geological Investigations, Naval Petroleum Reserve No. 4, Report No. 17, March 1948.

2/ Detterman, R. L., Webber, E. J., and Mathewson, D. E., Stratigraphy and structure of the area of the Colville River between Nimuluk Creek and Umiat Mountain, Alaska: Geological Investigations, Naval Petroleum Reserve No. 4, Report No. 15, March 1948.

(R-30)

The southern limit of the detailed photo studies of well-exposed structures is at the north limb of the Kigalik anticline, and the northern limit is at the north limb of the Wolf Creek anticline.

Exposures east of the Ikpikpuk River are excellent, and quantitative photo mapping of structures has been done in this area. Exposures between the Ikpikpuk and Meade Rivers are extremely poor and so discontinuous that reliable structure contouring is not possible. West of the Meade River exposures become increasingly good. Unfortunately, the area west of the 158th meridian is not covered by vertical photography.

The overall pattern of structures in this area suggests several thoughts that may have considerable influence in future searches for structural highs within this area. First, the major northward-flowing streams (the Ikpikpuk, Titaluk, and part of the Meade) seem to cross the structural trends at very definite structural lows. If this is true, further search for structural highs should be concentrated in the areas between the major streams. Second, there seems to be a relationship between postulated structural highs and points of axial divergence. Third, the known highs on some anticlines and the photo-postulated highs on others tend to be aligned in the direction N. 30° E. The cause of this alignment is not known, but may possibly be due to similarly aligned irregularities in the basement. Fourth, at points where folds bifurcate the following facts seem evident: (1) The larger or dominant structure is little affected by the bifurcation. (2) The smaller or minor structure seems to plunge in a direction away from the point of bifurcation. (3) Beyond the limb of the dominant structure there is a reversal of plunge creating a small closure or saddle on the minor structure.

MAJOR ANTICLINES OF THE AREA

The structures of the area are discussed from north to south in the order they would occur if all of them crossed the 155° meridian.

Wolf Creek anticline

1. Structure.--The Wolf Creek anticline is the northernmost structure depicted on the accompanying illustration. It is a very long anticline, which probably extends as a continuous structure completely across the area covered in this report.

In general the Wolf Creek anticline differs little from that of any of the other structures in the area. Its eastern end, to which the name the Wolf Creek anticline has previously been restricted, is asymmetric with the steeper limb on the north. Westward along the structure bedding traces become more and more vague, but all indications point to a gradual flattening of the north limb. At the Ikpikpuk River the dips on both limbs become extremely gentle and the entire structure seems to flatten. There is a possibility that structural highs are present both east and west of the Meade River, with the river flowing through the saddle between. Between the Ikpikpuk and Titaluk Rivers there appear to be no structural highs, although the anticline seems to be continuous across this area. A large part of the Wolf Creek anticline is obscured by the Gubik mantle. The position of the axis of the fold is in places uncertain. In these places surface geology can probably contribute very little toward improving the location of this axis. The representation of this structure as continuous between the Ikpikpuk and the Titaluk Rivers is an interpretation that has little supporting evidence.

In the eastern part of the Wolf Creek anticline (that part of the anticline to which the name Wolf Creek anticline has previously been restricted) there is considerable plunge of the fold to the east, probably amounting to at least 450 feet. Stefansson and Thurrell were able to prove only 20 feet of plunge to the west anywhere along this part of the fold.1/ Hence, the probable high in this area is believed to have at least 20 feet of closure. Careful study of the air photos in this region did not reveal any direct evidence that would increase the probable amount of closure of this high. There is a small possibility, however, that a traverse by boat down a small creek flowing north at approximately 155° west longitude may supply some additional information. A study of the photos indicates that there are some small outcrops along the creek approximately along the line of the projected axis of the anticline. If these crops proved to belong in a recognizable stratigraphic zone, westward plunge of considerable magnitude might be demonstrable. Geological Survey Party No. 1 will be in the area at a time when water should be sufficiently high to make such a traverse.

Photo studies supply one more indirect clue as to possible closure. Near the eastern end of the anticline, at the assumed structural high, the black shale of Formation F lies at or very near the surface. At Umiat, only 35 miles to the east, a sandstone bed is present in Zone F at a depth of approximately 100 feet. Westward along the axis from the assumed high there is a definite drop in elevation, probably amounting to well over 100 feet. If there were no plunge in either direction, this sandstone bed, if it persists, should be exposed by the elevation drop west of the assumed structural high. If the fold was plunging to the east, this bed should outcrop at a distance not too far west of the apparent high. A careful study of the structure in the vicinity of the axis reveals no trace of this resistant bed. Hence, a westward plunge of the fold seems to be indicated in this area.

If the above-mentioned resistant sandstone bed is present at the Wolf Creek anticline, it could be used as a marker bed to attempt to prove closure on this possible structural high by core tests. Two holes of not more than 200 feet depth should be adequate to reach the bed and to establish or disprove the closure that has been suggested by the field and photo studies.

2. Stratigraphy.---At the eastern end of the Wolf Creek anticline the middle of Formation H crops out on the north limb, and the base of Formation G crops out along the axis. Proceeding westward along the anticline a rather steady downward trend in the section is indicated both by the field studies and the photo studies. The base of Zone E or the upper part of Zone D lies at the crest of the fold at the western edge of the area included in this report.

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

3. Logistics and other problems.

a. Transportation.---Transportation of heavy equipment to the eastern end of the Wolf Creek anticline from either Barrow or Umiat appears feasible. The entire route from Umiat, after crossing Seabee Creek, would be along hard capped ridge tops having very little variation in elevation and no steep or difficult climbs. From Barrow two routes are feasible---one via the old Seabee trail to Umiat which passes within a few miles of the anticlinal crest or another via Admiralty Bay and the Chipp and Ikpikpuk Rivers to the Titaluk anticline which forms an east-west drainage divide. Travel along this divide should be good, and it would not be necessary to cross any streams to reach the crest or south limb of the Wolf Creek anticline. The approximate distance from Barrow is 230 miles. The distance from Umiat is approximately 45 miles.

b. Water.---Water in sufficient quantities should be obtainable the year around from Wolf Creek, its adjacent lakes, or from the large lakes at the head of Prince Creek.

c. Landing fields.---A small air field could be constructed along the crest of the Wolf Creek anticline. The ridge top along the crest of the fold is level, bed rock is at or very near the surface, and no polygonal markings are evident. Gravel for construction could be obtained from the weathered conglomerate in the ridges along the north limb of the fold or from the Maybe Creek gravels.

Titaluk anticline

1. Structure.---The Titaluk anticline is the central structure of the group studied. It includes the anticlines formerly referred to as the Meade River anticline, the Titaluk anticline, the Ikpikpuk anticline, and the Maybe Creek Dome. In general it is a broad, nearly symmetrical fold which extends completely across the area covered in this report, and is probably a continuously connected fold as indicated on the accompanying illustration. There are, however, two areas---one just west of the Ikpikpuk River and one just east of the Meade River wherein structural criteria for recognizing the anticline are lacking, and in these areas the anticline may die out or diverge rather than continue as shown on figure 1.

That part of the Titaluk structure lying between the Meade River and the west edge of the area studied seems to be intermediate in character between the more gentle folds to the east and the sharp faulted structures to the west. Photography west of the 158° meridian is lacking so that this part of the Titaluk anticline could not be studied comprehensively. As soon as more vertical photography becomes available in this region, the area west of the Meade River should be restudied.

There are at least three examples of bifurcation along the axis of the Titaluk anticline. One of these is just west of the Meade River between the eastward-flowing portion of the upper Meade and Shaningarok Creek. Although the interpretation of a bifurcation of the anticline at this point differs from the previous field interpretation, it is not in conflict with the field evidence.

Webber 1/ believes that the southern section of the anticline plunges both to the east and west. Pictures are not available to study the region in which the westward plunge is postulated. Some indication of eastward plunge was noted in the photos, but this plunge is probably local in nature. East of the Meade River the plunge appears to be in the opposite direction, i.e., to the west, and a small closure is probably present. From this small dome the rest of the fold rises to an apparent major structural high near the headwaters of the Titaluk River. In the immediate vicinity of the Meade the dips on the flanks of the anticline are much steeper than elsewhere, and the structure narrows markedly. It seems unlikely a major structural high occurs at or near the Meade. The northern branch of the anticline seems to be definitely rising as it leaves the western edge of the area.

The apparent high near the headwaters of the Titaluk is quite symmetrical in appearance, but the closure to the west probably does not exceed 100 feet. The Ikpikpuk high has never been visited by field parties, but Geological Survey Party No. 1 will attempt to map the structure this summer. There seems to be a steady decline to the east from this assumed high to the northward-flowing portion of the Titaluk River. A reversal in the direction of plunge seems to occur almost exactly at the Titaluk. Just west of the river the fold apparently bifurcates again, and at this point the southern branch, named the Cache Ridge anticline, diverges to the southeast. Between the Titaluk and the Ikpikpuk Rivers the Cache Ridge anticline becomes the dominant structure. Along the Titaluk anticline axis there are few bed traces between these two rivers, but the fold is probably continuous though much smaller than it is farther west. It probably does not have structural relief much in excess of 100 feet. There are no indications of reversals in this area, but there is probably a gentle regional plunge to the east.

At the Ikpikpuk River the crest of the Titaluk anticline becomes flat and then rises to the east, producing the so-called Ikpikpuk section. Thus the Ikpikpuk River, like the Titaluk River, appears to cross the anticline in a structural low. Two minor folds crossing the Ikpikpuk River south of the Titaluk anticline were mapped by Webber 2/ in 1947, but east of the Ikpikpuk no indication of these structures can be seen in the bedding traces visible on the photos. If present here, they must be very minor and probably have little effect on the overall structural pattern.

From photo studies it appears that there is a high located on the Titaluk anticline at approximately 154° 25' W. The field party should be able to prove closure to the east with a magnitude of approximately 300 feet. Closure to the west will be much more difficult to prove, but it may be possible to demonstrate closure of approximately 100 feet. This will depend on the exact location of the axis of the fold in relation to visible bed traces. There are suggestions that the westward closure may exceed 200 feet, but proof of this amount of closure will probably require subsurface work.

1/ Webber, E. J., Personal communication, March 1949.

2/ Webber, E. J., Stratigraphy and structure of the area of the Titaluk River and upper part of the Ikpikpuk River, Alaska: Geological Investigations, Naval Petroleum Reserve No. 4, Report No. 16, 1948.

The Ikpikpuk section of the Titaluk anticline is in general a broad symmetrical structure. The dips on the flanks average not more than two degrees. North of 69° 25' the north limb of the anticline is largely concealed by the Gubik mantle. The presence of this veneer of unconsolidated material practically obliterates all traces of structure and other indirect indications of the structural configuration. In their traverses along the Ikpikpuk River Smith and Mertie 1/ measured dips of 10 to 15 degrees, presumably on the north flank of the Titaluk anticline, but Webber 2/ was unable to find any dips approaching this magnitude within the area. He did find one bed dipping north at less than one degree. He emphasizes that in this locality exposures are poor along the river and the anticline cannot be accurately located.

From the crest of the Ikpikpuk high the axis plunges steadily to the east as far east as the 153° 50' meridian. Any reversals in plunge within this area must be extremely small in nature. At 153° 50' a reversal probably occurs, which produces some closure at the west end of the Maybe Creek Dome. No new direct evidence of westward closure of the Maybe Creek dome was obtainable. A single continuous bed trace was noted, however, which follows along the south flank of the anticline. A series of elevations were taken on this bed, compensating where necessary for the general southerly dip of the bed. These measurements indicated a sag at a point in direct line with a synclinal axis approaching from the southwest. There is reason to believe that this syncline was produced in the last stages of regional folding. This is indicated by the anomalous directional trend of the synclinal axis, and by the presence of post-folding faults a short distance to the south. If we assume that this fold was produced subsequent to the main folding of the area, the formation of this fold at a later date may have exerted considerable influence upon the already existent folds. Had this been the case, it would have produced a sag in the bed extending along the south limb of the Titaluk anticline precisely at the point at which a sag now exists, and it thus may have produced a certain amount of closure on the west end of the dome. The behavior of the strikes as measured on the photos along the projected synclinal axis indicates that such a condition may exist.

A careful review of all photos in the area of the Maybe Creek Dome leads to the definite conclusion that surface field studies will not be able to add substantially to data already existing, nor will they be able to prove western closure of the dome (?) to the satisfaction of all concerned. Closure could be established by drilling two or three holes to the base of the black shale of Formation F or to some recognizable horizon well down into the shale section. This would require a hole of approximately 400 feet at the crest and 200 feet on opposite sides of the crest. This difference in necessary drilling depth is due to differences in topographic relief.

Eastward from the Maybe Creek Dome Titaluk anticline probably merges with the Wolf Creek anticline and continues eastward as the Fossil Creek anticline.

1/ Smith, P. S., Mertie, J. B., Jr., Field notes: U. S. Geological Survey, 1926.

2/ Webber, E. J., Stratigraphy and structure of the area of the Titaluk River and upper part of the Ikpikpuk River, Alaska: Geological Investigations, Naval Petroleum Reserve No. 4, Report No. 16, 1948.

(R.30)

2. Stratigraphy.--West of the Ikpikpuk River there is little definite information as to stratigraphic position of beds involved in the Titaluk anticline. Such field information as is available, coupled with the photo appearance of exposures, indicates that the outcropping beds in the anticline are younger from west to east. Near the Meade River beds of Zones A to C of the Nanushuk group may be exposed. From here eastward to the Titaluk Zone D may lie near the surface. From the Titaluk to the Ikpikpuk River the exposed rock probably belongs in Zone E. From the Ikpikpuk to the crest of Maybe Creek Dome there are exposures of Zones E, F, and the lower part of Zone G.

There is no indication that any Tertiary deposits are present near the Titaluk anticline. In the Ikpikpuk section of the anticline where the north limb of the fold is mantled by the Gubik, Tertiary beds could be present beneath the mantle, but there is no field or photo evidence to substantiate such a conclusion.

3. Logistic and other problems.

a. The Meade River section.--Transportation of heavy equipment to this part of the area structure could follow routes already established. Water for drilling could be obtained from the Meade River or Shaningarok Creek. Float planes could probably land on the river or on some of the adjacent lakes.

b. The Titaluk River section.--Transportation of heavy equipment to the probable structural high near the headwaters of the Titaluk River probably would have to be done by overland hauling from Barrow, possibly along the Meade River. The river itself would not be navigable for large boats except at high water.

Water could probably be obtained in sufficient quantities for year-round drilling from the Titaluk River or adjacent lakes.

Float planes could land nearby,or a small field could be constructed in the river flats.

c. The Ikpikpuk section.--Transportation of heavy equipment to the Ikpikpuk high could be from either Barrow or Umiat. From Barrow via the Ikpikpuk River the distance is approximately 220 miles. From Umiat via the old Barrow trail and the regional divide the distance is approximately 65 miles.

Water and landing facilities should be available in the valley of the Ikpikpuk River approximately five miles west of the assumed high.

d. The Maybe Creek Dome section.--Transportation to the Maybe Creek Dome section could be from either Umiat or Barrow by the routes suggested for the Wolf Creek anticline. The distance from Barrow is approximately 230 miles, and from Umiat approximately 55 miles.

(R.30)

Water could best be obtained from the large lakes at the head of Prince Creek approximately six miles west of the dome. These lakes appear to be the only places suitable for landing planes anywhere in the vicinity of the dome, although it might be possible to build a small field near the crest of the dome.

Cache Ridge anticline

1. Structure.--The Cache Ridge anticline extends in a general northwest direction along the divide between the Kigalik and Titaluk Rivers. At its northern end it merges with the flank of the Titaluk anticline, and at its southern extremity it probably merges with the Knife Blade Ridge anticline. It is not as large a structure as the Titaluk or Wolf Creek anticlines. Only one structural high is believed to be present along the Cache Ridge anticline. It is approximately at the 155° 50' meridian. This high may well have closure both to the east and west of as much as 250 feet. The flanks at this point are steeply dipping and the structure is sharp and narrow rather than broad and flat, as is generally the case with the structures to the north. There are some indications of faulting in the vicinity of the supposed high, but none of the faulting seems to have caused large displacement of beds.

2. Stratigraphy.--No definite information as to age of the rock exposed in this area is available. The change in rock character from that of Zones A to D exposed to the south along the Kigalik anticline seems to indicate that the surface rock near the Cache Creek anticline is higher in the section, probably in the upper Zone D or the lower part of Zone E.

3. Logistic and other problems.--The transportation of heavy equipment from Barrow to the high on Cache Creek anticline is probably easiest along the Ikpikpuk and Titaluk Rivers. The distance would be approximately 240 miles. Transportation from Umiat, which is only about 100 miles away, would be feasible but difficult. Most of the route would be over hard, rock-capped ridges.

The nearest adequate source of water is in the valley of the Titaluk River approximately eight miles north of the anticline.