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U.S. Geological Survey

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Geological Investigations

Naval Petroleum Reserve No. 4

Alaska

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PRELIMINARY REPORT ON STRATIGRAPHY AND STRUCTURE OF THE AREAS OF THE ETIVLUK, KUNA, AND NIGU RIVERS, ALASKA

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And

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November 1949

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On July 2, 1949, the party was moved approximately 60 miles southwest to the headwaters of the Kuna River. The geologic investigations along the 40 miles of the Kuna River were completed on July 14th, at which time the party reached the Colville River. Studies were then continued along the latter to the mouth of the Ipnavik River. On all rivers traveled, the geologic investigations covered an area away from the river for a distance of 10 to 15 miles on either side.

From the Ipnavik River, the party floated down the Colville River to the mouth of the Etivluk River. On July 23, 1949, the party was flown from that point to Howard Pass, the portage between the Etivluk and Aniuk River. Extensive geologic studies were carried on in the vicinity of Howard Pass. Approximately 250 square miles were traversed in this area. The traverse was ultimately joined with the upper Etivluk traverse started earlier in the year.

On August 4, 1949, the party was moved to the Killik River, approximately 60 miles east of Howard Pass, where the remainder of the season was spent studying the Lisburne and Noatak formations.

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Geological Survey Party No. 5 did not carry a plane-table traverse, but control was established by means of planimetric maps compiled from trimetrogon photographs and aerial photos. Altitude on all stations was established barometrically. The formations and rocks encountered were studied and sampled extensively for macro- and microfossils whenever possible. The rivers traversed had few cutbanks where the geology could be studied. Most of the outcrops are in the form of rubble-covered ridges, making it hard to map structures.

SUMMARY OF STRATIGRAPHY

Sedimentary rocks of Mississippian, Triassic, and Lower Cretaceous ages, and basic igneous rocks which have not been definitely dated but seem to be Pre-Lower Cretaceous, were studied on the Etivluk, Kuna, and Nigu Rivers and in Howard Pass. Only Lower Cretaceous sandstones, silts, and shales were present along the Colville River.

In this report references to thickness are approximate, unless otherwise indicated. This is due to the abundance of small faults and tight folds and the scarcity of good outcrops. It was impossible to measure a continuous stratigraphic section of an entire formation along any of the rivers.

Mississippian rocks

Formations of Mississippian age have been tenatively broken down into three formations; Kanayut conglomerate, Noatak formation, and Lisburne limestone. The Kanayut conglomerate has been suggested by A. L. Bowsher for a series of coarse clastic beds in the Kanayut Lake area. What appear to be correlative beds were mapped in the Killik River area and therefore the name is used in this report. Rocks of Mississippian age are for the most part massive quartzitic conglomerates, quartzites, and thick-bedded arenaceous limestones with interbedded, hard silty shales.

Kanayut formation

The basal part of the Mississippian was fairly well exposed on the upper Killik River, and to a lesser degree in the upper Etivluk-Howard Pass area. The lower part of the Kanayut is a massive, thick-bedded conglomeratic quartzite, some of it red in color. The conglomeratic constituents are quartz and varicolored chert pebbles and cobbles as much as 3 inches in diameter. Beds 15 to 30 feet thick are common. Upward the section becomes less massive and less conglomeratic with more shale interbeds. The quartzite becomes fine-grained to silty near the top and is thin-bedded, with cross bedding common. In general the color is green in the upper part of the section. The shale interbeds are hard and in places are almost slates. In the lower part they are commonly red and green, a characteristic of terrestrial sediments. The Kanayut is on the order of several thousands of feet thick in the area of the upper Killik River. It seems somewhat thinner in the Howard Pass region. There is a marked westward facies change in the Kanayut. At Howard Pass and the upper Etivluk River, the formation is almost nonconglomeratic, and is a hard, fine-grained quartzite.

Noatak formation

Previously in northern Alaska, all Mississippian rocks older than the Lisburne limestone have been included in the Noatak formation. Under the present division of the Mississippian, the Noatak is restricted to the uppermost part of the sequence that was previously assigned to the Noatak. In the area traversed by Party 5 the Noatak (restricted) has a maximum thickness of 700 to 800 feet. The best exposures are in the area of Howard Pass and the upper Etivluk River. In this area it is a thin, crossbedded, fine-grained, gray quartzite. The only conglomeratic constituents are an occasional small pebble of chert or quartz. Limestone concretions are present. Limonite is a common constituent, and gives the rock a spotted appearance on fresh surfaces, and a rusty appearance on weathered surfaces. Thin-bedded, well-indurated, calcareous silt shale, and thin, interbedded arenaceous limestones form the upper part of the Noatak formation. Both the shales and limestone are locally fossiliferous. Corals, crinoid stems, bryozoa, ammonites, and brachipods were found. At one place near the Noatak-Lisburne contact on the Killik River, the shale was almost a solid mass of bryozoa, with some spiriferid - and rhynoconellid-type brachiopods. The contact was conformable and sharp. The age of the fossiliferous limestone, north of the Lisburne mountain in Howard Pass, is questionable, but it is believed to be part of the Noatak formation. Lithologically this limestone is quite dissimilar to limestones of the Lisburne as seen on the Killik River, and in the mountain just to the south; it is thin-bedded, dirty, and arenaceous, with numerous silt-shale interbeds.

Lisburne limestone

The best exposures of Lisburne limestone in the area traversed are on the upper Killik River. Here it is massive, crystalline limestone, locally fossiliferous, with chert in both nodules and veins. The limestone gives off an organic odor when struck with a pick. The Lisburne between the Killik and Etivluk Rivers appears to die out just west of Kurupa Lake, probably owing to elimination at the surface by faulting or folding. The limestone ridge approximately 20 miles in front of the range on the Etivluk River is believed to be Lisburne. Because of the close association of this limestone with Monotis-bearing beds, the limestone was tentatively identified in the field as Traissic, but identification of the fossils prove without a doubt that it is Mississippian in age. The section is approximately 500-600 feet thick at this point. It consists of massive, crystalline limestone, somewhat silicified. Fossils are scarce and poorly preserved. Monotis-bearing Triassic rock is found approximately 500 feet stratigraphically aobve the limestone. The limestone ridge in Howard Pass is also believed to be Lisburne because it is similar lithologically to the limestone in the ridge 20 miles in front of the range on the Etivluk River. No fossils were seen in the Howard Pass Lisburne, however.

Triassic rocks

Rocks of Triassic age are found over much of the area traversed; however, due to the complexity of the folding there is considerable repetition in the section. The total thickness of Triassic is believed not to exceed 4,000 feet. The Triassic fossil Monotis is abundant throughout. Sedimentary rock types in the Triassic include limestone, chert, and silty clay shale. Fossil-bearing limestone interbeds are common in the shale sequences. Best exposures of the shale are near the base of the Triassic on the Etivluk River. Multicolored cherts are probably the most outstanding feature of the Triassic beds. Red, green, black, gray, and yellow are the most common colors. Some of the cherts seem to be silicified limestones. Some of the coloring and the silicification are probably the result of igneous activity that took place during the Triassic. Red and green argillites as much as 200 feet thick are common in the Triassic--usually near the igneous contacts. Lithologically they resemble the "basement rock" found in the Cape Simpson hole (April 1948).

Lower Cretaceous rocks

The sedimentary rocks of the Lower Cretaceous consist of sandstone, conglomeratic sandstone, conglomerate, black clay shale, siltstone, and silty shale. The sandstone and conglomerate are green, except in the upper part of the section along the Colville and lower Etivluk Rivers, where they are buff. The basal part of the Lower Cretaceous consists of massive cobble to boulder conglomerates that form prominent ridges. The boulders are well-rounded and as much as 30 inches in diameter. The major constituents of the conglomerate are Triassic chert, limestone, and a minor amount of igneous material. The conglomeratic beds are lenticular and cross-bedded. They exhibit rapid facies changes. There is little or no size sorting in the conglomerate, indicating that deposition was rapid. Green sandstone and a gritty conglomerate stratigraphically overlie the massive basal conglomerate. These beds are sparsely fossiliferous. The fossils are poorly preserved specimens of Aucella sp., usually found in or near the grit. This basal part of the Lower Cretaceous is on the order of 1,000 feet thick. Overlying this section is a thick sequence of black clay shale that contains interbeds of siltstone and limestone. The beds are complexly folded and faulted, but they are probably several thousand feet thick. This sequence is believed to correspond to the shale member of the Killik group as used by W. W. Patton in the Kiruktagiak area.

To the north in the vicinity of camp 5 is another section of sandy and conglomeratic beds. The cobbles in this conglomerate are smaller, as much as 7 inches in diameter, and more rounded than in the basal conglomerate. The sandstone is a dirty, fine-grained, gray rock. Lithologically this sequence is somewhat dissimilar to the sandstone-conglomerate series to the south, and the regional dips are persistently to the south. Therefore, the sandstone-conglomerate section at camp 5 is believed to be stratigraphically higher than the sequence to the south. It is correlated with the sandstone-conglomerate section at the base of the Torok shale member of the Nanushuk group. North of this sandstone is a sequence of 3,000 to 4,000 feet of black clay shales that contain interbeds of siltstone and limestone. This is correlated with the Torok shale. The shale was sampled extensively for microfossils. These sediments crop out only in cut banks along the streams, swing to their tendency to erode rapidly.

Immediately overlying this the shale member is the buff sandstone that probably correlates with the Tuktu sandstone member of the Nanushuk group. Fossils characteristic of Faunal Zone 1 were found in this sandstone along the Colville River between the Kuna and Ipnavik Rivers. In general this sandstone is fine-grained, thin-bedded, argillaceous, cross-bedded, and somewhat calcareous.

Igneous rocks

Igneous rocks are much more abundant in the area traversed than was previously recognized. They are especially abundant in the Kuna River and Howard Pass areas. One body is approximately 13 square miles in size. This is probably a small laccolith; most of the igneous bodies appear to be sills and therefore intrusive in origin, as they parallel the bedding of the enclosing sediments. All except one of the intrusives are mafic, and are gabbro or basalt. The one exception is a silicic sill approximately 200 feet thick near Fay Creek on the upper Etivluk River; this sill bordered on the south by mafic rock. The igneous rock weathers a dark-reddish brown. It is somewhat more resistant than the surrounding country rock, and forms little hillocks and hogbacks. In a number of places on the Kuna River it forms the cap rock of the ridges. All intrusives were found in Triassic or older rocks, thus dating the age of intrusion as pre-Lower Cretaceous. Nearly all intrusives were in rocks of Triassic age, and at approximately the same horizon in the Triassic.

Structure

Numerous small fold axes were mapped in the area covered by Party 5. The complexity of the folding and poor exposures made it impossible to get a clear picture of the major structures. Further work with the aerial photographs may, however, clarify some of the regional structural relations. Structure shown along the Ipnavik River is after Stefansson. 1/ The small area of Mississippian rock surrounded by Triassic north of Fay Creek is believed to be a klippe. All contacts shown on the map are shown as probable contacts, because, with one exception, none of the contacts are exposed, and they could not be accurately located. The exception is the Noatak-Lisburne contact on the Killik River. Some contacts may be fault contacts. The belt of Lisburne limestone, which forms a ridge 20 miles north of the Brooks Range on the Etivluk River has probably been brought to the surface by a lowangle thrust fault of major proportions. The Noatak klippe on Fay Creek and the Lisburne limestone near Lake Betty are believed to be remnants of this thrust plate. However, there may have been a series of smaller thrust rather than one large one. Faulting north of the Range appears to be more common than originally suspected. The intrusives, in many cases, may have gained entrance along these fault zones.

Oil possibilities

In general, the geologic structures in the area traversed are unfavorable for the accumulation of oil. Rocks with good porosity were seen in only one part of the section. This was in and near the grit conglomerate and green sandstone in the base of the Lower Cretaceous. The determination of porosity was made in the field by the water-drop method. Laboratory determinations will be made and incorporated in the final report.

HOWARD PASS AND ETIVLUK RIVER AREAS

The first part of this report has been a generalized brief discussi f

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1/ Stefansson, Karl, Report No. 14, Stratigraphy and Structure of the Area of the Ipnavik River, Alaska, April 1948.

the various formations and rock types of the entire region traversed by Party No. 5. In the second part the geology and stratigraphy are described area by area in somewhat more detail. In this report the Etivluk River and Howard Pass areas, while not worked as a continuous traverse, will be considered as one area.

Kanayut formation

The Kanayut formation, as described by Bowsher for the Kanyut Lake area, is not present in the Howard Pass - Etivluk River area; but, rock types believed to be a western facies of the Kanayut were seen. The north front of the range in the region about 4 to 5 miles south of Camp 1 is composed of rocks probably equivalent to the Kanayut. The peaks are of quartzite, which is in part conglomeratic. The conglomeratic constituents are for the most part pebbles of light- to dark- colored chert, with an occasional pebble of quartz. The pebbles are well-rounded and usually less than one-half inch in diameter. The grain size varies from fine to coarse, but is predominately fine. The rock is uniformly light gray, thin - to medium-bedded, and has a rectangular blocky fracture. The color becomes darker on weathered surfaces. Near the top of this formation is a shale section several hundred feet thick. This is approximately 5 to 6 miles south of Camp 1. It is a silty shale, in places almost a slate, highly fractured with a pencil-type fracture. Interbedded with the shale are thin beds of gray quartzite. The shale is highly contorted. However, in the quartzite just to the north the general dip is to the southwest. The shale is blue to bronze in color and weathers to a brown; it is the least resistant member of the Kanayut formation, and is found in the low rounded hills just south of the mountain front.

Noatak formation

The rocks in the southern part of the range near Howard Pass have been tentatively correlated with the Noatak formation. Good exposures were hard to find. The hills and peaks are covered with rubble. The only exposures are on sheer cliffs. The Noatak, is considerably more resistant than any of the other formations in this region, and is the ridge former. The Noatak here is nearly nonconglomeratic; most of it is a fine-grained, hard, thin-bedded gray quartzite, with common cross bedding and with a considerable amount of limonitic material. Slightly metam orphosed siltstone and shale form a considerable part of the section in Howard Pass. In the upper 200 to 250 feet siltstone and shale are particularly abundant. The shale is slightly calcareous, and thin arenaceous limestone lenses occur throughout this part of the formation. They are usually soft compared to the rest of the Noatak, micaceous, and contain mud lumps and pyrite concretions as common constituents. Carbonized plant fragments are locally abundant. The shale is predominately gray green, with the rusty weathered surface so common to the Noatak in this area. Where it is more highly metamorphosed, the shale and siltstone have a schist-like appearance. This part of the Noatak section forms prominent "hog back" ridges west of the main lake in Howard Pass. A few fossils were found in the shales and siltstones. The limestone lenses were somewhat more fossiliferous. One thin, red, rusty bed of limestone found on both sides of the valley was quite fossiliferous; its exact thickness was undetermined, as it was only seen as rubble. It is believed to be only a few feet thick. Its extreme rusty color a nd highly fossiliferous character make it a good horizon marker. The Noatak at Howard Pass, forms a monocline that dips southwest.

Lisburne limestone

There are two major areas of Lisburne limestone in this region, one in Howard Pass, and the other along the Etivluk River. In addition, a small klippe of Lisburne limestone lies just south of Lake Betty, 10 miles south of the northernmost Lisburne ridge. The presence of the Lisburne ridge 20 miles in front of the range is best explained by a major low-angle thrust fault. The ridges, although extending across country for a number of miles, are in places offset as if by faulting. The klippe between this ridge and the range is further evidence that brings the Lisburne to the surface is a low angle thrust. The klippe rests on rock of Triassic age. Fault breccia was found at the base of the northern limestone ridge, the angular rock fragments are recemented with calcite. The rock in this ridge is a finely crystalline limestone, with numerous bands of chert. It is considerably more arenaceous than the Lisburne farther east in the range. As a result of silicification, it has rough weathered surfaces. A strong organic odor is present on a fresh fracture. The limestone is light to medium gray and the chert blue gray to black. The ridge is mantled with rubble, but the bedrock apparently dips south at about 45°. The Lisburne limestone here is almost nonfossiliferous; a diligent search resulted in the finding of only a few poorly preserved brachipods and a coral, which have been tentatively identified as Mississippian, by Dr. J. S. Williams.

The Lisburne limestone in Howard Pass is quite similar to the northern belt of limestone except that it is more massively bedded and is medium crystalline. Along the southern edge of the ridge the rock is almost a marble where it is in contact with an igneous intrusive. Other than this narrow zone of contact metamorphosed limestone there seems to be no alteration due to the intrusive. Here, as in the northern ridge, the limestone is arenaceous and silicified (and is banded with chert). The Lisburne in Howard Pass is nonfossiliferous. A day was spent looking for fossils, but none were found.

Triassic rocks

There are three belts of Triassic rock in the area of Howard Pass and the Etivluk River. The two southernmost ones are comparatively narrow, 1 to 2 miles wide. The northern belt is approximately 12 miles wide. The structural relationship of the Triassic rock to surrounding rock is not well known. In the northern belt the Triassic and Lisburne contact was not seen. This belt of Triassic may be part of a bifurcating anticline, with the Lower Cretaceous west of Camp 4 representing the syncline between the two limbs of the anticline. Structural data along this belt is meager, but the few dips obtainable tend to support this hypothesis. The contact with the Lower Cretaceous on the south edge of the belt appears to be conformable, as do all Triassic-Lower Cretaceous contacts on the Etivluk River. There is some evidence for a fault contact between the Noatak formation and Triassic rocks between camps 1 and 2. Some small drag folds, along with abundant slickensides were seen. The belt of Triassic rock in Howard Pass is too poorly exposed to give any idea of structure; however, the zone of Monotis-bearing rock is approximately the same distance stratigraphical above the Lisburne as it was farther down the river. This does not necessarily mean that the contacts are conformable. Abundant colored chert was found in all three belts of Triassic rock. Some of the coloring is undoubtedly due to igneous activity, and some of it is a surface stain, probably the result of weathering. This is particularly true of the green cherts. The color does not extend into the rock more than about 1/32 of an inch. There is a considerable amount of dark clay shales in the Triassic. Good exposures were seen in cutbanks on the stream just north of Fay Creek. This nonresistant shale member probably occupies part of the wide northern belt of Triassic, although it was not seen in outcrop. The shale is dark blue gray, fissile, in places paper thin, with interbeds of both siltstone and sublithographic limestone. The siltstone is banded, brittle, and micaceous. Ironstone concretions are found throughout the shale, together with mud lumps, ripple marks, and rain-drop imprints.

In the northern belt of Triassic near the Lisburne ridge, there is a considerable section of limestone. Lithologically it is dissimilar to the Lisburne; it is almost a microcrystalline rock, thin, hard, brittle, and with a pencil fracture. It is yellow gray in color. Monotis was found abundantly throughout.

Lower Cretaceous rocks

The entire lower part of the Etivluk River is in rock of Lower Cretaceous age, and there are two smaller areas of Lower Cretaceous to the south. The two southern belts represent the green basal conglomerate and sandstone section. The northern belt starts with the Torok shales and goes up the section into the Tuktu sandstone. Thus the three zones represent almost a complete section of Lower Cretaceous.

The conglomerate ridge formed in the middle belt is the lowest part of the section; all the conglomeratic constituents there are pre-Lower Cretaceous in age. The grit conglomerate in the sandstone section just above this, as exposed in the southern belt, is composed almost entirely of pebbles of Triassic chert. The sandstone is a resistant member, forming high ridges in the vicinity of Camp 2; it is fine- to coarse-grained and somewhat argillaceous. The beds average less than 1 foot thick, but locally are as much as 5 feet thick with cross bedding common. Carbonized plant fragments are abundant. The grit conglomerate, and sandstone near it, are moderately clean and have good porosity. Smith Mountain, west of camp 5, on the Etivluk River, is also part of the Lower Cretaceous; it is predominantly sandstone and conglomerate. The conglomeratic constituents are chert, shale, and a little limestone. They are pre-Lower Cretaceous in age. The constituents are well-rounded and range in size from pebbles to 7-inch cobbles. However, pebbles are the predominant type. The conglomeratic beds are lenticular and cross-bedded. The sandstone is slightly finer grained here, and is somewhat siltier, with a browner color than that to the south. There are numerous shale interbeds throughout this sequence. If there is no repetition due to unobserved folds and faults, the total thickness of this sequence is approximately 5,000 to 6,000 feet. It immediately overlies a shale section believed to correlate with the Killik shale, and it forms the base of another thick shale section believed to belong in the Torok of the Nanushuk group. The Killik shale is poorly exposed south of Smith Mountain.

The best exposures of the Torok shale are at Camp 6 on the lower part of the river. For 5 miles along the river there is an almost continuous exposure of tightly folded and faulted dark, silty, clay shale. Limestone and siltstone interbeds are common throughout. The siltstone is cross-bedded, banded, and somewhat calcareous. Mud lumps, worm tubes, and pyrite concretions were also found. The shale was sampled for microfossils. No megafossils were found. The down-river end of this continuous exposure is a ridge of sandstone believed to be correlative to the Tuktu sandstone member, however, there is no paleontological evidence to support this correlation. This is a buff colored sandstone, fine-grained, argillaceous, and somewhat calcareous. In general it is moderately thin bedded with cross bedding common. Plant fragments and carbonized material were found over much of this section. The porosity of this sandstone is low and unfavorable for oil production.

KUNA RIVER AREA

The Kuna River traverse was started during the middle of the summer when the water in the rivers is lowest. Consequently it was impossible for the party to start in the mountains. For this reason, no formations older than Triassic were seen along the Kuna River except at one locality. The one exception is an exposure in a cutbank at camp 9. The exposure is predominantly shale, with a few limestone interbeds. Fossils tentatively identified as Mississippian by J. S. Williams were found in one of these interbeds. Triassic fossils were found a short distance away in chert. The limestone is very fine grained, almost sublithographic, and is dark blue gray. The thickness of exposed beds is approximately 200 to 250 feet. It is also possible that the Lisburne is present in the Brooks Range at the headwaters of the Kuna River. This area has never been traversed, and photographs taken during the summer of 1949 were not available to the field men.

Triassic rocks

There is only one major belt of Triassic rocks on the Kuna River; however, in the area south of this belt Triassic rocks occur as narrow zones infolded in rocks of Lower Cretaceous age. Most of these zones are restricted to less than 100 section feet. Two zones near camp 8, infolded with Lower Cretaceous shale, are Monotis-bearing cherts. Monotis is Upper Triassic in age, and the fact that it is found in close association with Cretaceous shale indicates that faulting must be associated with the folding. The multicolored cherts of the Triassic are not as common here as they are on the Etivluk, and most of them are black or dark gray. In places the Triassic is a flint that contains perfectly preserved Monotis. At one place in the northern belt the ammonite Trachyceras was found, in addition to the other fossils.

Many small igneous masses and one large one were found in the Triassic. In many places they form the cap rock of the ridges because they are more resistant than the chert and limestone. In places the intrusives are in contact with only slightly altered limestone. The limestone is gray to black, finely crystalline rock. In it are some bands of chert. When freshly broken the limestone has a slight organic odor. The only fossils found were several small fragments of crinoid stems. This limestone may be part of the Lisburne limestone. South of camp 9 on the middle and west forks of the Kuna River is an area in which it is impossible to differentiate between the Triassic and Lower Cretaceous shales.

Lower Cretaceous rocks

The basal conglomerate section of the Lower Cretaceous was seen only in a hill northwest of camp 8. The conglomerate is massively bedded, with few interbeds of sandstone. The conglomeratic constituents are chert, quartz, and some fragments of igneous rock, and are as large as 12 inches in diameter. Some of the green sandstone and grit conglomerate crops out east of camp 8 in a series of hills. The sandstone was moderately thin bedded, fine- to coarse-grained, and moderately argillaceous. In one place it is in contact with an igneous intrusive. The contact appears to be a fault, as there are slickensides in the sandstone; also the sandstone has not been altered by the igneous rock, as could be expected if the magma were intruded into the sandstone.

A conglomerate-sandstone sequence which is probably the basal zone of the Torok shale was seen in a mountain about 5 miles west of camp 10; the mountain forms part of the south limb of a syncline. The conglomeratic constituents are chert, shale, quartz, and a minor amount of igneous rock, all well-rounded. They range in size from a quarter of an inch to 10 inches in diameter. The cementing material is weak and weathers readily, resulting in gravel-covered slopes along the mountain. The Killik shale member was not seen on the Kuna.

The Lower Cretaceous section north of camp 10 is predominately shale, and is correlated with the Torok shale. Here there is considerably more silt-shale to siltstone than there is clay shale. Good exposures were seen near camp 11, as cutbanks along the tributary streams as well as along the Kuna. The shale was sampled for microfossils. Numerous thin, silty, sandstone inter-beds in the shale are medium gray, fine-grained, extremely crossbedded, and in places ferruginous. The shale is mostly dark blue gray, hard, brittle, and slightly calcareous. There is abundant calcite veining throughout the shale section. Many small compact folds and some faults in the shale make it impossible to get a good continuous section. North of camp 11 the section becomes progressively more sandy, with sandstone the predominant rock type. This sandstone is dirty gray, fine-grained, and slightly calcareous. It may be part of the Tuktu sandstone, but is much different from the Tuktu as seen elsewhere.

COLVILLE RIVER AREA

The waters of the Colville, at the time of the traverse in late July, were very low. Many outcrops that were available for study would have been completely covered if the water level had been normal. Many of the steep bluffs were also accessible only due to this factor.

The Colville River flows approximately parallel to the general strike of the area and exposes only a small section of beds. All the outcrops studied were entirely along the river or on small streams draining into it. The rocks along the Colville are Lower Cretaceous in age and consist of shale, siltstone, and fine-grained sandstone. All the outcrops were channeled for microfossils. Megafossils were found in one location 6 miles above the Ipnavik River. The fossils are ammonites in the Tuktu sandstone.

As the lower Cretaceous siltstone, shale, and sandstone are very tightly folded and faulted, it was impossible to tell stratigraphic positions or measure sections. The tightly folded sediments strike at all angles, with reversals in dip within a few feet of each other. However, the general thrust or force seemed to be from the south. Most of the small fold axes trend east. Due to the complexity and uncertainty of the sequence, particular care was used in collecting fossils.

Cross bedding is prominent in the siltstone and sandstone. These rocks are hard, have a somewhat conchoidal fracture, and when broken have sharp edges. Some of the rocks are moderately calcareous and contain plant fragments. The siltstone and sandstone weather reddish buff, whereas the shale weathers gray brown.

The shales along the Colville are mostly clayey to silty in composition. Most of them are black and thin-bedded; some are moderately calcareous and interbedded with beds, 4 to 18 inches thick, of fine-grained sandstone and siltstone. The shales are very incompetent and are folded and faulted into many small drag folds. The shales take on a mirror-like polish due to slipping along the bedding planes. The shales weather a gray brown, but when broken reveal the fresh black color. The shales of the area are barren of fossils and are probably near-shore marine sediments.

KILLIK RIVER AREA

The geologic investigations were begun on the upper Killik River 6 miles below the confluence of April and Easter Creeks. The aim of the investigation was to measure and study in detail the Kanayut, Noatak, and Lisburne formations. The formations studied were undifferentiated Devonian?, Kanayut, Noatak, Lisburne, and a few feet of Triassic on which the Lisburne rest. It is doubtful whether the Devonian was reached, but the fossils collected in what was thought to be Devonian sediments should be good evidence one way or the other. As yet these fossils have not arrived for determination.

This particular area was not as favorable as first thought for measuring sections. The region was an area of large overturned folds and thrust faults.

Devonian?

The Devonian? sediments are mostly low-grade slates. There is a sharp lithologic break between the slates and the Kanayut conglomerate. The slates seem to be several hundreds of feet thick, with regional dip of 40° S.

The slate is dark gray to black and weathers a gray brown color, which was slightly iridescent. The slates were considerably fractured and folded, small recumbent folds occur and fractures are filled with quartz. The fossils found were in a hard, slightly calcareous, sandy layer interbedded with the slates. These slates seemed to correlate lithologically and stratigraphically with the Devonian slates south of Chandler Lake. At this point on the Killik the slates appeared to be thrust upon the Kanayut. Farther south a conglomerate similar to the Kanayut seems to rest conformably on slates. This conglomerate seems to be older than the Kanayut and younger than the slates. This same phenomenon also occurs 10 miles S. of Chandler Lake.

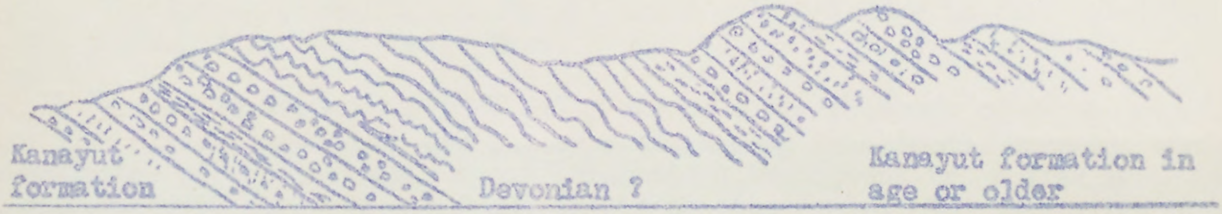

Figure 3. Schematic diagram of the Kanayut-Devonian contact, upper Killik River.

Kanayut formation

The Kanayut conglomerate, which is Lower Mississippian, forms a wide belt of rugged mountains on the Upper Killik River. This belt is approximately 10 miles across, and the general altitude is about 5,000 feet.

The Kanayut consists mainly of quartzites and quartzitic conglomerates with interbeds of black shale, and red and green siltstone. Some of the quartzite may be meta-quartzite, but this can be proved only by microscopic examination.

The quartzite and quartzitic conglomerate grade into each other. The quartzite is light gray green when fresh, as is usually the color of the conglomeratic matrix. Small limonite grains throughout the quartzite are probably weathered pyrite crystals. The pebbles in the conglomerate are predominantly varicolored cherts but some are of quartz. Some of the pebbles are angular but others are subrounded to rounded. The general size of the pebbles ranges from a quarter of an inch to 1 inch in diameter. There are, however, some beds of conglomerate that are maroon and green, and these seem to be more lenticular than the more massive gray-green rocks. Upon close examination the color was found to be due to the matrix being made up of colored chert.

The massive beds of quartzite and quartzitic conglomerate are usually 15 to 30 feet thick and form prominent steplike ledges up the mountain faces, whereas the interbeds of shales and silts sap away.

The red and green siltstone and shale are usually from 2 to 15 feet thick. These sediments are probably terrestial deposits. However, they may be alteration products of hydrothermal solutions. Black shales, which are quite silty and hard, also form interbeds between the conglomerates and quartzites. Some shale units are several hundreds of feet thick, and throughout are thin bands of hard siliceous siltstone. These shales and some of the siltstones contained both brachipods and ammonites of probable Mississippian age. Further study will establish their definite age.

The Kanayut formation in this area is much coarser and more conglomeratic than that on the Etivluk River and is like the formation at Chandler Lake.

Noatak formation

The Noatak formation on the Killik is quite similar to that described on the Etivluk River and Howard Pass.

The rocks are mostly hard silty shales with interbeds of arenaceous limestone. These limestones and shales contain many brachipods, corrals, and ammonites of Mississippian age. Interbedded throughout the shales are clean, medium-bedded quartzites and quartzitic conglomerates. The quartzites when fresh are light-neutral gray and are altered very little by weathering.

The area of the Noatak on the Killik River is in a fault belt and the structure is so complex that no attempt was made to measure the formation.

The contact between the Noatak and Lisburne limestone was found on both sides of the Killik River. The contacts are conformable and grade from a black fossiliferous shale to an interbedded ankeritic limestone, to a medium-bedded, crinoidal limestone which was considered as the base of the Lisburne formation.

Lisburne limestone

The Lisburne limestone on the Killik River has its usual position at the front of the range. The Lisburne was very complexly folded and the maximum thickness that could be accurately measured was 700 feet, although it was thought to be at least 400 to 500 feet thicker. At the north front of the mountains the Lisburne overlies the Triassic cherts and shales. This structure could be explained by a large overturned fold or a large thrust fault.

The Lisburne here is mainly a thick-bedded limestone with massive beds of chert. Throughout the formation crinoidal limestones are predominant; other abundant fossils are bryozoa, brachipods, crinoids, corals, and ammonites.

The limestone when freshly broken gives off both an H_2S smell and a strong petroliferous odor. The petroliferous odor seems to be strongest in dark limestones. Many beds of the limestone are silicified and weather very sharp and rough. Throughout the massive limestone are beds of platy arenaceous limestone which weather into yellow clay soil. These beds seem to be more abundant in the lower part of the Lisburne.

A large part of the Lisburne is apparently missing in the Killik area, probably as the result of faulting.