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PRELIMINARY REPORT ON THE STRATIGRAPHY AND STRUCTURE OF THE SHAVIOVIK AND UPPER SAGAVANIRKTOK RIVERS AREA, ALASKA

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PRELIMINARY REPORT ON THE STRATIGRAPHY AND STRUCTURE OF THE SHAVIOVIK AND UPPER SAGAVANIRKTOK RIVERS AREA, ALASKA

By

A. Samuel Keller

and

Robert L. Detterman

November 1951

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PRELIMINARY REPORT ON THE STRATIGRAPHY AND STRUCTURE OF THE SHAVIOVIK AND UPPER SAGAVANIRKTOK RIVERS AREA, ALASKA

By

A. Samuel Keller and Robert L. Detterman

INTRODUCTION

During the 1951 field season, U. S. Geological Survey Navy Oil Unit party 1 conducted stratigraphic and structural studies of the rocks in the area between the westernmost fork of the Shaviovik River and the East Kuparuk River. This area is drained by the Sagavanirktok River and its major tributaries; the Echooka River, the Ivishak River, and Lupine River. Owing to the nature of the investigation, the studies were confined to a relatively narrow geographic strip, rarely exceeding a distance of 20 miles north of the northernmost occurrence of the Lisburne limestone of the Brooks Range province. The work was thus conducted in an area of approximately 2,000 square miles, which lies wholly within the Brooks Range and Arctic Foothills provinces; within this area approximately 1,000 square miles was mapped geologically.

The party consisted of six men: A. S. Keller and R. L. Detterman, geologists; I. W. Marine and D. E. Reed, field assistants; L. G. Barbin, cook-field assistant; and T. F. Derrington, weasel mechanic. The party utilized 3 weasels for transportation of equipment and personnel during the season, during which time 15 camps were established. Work was initiated on the Shaviovik River on May 24, 1951, and the party concluded its investigations on the Kuparuk River drainage on August 24, 1951.

In 1947, G. Gryc and E. H. Lathram conducted reconnaissance studies of the rocks in the vicinity of camps 12-15 (pl. 1); and during the same year, G. Gryc visited outcrops on the Ivishak River in the vicinity of camps 6-7 (pl. 1). These studies were made by the Navy Oil Unit of the U. S. Geological Survey in conjunction with the investigations of NPR-4. No other work of a geologic nature had been done in the area in the past.

The primary objective of the 1951 party was the correlation of the Mesozoic and upper Paleozoic strata of the foothills province west of the Itkillik River, with that of the Shaviovik and Canning Rivers region. A secondary objective was to determine the cause of the pronounced northeasterly swing in the trend of the Brooks Range front in the Sagavanirktok drainage and to determine the structural implications of this swing.

The area was mapped at a scale of 1:20,000 on vertical photographs and transferred to trimetrogon drainage maps at a scale of 1:48,000 and 1:96,000. An altimeter traverse was carried concurrently with the geologic mapping.

GENERAL GEOLOGY

Topography.--The Shaviovik and upper Sagavanirktok Rivers area is divisible into two distinct physiographic provinces: the Brooks Range province and the Arctic Foothills province. Only the northerly part of the Brooks Range province was studied. Within this physiographic belt, the peaks of resistant Lisburne limestone attain altitudes in excess of 5,100 feet; relief is of considerable magnitude. North of the Lisburne mountain range lies the foothills province. In the northeastern part of the area this province consists of low rolling hills and reduced featureless lowlands, the monotony of which is broken only by the resistant northeast trending hogback and whaleback ridges and cuestas of the Sadlerochit formation and the resistant basal sandstone rubble ridges of the Okpikruak formation. On this more or less featureless lowland, which is underlain by the nonresistant shale facies of the Kingak and Okpikruak formations, the Ignek formation remains as resistant synclinal mesas. To the southwest, the southern part of the Arctic Foothills province is mountainous locally owing to the pronounced change in facies of the Mesozoic sediments. The northwestern part is a flat, featureless lowland underlain by the nonresistant shale facies of the Torok formation, upon which rest the gently folded resistant Nanushuk group sediments.

Drainage.--The major streams of the area are consequent streams with well-developed floodplains. Both dendritic and trellis patterns are well developed locally in the tributaries of the major drainages. In wide floodplain areas associated with the larger streams, extensive ice fields have developed, with the stratified ice locally exceeding 10 feet in thickness. Gravel terraces are common along the major drainages. The Echooka River has two well-developed terraces, the higher of which can be traced for 10 to 15 miles and is 20 to 25 feet above the lower. The terraces are composed of well-sorted gravel, derived at least in part from the glacial moraines. The lower terrace is from 5 to 10 feet above present stream level, is comparatively flat, and can be used as a landing field for small wheel-type aircraft. Similar terraces are present along Kashivi Creek, the Ivishak River, Nosebleed Creek, Ribbon River, and the Sagavanirktok River.

Glaciation.--Pleistocene montane glaciation has been extensive in the area studied. It is apparent that all the major streams at one time supported valley glaciers. In at least one place it is evident that the ice from two adjoining glaciers covered the interstream area. Glacial features, however, are generally restricted to the areas immediately proximal to the present stream valleys. Morainal cover rarely extends from the Brooks Range front more than 15 to 20 miles.

The glacial phenomena in general are of two categories: (1) the primary features in the mountain province; and (2) secondary features in the foothills. Among the primary features are the broad U-shaped valleys, which extend far back in the Brooks Range proper. Intersecting these straightened valleys are hanging tributary valleys, from 50 to 200 feet above the main valley floor. The spurs between the side tributaries have been truncated. Cirques, cols, aretes, and more rarely, horns have been

developed within the mountains, in the Lisburne limestone which lends itself especially well to the formation of these glacial features. In general, moraines are restricted to the foothills belt, although they are also present in the Echooka River valley within the mountains.

Secondary features within the foothills include terminal and lateral moraines, eskers, drumlins, pot-hole lakes, and large erratics of Lisburne limestone and older rocks. The drumlins and eskers are not particularly well developed, and the former are mostly rock drumlins. The moraines are composed of unsorted till, fragments ranging from silt size to boulders 2 feet in diameter. About 50 percent of the erratics are Lisburne limestone and the remainder Kanayut conglomerate with a minority of older rocks. The erratics are as much as 15 feet in diameter and have been transported from a few miles to more than 15 miles from their source.

The interstream area between camp 1 and camp 2 has been cloaked with moraine to an altitude of 1,700 feet. Westward the morainal mantle extends higher. In the area of camp 11 it is found at altitudes of 2,200 to 2,300 feet, and at camp 15 it obscures the Mesozoic sediments to an altitude of 2,600 feet. Erratics were found at altitudes ranging from 2,300 feet at camp 1 to 3,500 feet at camp 15.

Numerous small glacial lakes and ponds are present in the morainal areas, and the elevation of two adjacent lakes may vary by as much as 50 to 200 feet.

STRATIGRAPHY

Stratigraphic studies in the Shaviovik and upper Sagavanirktok Rivers area include sedimentary rocks of the Mississippian Lisburne limestone; the Permian (?) Sadlerochit formation; the Triassic Shublik formation; the Jurassic Kingak formation; the Lower Cretaceous Okpikruak formation; and the Lower Cretaceous Ignek formation and its western counterparts, the Torok formation and Nanushuk group. In addition to the detailed study of the formations listed above, a cursory examination was made of the pre-Lisburne rocks in the area south of camp 2 on the Echooka River.

Correlated columnar sections have been prepared to facilitate study of these formations, and are presented on plates 3, 4, and 5. As a result of the season's work, correlation of the Mesozoic and upper Paleozoic rocks east of the Shaviovik River with those west of the Itkillik River may be made; these correlations are discussed in full on the following pages.

Because no detailed fossil examinations have yet been completed, it must be emphasized that positions of mapped contacts, as well as the ages of some of the formations, are subject to change. For the present, geologic contacts and ages of rocks are based largely on direct field analysis.

Pre-Lisburne rocks

Although the paramount purpose of the party was the stratigraphic study of Mesozoic and upper Paleozoic rocks, a cursory examination was made of strata of pre-Lisburne age in the valley of the Echooka River. From a point approximately 3 miles south of the north front of the Brooks Range, a maximum of 7,000 feet of these rocks is exposed in a series of apparent south-dipping beds along the valley sides.

In general, these strata may be subdivided into two units: an upper shale-schist-slate-quartzite unit, and a lower phyllite unit. The lower unit consists predominantly of micaceous rock, locally chloritic, with well-developed cleavage that obliterates the original bedding of the sediments. The rock is fissile, splits along the micaceous cleavage planes into thin sheets, is reddish-gray, and weathers to a rust-brown color. Quartz veins are commonly associated with the phyllite unit.

The upper unit consists of shale, schist, slate and quartzite, and probably does not exceed 500 feet in total thickness. The quartzite is blue gray, medium-grained, and represents less than 50 feet of the total section. A few lenses of dark chert-pebble conglomerate are present. The slate and shale are dark blue to black, thin-bedded, hard and brittle, with mud lumps along the bedding planes. The schist has a moderately well developed banded structure and is mineralized to a minor extent. Development of mica in the schist is limited.

Although the relationship of the upper unit to the overlying Mississippian Lisburne limestone is somewhat obscure, no marked angular discordance appears to be present between the two units.

The relationship of the lower phyllite unit to the upper shale-schist-slate-quartzite unit is obscured by a high-angle reverse fault. On the basis of the marked difference in degree of metamorphism of the two, however, the lower is tentatively assigned to the Nerwokpuk formation, and the upper unit to the Noatak formation as described by Gryc and Mangus[1/] on the Canning River.

Carboniferous system

Mississippian series

Lisburne limestone.--Only a cursory examination was made of the Lisburne limestone, inasmuch as the primary objectives of the party prohibited the use of the time necessary for its detailed study. The competent limestone forms the north front of the Brooks Range; its distinctive light-gray weathered color makes it the most easily recognizable unit in the area traversed. Although the limestone is locally overturned and faulted,

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1/ Gryc, G. and Mangus, M. D., Preliminary report on the structure and stratigraphy of the Shaviovik and Canning Rivers area, Alaska: U. S. Geol. Survey Navy Oil Unit Prelim. Rept. 10, October 1947.

a normal contact with younger rocks has been preserved along the mountain front over most of the area.

In general, the section consists of medium crystalline to hydroclastic limestone, which locally is oolitic or lithographic. It is normally thin bedded, although somewhat more massive in the lower part of the sequence. The massively bedded limestone is generally lighter in color than the somewhat siliceous blue-gray thin-bedded variety. Chert, as lenses and nodules, is common throughout. The entire sequence of Lisburne limestone has a strong fetid odor.

On Flood Creek in the vicinity of camp 7, 2,900 feet of Lisburne limestone was measured along the north limb of an anticline. The base of the section was not seen. A medium to finely crystalline rock type, bedded from 10 to 15 feet, comprises the basal part of the unit. Upward the section is less massively bedded, more coarsely crystalline, and darker in color. About midway in the sequence is an 80-foot unit of tan-colored crinoidal limestone. Fossils other than these crinoids are relatively scarce. A few brachiopods of the Productid and Spirifer type and a few corals were noted.

This 2,900-foot sequence may represent all of the Alapah and part or most of the Wachsmuth members. However, fossil control is scanty, and as yet no fossil determinations have been made. The Kiruktagiak facies is not present in the Flood Creek section, nor was it seen in any of the area traversed during the field season.

The Lisburne limestone appears to thin both to the north and to the south. As the thinning is more pronounced to the north, a depositional high is indicated in that direction.

Permian (?) system

Sadlerochit formation

Stratigraphic studies of the Sadlerochit formation were confined to a relatively narrow geographic belt 1 to 3 miles wide that flanks the Lisburne limestone mountains. Owing to the resistant nature of the basal part of the Sadlerochit formation, in places it is found as erosional remnants that cap anticlinal cores of Lisburne limestone. This characteristic is strikingly illustrated in the area between the Lupine River and Nosebleed Creek (pl. 1). The ferruginous weathering, characteristic of the basal part of the formation, plus the tendency of certain horizons within the formation to form northeast-trending cuestas, affords an easy method of identification of the Sadlerochit formation in this area.

The formation attains a maximum thickness of 2,620 feet in the area of Flood Creek (pl. 1). On Kemik Creek and Gilead Creek, thicknesses measured were 2,000 feet and 940 feet respectively, although in neither case was the top of the section seen.

In general, the formation may be divided into three main parts. In the area extending from Kemik Creek to the Ivishak River (columns D and E, pl. 3), the basal part of the section conformably overlies the Lisburne limestone. Here the basal 500 feet characteristically consists of massively bedded, hard, well-indurated, argillitic, cherty to siliceous siltstone that is fine-grained, dark blue gray, noncalcareous, and locally limonite-spotted. Shaly banding is present locally. Light-colored quartzitic rocks and limonite nodules are common. Subvitreous gray-green chert occurs sporadically as beds and lenses, and secondary (?) chert coats many of the siltstone surfaces. Quartz veins occur locally in the siltstone. Iron-stained weathered surfaces are a distinctive feature of the basal part of the section. Within the basal 75 feet, brachiopods having Productid affinities, Spirifer sp., and unidentified horn corals and gastropods are common. Locally, the fossil horizons approximate coquinas of light-brown to wax-brown-weathering limestones.

Southwest from the Ivishak River, the basal 500 feet undergoes a pronounced change. The section in this portion of the area consists predominantly of interbedded blue-gray limy siltstone and medium-gray limy shale. Locally interbedded is light-weathering blue-gray limestone. Wax-brown-weathering siltstone is common near the base of the section. The fossils are somewhat more abundant in this area, but correlate well with those which are found in the more massive siltstone section to the northeast. A tentative Permian age has been assigned to these fossils by J. S. Williams.2/

The middle part of the formation consists of dense, well-indurated, blocky to fissile, red-brown-weathering siltstone, interbedded with hackly fracturing, medium-gray silt shale. Small-scale cross bedding is common in the more sandy siltstone. Limy disc-shaped siltstone concretions ranging in diameter from several inches to a foot become more common in the more shaly section to the southwest, and contain ammonites and pelecypods, also considered to possess Permian affinities.3/ Locally the fossils are replaced with marcasite.

The upper part of the Sadlerochit formation consists of a monotonous, cyclically bedded series of dense, sometimes siliceous and laminated siltstone and silt shale. Although commonly platy-bedded to fissile, the siltstone locally is massive with blocky fracture. Small-scale cross bedding is present in the finely laminated siltstone. Ammonite impressions occur sporadically. The section grades upward into thin-bedded siltstone and shale near the contact with Triassic rocks. The placing of the upper contact of the Sadlerochit formation is based upon the presence of a pebbly ferruginous weathered zone and a pronounced break in lithology.

Several well-developed cleavage systems are present within the section. The most pronounced of these strikes north and locally obliterates the bedding. Two secondary fracture cleavage systems strike N. 60° E. and N. 20° W.

2/ Williams, J. S., and Gordon, M., personal communication, September 1951.

3/ Williams, J. S., and Gordon, M., personal communication, September 1951.

Previous work in the Canning River area[4] and in the Sadlerochit Mountains[5] indicates that the Sadlerochit formation ranges from 500 to 1,000 feet in thickness in those areas. Furthermore, work in the Sadlerochit Mountains indicates that part of the Sadlerochit formation has shore line affinities in that area. Present work indicates that Sadlerochit sediments were shed southward into a subsiding trough in the Shaviovik and Sagavanirktok Rivers area. This postulation is borne out by the southward thickening of the Sadlerochit section, by the general southward shaling of the section, and by the southward increase in abundance of fossils.

As has been previously stated, the age of the fossils collected from the Sadlerochit formation in the Shaviovik and Sagavanirktok Rivers area has been tentatively determined as Permian. Although no angular discordance is present between the Mississippian Lisburne limestone and the Sadlerochit formation, an hiatus, erosional or otherwise, is indicated.

Inasmuch as the 850-foot section of the Siksikpuk group described by Patton and Keller[6] in 1950 was also judged to be of Permian age, a tentative, direct correlation between the two formations is postulated. The discrepancy in thickness between the two formations may be due in part to pre-Shublik erosion in the southwestern area. It is also conceivable, however, that the thinning of the section could be due to the fact that the basin of deposition of the Siksikpuk group was beyond the area of maximum subsidence of the Sadlerochit trough.

Triassic system

Shublik formation

Triassic rocks crop out in a relatively narrow belt across most of the Shaviovik-Sagavanirktok Rivers area. The belt is less than half a mile wide, and in general is within 1 to 2 miles of the north front of the Brooks Range. The distinctive dark color and fossiliferous nature of the Shublik formation, plus the fact that it is the only predominantly calcareous unit between the Lisburne limestone and zone E of the Nanushuk group, make it an important marker unit.

Lithologically the Shublik formation consists of a series of interbedded dark-gray to black calcareous silt and clay shale, siltstone, and black limestone. The shale constitutes approximately 50 percent of the total thickness, is earthy to moderately fissile, and occurs as beds from several inches to several feet thick, with thinner interbeds of

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4/ Gryc, G., and Mangus, M. D., op. cit.

5/ Whittington, C. L., and Sable, E. G., Preliminary report on the geology of the Sadlerochit River area, Alaska: U. S. Geol. Survey Navy Oil Unit Prelim. Rept. 20, November 1948.

6/ Patton, W. W., and Keller, A. S., Stratigraphy and structure of the Siksikpuk and Nanushuk Rivers area, Alaska: U. S. Geol. Survey Navy Oil Unit Rept. 42, April 1951.

siltstone. Locally the shale is bituminous and may contain fossil plant fragments. Mud lumps and mud-ball concretions are characteristic of much of the section. The gray, calcareous, sandy siltstone which is the predominant lithologic rock type in the eastern part of the area occurs as interbeds in the shale farther west. The siltstone is moderately well indurated and locally has hackly fracture, with both calcite and quartz veins along the fracture planes. Beds of sandy to cherty limestone, from several feet to 10 feet thick, occur throughout the unit, although their occurrence is somewhat more common in the upper part of the section. A very abundant fauna is generally associated with the upper limestone beds. All lithologic types of the Shublik formation produce a strong fetid odor on a fresh break.

A section 180 feet thick was measured on the north limb of a small anticline on Gilead Creek (pl. 3, column B). The top of the formation was not seen, but the base appears to rest upon the underlying siltstone and silt shale unit of the Sadlerochit formation with no apparent angular discordance. Dark-gray hackly siltstone is predominant, with fissile black silt shale forming approximately 30 percent of the sequence. Ten feet from the top, a thin limestone bed occurs which contains abundant Monotis sp., Halobia sp., and several unidentified ammonite species. A few miles farther west on Gilead Creek, a sandy limestone believed to be in the upper part of the Triassic system, carries a profuse gastropod fauna.

A section 300 feet thick was measured on a tributary of the west fork of the Ivishak River (pl. 3, column A), in the vicinity of camp 8. Both upper and lower contacts were seen and this thickness is believed to represent a maximum for the Shublik formation in the Shaviovik-Sagavanirktok Rivers area. The contact with the Sadlerochit formation was marked by a 6-inch zone of pebbly ferruginous material, such as might be found on an eroded surface. No angular discordance was noted. Black calcareous siltstone and silt shale in about equal proportions comprise the bulk of the section. Locally the shale is bituminous but locally fossil plant fragments occur along bedding planes. A few thin sandy limestone layers are interbedded with the shale and siltstone in the lower part of the sequence; a heavier-bedded cherty limestone occurs approximately 50 feet from the top. Associated with the lower limestone layers are a few brachiopods; the typical faunal assemblage of Monotis sp. and Halobia sp., plus unidentified ammonites are found in the upper cherty limestone.

Jurassic system

Kingak formation

No exposures yielding fossils

Owing to the nonresistant nature of the shale facies of the Kingak formation in the northeastern part of the area, only estimates of the thickness of this stratigraphic unit are feasible northeast of the Ivishak River. However, a minimum of 2,500 feet of sediment is represented on Kemik Creek. In the area extending from Kemik Creek to the Ivishak River, the formation consists principally of medium gray to black, earthy to fissile, and brittle noncalcareous shale. The section is commonly iron stained, owing to the weathering of the disseminated pyrite and marcasite, which occur within the buff-weathering siltstone beds and

Aucella Bronni (Rouiller) – 51AKe 48 (Mes Loc 22759)
Nondeterminable Ammonite – 51AKe 98 (Mes Loc 22763)

lenses associated with the shale. Much of the shale section exhibits a white salt efflorescence. Lenses and nodules of spalling ironstone are present throughout the unit, and local septarian nodules range in diameter from several inches to several feet. Fossils, although rare, include Aucella bronni and other unidentified species of Aucella, large Inoceramus, and several unidentified gastropods and ammonites. In general, these fossils occur within the dense limy siltstone lenses, although locally they are present in the shale.

Southwestward from the Ivishak River the Kingak formation becomes more coarsely clastic. In a section measured on the west fork of the Ivishak River (pl. 4, column E), the basal 400 feet consists predominantly of iron-oxide-coated, hackly fracturing silt shale, with interbeds and lenses of very hard, dense, rust-brown-weathering siltstone. Marcasite and/or pyrite cubes are well developed within the siltstone beds and lenses. Scarce Aucella sp. and unidentified brachiopods and ammonites are confined to the lenticular siltstone. Rhynconellid brachs, Pseudocadoceras gowingKi (Pompeckj)

Callov Secto

The area of the Lupine River affords the best exposures for study of the Kingak formation. An 1,800-foot section, measured in the vicinity of camp 10 (pl. 4, column D), correlates favorably with several sections measured by Patton and Keller[7] in the Siksikpuk and Nanushuk Rivers area in 1950. It overlies the Triassic sediments with no apparent angular discordance. The top of the section has been eroded. The lower 200 feet of the unit consists predominantly of black, fissile, platy shale, highly oxidized on exposed surfaces. Green clay gouge zones are present locally, and thin-bedded dark platy limestone occurs near the base. Overlying this portion of the formation is approximately 300 feet of a gun metal-blue-stained, brittle to fissile black shale. Lithologically, it is identical with the shale that flanks the infolded coarse clastics of the Topok formation in the area of the lower east fork of the Nanushuk River.[8] Its stratigraphic position in the Lupine River section tends to validate the correlation made in 1950, that these shales are a facies of the lower bedded cherts in the Kingak formation in the Siksikpuk River area.[8] Siltstone lenses are present within this shale section, and are commonly coated with rust-brown siderite and prismatic calcite. Fossils are abundant at this stratigraphic horizon and include Aucella bronni and other unidentified Aucella species, Phylloceras and other unidentified ammonite species, and a few belemnites. The fossils occur in both the shale and the lenses of siltstone. Lots 51AKe 185 (Mes Loc. 22766), 51AKe154 (Mes Loc 22769), 51AKe153 (Mes Loc. 22768), 51ADt149 (Mes Loc 22749), 51ADt151 (Mes Loc 22750), 51ADt 152 (Mes Loc. 22751)

Graywacke sandstone beds increase in abundance progressively higher in the section, are lenticular in aspect, are greenish gray, highly argillaceous, exhibit "ropy"-appearing flow structure, and are commonly siderite- and calcite-coated. A cross-bedded, platy, gun metal-blue-stained sandstone occurs near the top of the section.

Locally, a rust-brown-weathering coquinoid limestone, composed principally of Aucella sp. occurs from the base of the section to 500-600 feet above the base. Lithologically, it is identical with that described

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7/ Patton, W. W., and Keller, A. S., op. cit.
8/ Patton, W. W., and Keller, A. S., op, cit. p. 8.

SIAKe 115 (Mes Loc 22764)
~~SIAKe~~
SIAKe 134 (Mes Loc 22745) →
Rests directly on Trs. section

Aucella bronni (Rouiller)
Aucella Rugosa (Fischer) →
Aucella mosquensis (von Buch)

Rests on Trs. section
Callovian section apparently →
missing

probably correlative →
with Oxfordian section
(Nothing lower)

51AKe 23 (Mes Loc. 22757)
~~51AKe~~
51ADt 18 (Mes Loc. 22738)
51ADt 33 (Mes Loc. 22740) ——→
51ADt 49 (Mes Loc. 22741)
51ADt 50 (Mes Loc 22742)

in a similar stratigraphic position in the Siksikpuk and Nanushuk Rivers area.9/ (Aucella bronni and A. rugosa)

Owing to pre-Torok or pre-Okpikruak erosion southwest of the Lupine River, much of the Jurassic sequence is missing in that area. In general, however, the lower parts of the unit contain a greater percentage of dirty, argillaceous, gray-green, siderite- and calcite-coated, curly-bedded sandstone. Black and green, subrounded chert-granule conglomerate lenses are present locally near the base of the section.

In general, the most coarsely clastic facies of the Kingak formation occurs in the southern portion of the area, and the formation shales rapidly northward. Fossil identifications to the present time have established the presence of an Upper Jurassic (Oxfordian-Kimmeridgian) sequence within the area studied. Further paleontologic work is necessitated, however, before the limits of the unit can be well defined. Now evident that lower Jurassic (Pliensbachian) is present 51 ADt 144 (Mes loc. 22747) See pl. 1

Lower Cretaceous rocks

Okpikruak formation

The Okpikruak formation has been identified both in the northeastern and southwestern parts of the geologic traverse. Over much of the central area the formation, if present, consists of shale which cannot be readily distinguished from shale of the Kingak formation. In this portion of the area, therefore, the sediments have been mapped as Kingak-Okpikruak formations undifferentiated. With further study of the fossils it may be possible to subdivide these rocks.

In the northeastern part of the area, 720 feet of section has been mapped as Okpikruak formation on the basis of the occurrence of Aucella okensis. Dark-gray, nodular to earthy clay to silt shale comprises the greater percentage of the upper 500 feet. Buff to gray dense, hard and noncalcareous to limy siltstones are present as beds and lenses. Fossils are generally restricted to the siltstone lenses and are commonly pyritized. A white salt efflorescence is present on much of the shale. The basal 220 feet of the Kemik Creek section consists of a subgraywacke type of quartzose sandstone which is medium-bedded, fine- to medium-grained, light gray, with iron staining common. Most of it is slightly argillaceous, noncalcareous, and well-indurated. The base of the section contains several thin lenses of ferruginous quartz grit conglomerate.

The Okpikruak formation overlies the Kingak formation with no marked angular discordance in this area. The top of the section is eroded.

In the vicinity of Elusive Lake (pl. 4), the Okpikruak formation is much coarser-grained and of a graywacke nature. Inasmuch as the formation in this area overlies the basal section of the Kingak formation, an erosional hiatus is indicated between the two formations in the southern part of the traverse.

probably Oxfordian section (no older)

9/ Patton, W. W., and Keller, A. S., op. cit. p. 9.

The Elusive Lake section of 1,560 feet consists predominantly of a monotonous cyclically bedded series of graywacke sandstone, siltstone, and silt shale. Sandstone is gray to green, fine- to medium-grained and argillaceous. The siltstone is dense, hard, and noncalcareous. Bedding in both the sandstone and siltstone varies from several inches to several feet. Limy to nonlimy siltstone lenses and concretions are present near the base of the section. In general the sequence becomes coarser and more resistant upward. The top of the section is eroded.

The upper 884 feet of the Okpikruak formation, underlying the coarse clastic facies of the Torok formation, is exposed on Section Creek (pl. 4, column A). In this section, the typical dirty graywacke sandstone occurs as beds as much as 15 feet thick. A few thin conglomerate lenses of well-rounded black and green chert pebbles are associated with the silty, dark-gray, fine-grained sandstone. Cyclically bedded siltstone and silt shale comprise approximately 50 percent of the section. A high-angle reverse fault cuts out the bottom of the sequence.

The Okpikruak formation exhibits the same general depositional pattern as does the Kingak formation. The coarsest-grained sediments of the Okpikruak formation were deposited in relatively the same basin as were the coarse clastic sediments of the Kingak formation; both formations shale rapidly northward.

Ignek formation

As a result of the field work done in the Shaviovik and Sagavanirktok Rivers area, the Ignek formation, as studied in the eastern area, is tentatively correlated with the Torok formation and Nanushuk group of the western area. This correlation is illustrated on plate 5.

Rocks possessing the subgraywacke facies characteristics of the Ignek formation are confined in their occurrence to an area roughly delimited by camps 4, 5, and 6 (pl. 1). Inasmuch as the geologic traverse was made in a southwesterly direction, it was deemed advisable to use the formation names of the western counterparts of the Ignek formation on the areal map accompanying this report. The Ignek formation, in the area of camps 4, 5, and 6 has therefore been subdivided and mapped as the Torok formation, and zones B-C undifferentiated, of the Nanushuk group.

In the area defined above, 3,600 feet of sedimentary rocks are exposed. These were deposited on the uplifted and differentially eroded surface of shale of the Okpikruak and Kingak formations.

Several sections of the formation were measured in the area east of the Ivishak River and north of Kashivi Creek, the most complete of which is illustrated on plate 5 (column B). In this 2,600-foot section the facies is lithologically uniform and the sediments reflect deposition in a deltaic or near-shore environment. The sequence is composed of upto 60 percent sandstone and 40 percent siltstone and shale. The sandstone is fine-grained, dark gray, noncalcareous, highly argillaceous, and highly micaceous. Macerated plant remains, carbonized plant fragments, and

Lots 51 ADt 101 (Mes Loc. 22752)
51 ADt 112 (Mes Loc 22753)
51 ADt 113 (Mes Loc 22754)

limonite concretions are common throughout the sequence. Typically, the sandstone displays small-scale cross bedding, and curly bedding or hassock structure. The siltstone is thin-bedded and ferruginous; the shale is medium to dark gray, with a few fetid blue-gray limestone lenses near the base of the section.

On Gilead Creek additional younger rocks are exposed. Owing to the faults in the area and general lack of stratigraphic control, the thickness of additional section may only be estimated. However, a minimum of 1,000 feet of younger strata is considered to be present. This estimated 1,000 feet possesses the characteristics of the transitional (near shore) Nanushuk group sediments (zone C) in the western area. Sandstones range from thin-bedded, noncalcareous, carbonaceous fine-grained rocks to reddish-orange-weathering, medium-grained, salt-and-pepper-textured rocks containing a relatively high percentage of white quartz.

Summarily then, a minimum of 3,600 feet of the Ignek formation is considered to be present in the area. The section is essentially nonfossiliferous, although Inoceramus sp. (subround) and Cleoniceras sp. occur locally fairly high in the sequence. As the section changes but little, lithologically, the fossils are probably not restricted to any one horizon within the formation, and may range close to the base.

Although the presence of white quartz in Cretaceous sandstone cannot be assumed to represent a hard and fast time marker, nevertheless observations elsewhere in the foothills belt imply that the deposition of detrital white quartz occurred sometime between middle zone B and middle zone C time. In addition Inoceramus sp. (subround), although relatively long ranging, has never been found in the foothills belt in rocks younger than zone C. Assuming that the quartz-bearing salt-and-pepper sandstone, which is approximately 3,000 feet above the base of the formation, represents basal zone C sediments, and assuming a thickness for zone B comparable to its thickness to the west, then the basal 2,000 feet of the Ignek formation is correlative with the Torok formation, and the upper 1,600 feet is correlative with zones B-C of the Nanushuk group.

Inasmuch as this 2,000-foot section is thinner than the Torok formation to the south, it is reasonable to assume that this thinning is due to onlap of the formation over a high present in Ignek time to the north and to the east.

Torok formation

Southwestward from the high referred to above, the Torok formation becomes more shaly, and in all probability thickens. In the area from the Ivishak River to the Lupine River, the formation consists primarily of interbedded medium-gray, noncalcareous, platy to fissile silt shale and finely laminated cross-bedded siltstone. The siltstone is generally in beds as much as 2 inches thick and weathers buff. Buff-weathering nonlimy siltstone concretions are common. The section is essentially nonfossiliferous, although Inoceramus sp. (subround) occurs locally in the shale. Because of the nonresistant nature of the formation in this locality, no estimate of the thickness of the unit may be made for this area.

The most pronounced change in the Torok formation occurs in a belt roughly delimited by camps 11, 12, 13, and 15 (pl. 1). The Torok formation there is correlative with the belt of infolded coarse clastics of the Torok formation of the Castle Mountain-Fortress Mountain trend.[10] The formation rests unconformably on the Okpikruak formation, the Kingak formation, or the Triassic formation (pl. 1), depending upon the amount of pre-Torok erosion.

Several sections of the formation were logged in this area. The Elusive Lake section, 3,400 feet thick, is the most complete and is illustrated on plate 5 (column A). The top of the section has been eroded. The basal part of the Elusive Lake section is soft black clay to silt shale with a few interbeds of siltstone. Local massive pebble and granule conglomerate lenses consist of large angular to subrounded black and green chert granules, pebbles, and cobbles in a medium-grained, gray to green sandstone matrix. They are markedly nonpersistent along the strike and lense rapidly. Although relatively common near the base of the unit, their position is not confined to any one stratigraphic horizon, and they may occur anywhere within the sequence.

The greater percentage of the 3,400 foot-section consists of an interbedded series of graywacke sandstone, siltstone, and silt to clay shale. The sandstone is fine- to medium-grained and medium gray to green. Black and green chert is the preponderant detrital component. Locally the sandstone contains shale lenses and "pebbles" and carbonized wood fragments. The siltstone is in general dark gray and siliceous. Clay shale and silt shale are medium gray, noncalcareous and locally contain chert granules and pebbles.

The entire sequence is nonfossiliferous, without any reliable horizon markers.

Nanushuk group

Rocks of the Nanushuk group are exposed in a gently folded syncline at the western end of the area traversed. The lithology and stratigraphic thickness of these rocks correlates favorably with those described by Patton and Keller[11] in the Arc Mountain synclinal trend to the west. Thirty-four hundred feet of zones B through E sediments were measured along the south flank of this syncline. In general the rock may be classified as subgraywacke in contrast to the underlying Kingak, Okpikruak, and Torok formation graywackes of the western area.

Zone B.--The predominantly marine zone B comprises 800 feet of the total sequence. The base of the unit was not seen. Siltstone, silt shale, and interbedded silty sandstone are the main lithologic types represented. About 60 percent of the unit is composed of gray-brown, rust-brown-weathering siltstone and hackly-fracturing noncalcareous silt shale. Small limonitic nodules are common near the base. Worm trails, tubes, and plant fragments are abundant throughout.

10/ Patton, W. W., and Tailleur, I. L., The stratigraphy and structure of the Okpikruak and Kiruktagiak Rivers area, Alaska: U. S. Geol. Survey Navy Oil Unit Report No. 34, 1950.

11/ Patton, W. W., and Keller, A. S., op. cit.

Sandstone in the zone B sequence is very fine grained, dirty, argillaceous, slightly calcareous, and dark gray to green. It commonly weathers brown. Sandstone beds in the basal portion are somewhat lenticular. Locally the rock is laminated, and the greater percentage is thin bedded and commonly cross bedded. The marine fauna found near the base includes Inoceramus sp., Protocardium sp., Tellina sp., and the ammonite Cleoniceras? sp. Probably Yat. clamicarus.

Zone C.--Zone C in this area is defined as that portion of the Nanushuk group that includes strandline sandstone and marginal deposits. The sequence is thus gradational from zone B. One thousand feet of zone C strata are present in the area. The base of the section is somewhat arbitrarily placed at the base of a massively bedded, medium-grained, salt-and-pepper-textured, fairly clean sandstone. This sandstone horizon occurs 980 feet above the base of zone B in the Nanushuk group type locality on the Chandler River. This horizon was also considered to represent the base of the zone C section in the area north of camp 4, as has been previously indicated in the discussion of the Ignek formation.

Above the basal sandstone, the strata are more thinly bedded and the sandstone is finer-grained, argillaceous, and locally calcareous. Silt shale and gray-green cross-bedded siltstone occur as interbeds. This latter sequence comprises approximately 50 percent of zone C. Coal float was noted locally.

Zone D.--The zone D unit, confined to nonmarine sandstone, conglomerate, and coal, is 1,500 feet thick in the area. Its contact with zone C is arbitrarily placed at the first occurrence of massively bedded, nonmarine, white quartz conglomerate. The contact is of course gradational. The conglomerate is not restricted to the base of the unit, but may occur throughout the sequence. Typically, it forms resistant ledges at the top of the synclinal mesas. Rounded white quartz granules and pebbles form as much as 30 percent of the conglomerate. The remainder is composed of assorted black, gray, and green chert, and an occasional Lisburne limestone pebble.

Sandstone and siltstone comprise the bulk of zone D. The sandstone is fairly clean, medium-grained, salt-and-pepper-textured, and generally weathers rust brown to yellow brown. The siltstone is thin-bedded, medium gray and limonite-stained. A small amount of coal occurs near the base of the section and ironstone nodules occur throughout.

Zone E.--Approximately 100 feet of poorly preserved zone E section was measured. It conformably overlies zone D, and the contact between the two units is gradational. The sequence includes thin-bedded, fine-grained, highly argillaceous, gray-green, slightly calcareous marine sandstone, and interbedded siltstone and silt shale. The marine nature of the facies is the criterion upon which the placing of the lower contact is based.

IGNEOUS ROCKS

The only igneous rock in the area traversed occurs on the upper part of Flood Creek, south of the 2,900-foot section of Lisburne limestone measured on the same stream. The igneous body intrudes the Lisburne limestone and is localized along planes of weakness in an overturned and faulted major anticline.

Although petrographic studies have not been made of the rock, it appears to be of the diabasic nature of the intrusives farther west. It is a green, finely crystalline rock which istexturally more felsitoid than granitoid, and commonly porphyritic, with large phenocrysts of amphibole and inclusions of calcite. The host rock has been partially assimilated, and the contact rock has the characteristics of a hornfels.

Contact metamorphism has been relatively mild and marmorization extends only a few inches from the contact. Pyritization is slight and is also limited to the contact zone.

No igneous intrusions were seen in rocks younger than the Lisburne limestone.

STRUCTURE

As has been previously stated, a paramount purpose of the party was the determination of the reason for the pronounced northeasterly swing in the trend of the Brooks Range front east of the Sagavanirktok River. Several theories have been advanced in the past, one of which explains this phenomenon as due to a northward faulting of the Lisburne limestone. As is indicated on plate 1, however, the normal contact of the Lisburne limestone with younger strata has been preserved over 70 percent of the area traversed.

From the area of the west fork of the Shaviovik River to the vicinity of Ribdon River, 20° W. plunge of Lisburne limestone is clearly marked in the N. 60° E.-trending structures. West plunge of up to 35° is expressed in minor folds of the Sadlerochit formation. This degree of plunge lessens considerably, and reverses locally, in structures in the the Kingak and Okpikruak formations. These reversals occur in the extreme northeastern and extreme southwestern parts of the area traversed. West plunge of synclines in the Torok formation and Nanushuk group rarely exceeds 6° to 8° and reversals are present locally. In several areas of the geologic traverse, streams have localized along the contact where the Lisburne limestone plunges beneath the Sadlerochit formation. This phenomenon gives rise to the erroneous concept that tear faults are present along these streams.

As might be expected, folding and faulting was most intense proximal to the Brooks Range proper and became less intense northward. Folding and faulting were less severe in the northeastern part of the area, reflecting uplift of an epeirogenic nature. This is in contrast to the more intense orogenic folding and faulting expressed in the early Mesozoic sediments in the extreme southwestern portion of the area.

Faults are commonly localized along overturned anticlinal axial planes. Inasmuch as they are high-angle reverse faults, the hade seldom exceeds 30°. Stratigraphic throw on these faults is relatively small; faults of maximum stratigraphic throw are localized in the area west of the Sagavanirktok River.

Northwest-trending transverse faults are present locally along the east side of the Ivishak River south of Kashivi Creek, and along Nosebleed Creek (pl. 1). Stratigraphic displacement on the former probably does not exceed 2,000 feet.

It interrupts the regional picture only to a minor extent, inasmuch as the fault block also assumes the west plunge evinced by the Lisburne limestone folds (pl. 1). On Nosebleed Creek transverse faults cut the saddle between the predominantly west plunging structures on the east side of the river and a doubly plunging anticline on the west side of the river. Stratigraphic displacement on the more westerly fault in this area (pl. 1) exceeds 2,000 feet.

No thrusting of Lisburne limestone over younger rocks is evident in the area traversed. Minor imbricate-type thrusts are present, however, within the Lisburne limestone in the vicinity of the Ivishak River.

REGIONAL SIGNIFICANCE OF STRUCTURE AND STRATIGRAPHY

Inasmuch as the geologic traverse cuts the strike of deposition of the upper Paleozoic and Mesozoic sediments, it is considered feasible to reconstruct the geologic history of the area. This discussion is not intended as a detailed analysis of all the forces that have acted on the geosynclinal basin. Such an analysis is beyond the scope of this report. It is intended, however, as a reconstruction and interpretation of the geologic history of the Shaviovik and Sagavanirktok Rivers area, as it is reflected in the stratigraphy and structure mapped in this area.

As has been previously stated, it is apparent that a Paleozoic high existed north of the area of traverse. Lisburne limestone if present at all in Topagoruk Test Well No. 1 comprises but a thin sequence which apparently thickens considerably southward to the Shaviovik and Sagavanirktok Rivers area. Inasmuch as a tentative Permian age assignment has been designated for the entire Sadlerochit formation, an hiatus, erosional or otherwise, is indicated in post-Mississippian time.

In respect to depositional features of shore lines and basins, those of the Sadlerochit formation in general parallel those of the Lisburne limestone. This is borne out by the shore-line characteristics of the Sadlerochit formation in the Sadlerochit Mountains; and by the thickening and shaling of the Sadlerochit formation southward into a subsiding trough in the Shaviovik and Sagavanirktok Rivers area. Inasmuch as no angular discordance is present between the Sadlerochit and Shublik formations, an upwarp, if present in post-Permian time, must of necessity have been quite gentle.

A quiescent blanket type of deposition is indicated in Triassic time, as the Shublik sediments change but little in lithology or thickness anywhere in the area of geologic traverse.

In Jurassic time, evidence of moderate diastrophism is reflected in the clastic nature of the Kingak formation in the southern portion of the area. However, the shaly nature of the formation in the northern part of the area indicates that although the southern area was undergoing moderate uplift, the northern area was subsiding. The rate of this subsidence is considered to have been relatively slow, and may have been interrupted by oscillations great enough to have developed local depositional breaks in the sequence.

In post-Jurassic time, the southern area was uplifted and differentially eroded. This is shown in the unconformable relationship of the Kingak and Okpikruak formations in that part of the traversed area. This moderate uplift in the southern area is reflected as only a gentle upwarping in the northern area where no discordance is apparent between the Kingak and Okpikruak formations.

During Okpikruak time, the graywacke nature of the formation in the southern portion of the area indicates that the intensity of the mountain building movement increased. Relatively slow submergence of the northern area was concurrent with the uplift to the south. This upwarp and submergence is reflected in a basal quartzose sandstone and an overlying shale facies in the Okpikruak formation of that locality.

In post-Okpikruak time, the entire area was uplifted and differentially eroded. This postulation is borne out by the unconformable relationship between the Torok and Okpikruak formations to the south, and between the Ignek and Okpikruak formations to the north. As reflected in the coarse clastic graywackes of the thick Torok formation in the southern area, uplift in the southern belt was relatively severe. The subgraywacke nature of the Ignek formation to the north reflects uplift of a much gentler epeirogenic nature.

Oscillation of the Cretaceous seas in later Cretaceous time is reflected in the transgressive and regressive marine and nonmarine strata of the Nanushuk group.

An important consideration in respect to the search for oil is thus reflected in the geologic history of the area. Whereas mountain building in the southern part of the area was initiated during Jurassic time and culminated in a relatively severe orogeny, uplift in the northern area was initiated in post-Okpikruak time and was relatively gentle throughout its duration. The importance of this fact should not be minimized, as it increases the possibilities of finding structures favorable for the drilling of Lisburne limestone at shallow depth in the eastern area.

PETROLEUM POSSIBILITIES

Stratigraphy.--The Lisburne limestone has long been considered a potential oil-bearing unit. The 80 feet of crinoidal limestone within the sequence at Flood Creek appears to have moderate porosity. Under favorable structural conditions, it may be considered as a reservoir rock.

The Sadlerochit formation throughout the area is extremely tight and no horizons are present with characteristics favorable for the accumulation of oil. These conditions, however, may exist farther north in a shore-line phase along the Paleozoic high.

The Triassic Shublik formation, although it is not considered to be a favorable reservoir rock, should not be overlooked as a possible oil source for favorable sand reservoirs higher in the sequence.

The Kingak and Okpikruak formations are predominantly shale in the northern area. In the southern area, their graywacke nature in general precludes any major oil reservoirs. The basal quartzose sand of the Okpikruak formation in the eastern area appears to possess characteristics that make it a potential oil-bearing sand. It is relatively clean, and in appearance compares favorably to sands in zones C-D of the Nanushuk group.

The graywacke composition of the Torok formation places it in the same category as the graywackes of the Kingak and Okpikruak formations. Accumulation of oil in this formation is unlikely.

Together with the quartzose basal sandstone of the Okpikruak formation, zone C sandstones are considered to possess the most promising characteristics for a reservoir rock. However, previous laboratory analysis of this basal part of zone C indicates that although porosity may be as high as 15 percent, permeability is low.

Structure.--No structures favorable for drilling were seen in the area traversed west of the Echooka River. The southwestern area is complexly folded and faulted and no favorable structures are apparent. From Echooka River to Ribdon River, west plunge is clearly marked. The only reversal along this belt occurs in a doubly plunging anticline which exposes Lisburne limestone along its crest and flanks.

The only area meriting consideration is the locality east of the west fork of the Shaviovik River. Here Lisburne tests could be made at relatively shallow depths. Two small anticlines exposing Jurassic rocks along their crests are present in the area. East plunge is clearly marked on the northern anticline (pl. 1). Inasmuch as west plunge is characteristic of this area, closure may be present on this relatively small structure. West plunge cannot be confirmed by surface geological methods, inasmuch as the western extremity of the anticline is gravel-covered. Depth to the Lisburne limestone on the crest of the structure should not exceed 4,500 feet.

The high-angle reverse faults in the same locality may afford structural traps, although no arching of sediment against these faults is evident.

SUMMARY

1. The Shaviovik and Sagavanirktok Rivers areas contain rocks ranging in age from pre-Cambrian (?) to upper Lower Cretaceous.

2. Maximum thicknesses of stratigraphic units have been established as follows: Lisburne limestone, 2,900+ feet; Sadlerochit formation, 2,620 feet; Shublik formation, 300 feet; Kingak formation, 1,800+ feet; Okpikruak formation, 1,560+ feet; Ignek formation, 3,600+ feet; Torok formation, 3,400+ feet; zone B, 800+ feet; zone C, 1,000 feet; zone D, 1,500 feet; and zone E, 100+ ft.

3. The Sadlerochit formation is Permian (?) in age and correlates directly with the Siksikpuk group.

4. The basal 2,000 feet of the Ignek formation correlates with the Torok formation and the upper 1,600 feet of the Ignek formation with zones B-C undifferentiated of the Nanushuk group.

5. Twenty degree west plunge of Lisburne limestone accounts for the northeasterly swing in the trend of the Brooks Range east of the Sagavanirktok River.

6. Whereas mountain building was initiated during Jurassic time in the southwestern portion of the area and was relatively severe in intensity, diastrophism was initiated in post-Okpikruak time in the northeastern portions of the area and was relatively gentle.

7. The northeastern portion of the area is considered to be more favorable for oil exploration than is the southern area.