BEDDED ROCKS (continued)

Metamorphic complex

Mafic rocks

Albite rhyolite

Felsitic rocks

Pink and gray, fine-grained quartz-feld-spar porphyry; locally shows flow structure. Possibly a felsic border factes

1 2

Fault, showing dip (U, upthrown side; D, downthrown side)

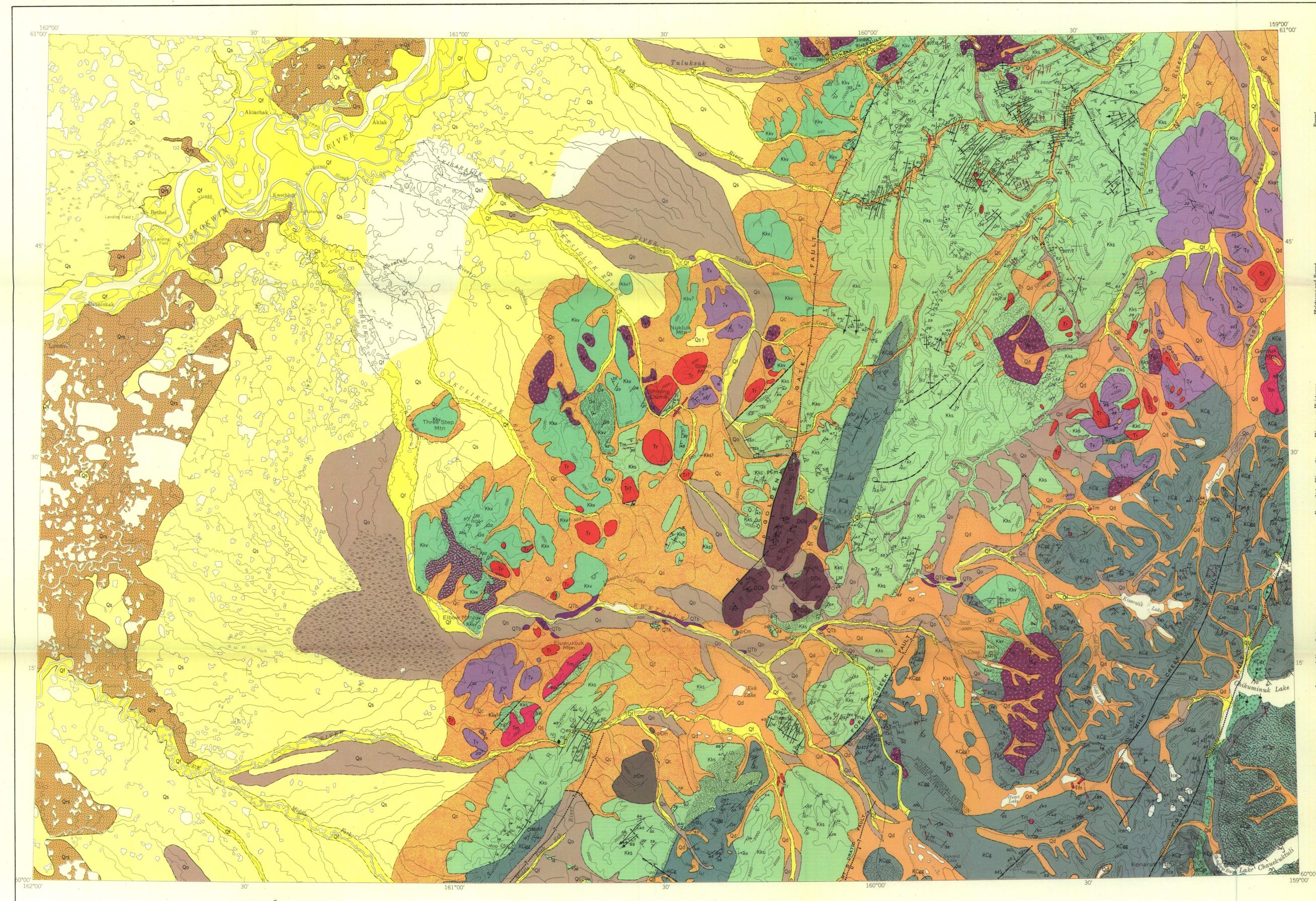
80

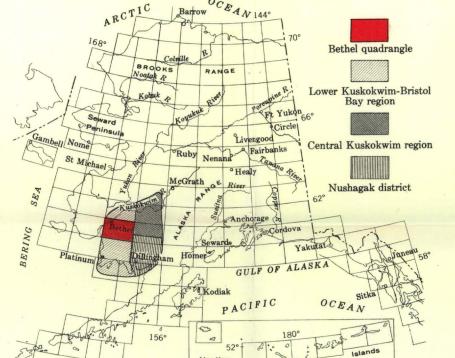
based on field

measurement

Vegetal debris

of granitic rocks similar to felsic rocks sociated with the Horn Mountain stock in the central Kuskokwim region (Cady et al., 1955, p. 79)





Showing location of the Bethel quadrangle relative to the Lower Kuskokwim-Bristol Bay region, the Central Kuskokwim region, and the Nushagak district.

INTRODUCTION

The geologic map of the Bethel quadrangle is one of several presenting the results of a reconnaissance study of the geology and mineral resources of the Lower Kuskokwim-Bristol Bay region, southwestern Alaska. Field studies, which began in 1946 and ended in 1953, were concerned primarily with the bedrock geology. Data were obtained by extensive boat and foot traverses from several base camps and numerous overnight camps. The routes of most of the traverses are shown by the distribution of strike symbols with numerical dip values. Trimetrogon vertical and oblique 1:40,000-scale aerial photographs facilitated both the planning of field work and the mapping. Recently obtained vertical photographs provided essentially complete coverage of the western third of the quadrangle. Surficial deposits have been mapped almost entirely on the basis of photointerpretation supplemented by a few field observations. The topographic base is highly generalized but adequate for presenting the results of this reconnaissance study. Locally the small scale of the map has necessitated the generalization or exaggeration of some geologic details.

Lithologic symbols have been used to indicate known occurrences of distinctive types of rocks. The geologic age of these distinctive types of rocks is the same as the formation in which they occur. The rocks are more extensive than shown on the map but have

not been traced out parallel to their strike. Efficient assistance in the field was given at different times by R. P. Nickolsen, L. A. Brubaker, S. P. Brown, V. E. Swanson, B. Mears, Jr., E. G. Wermund, and P. C. Tremel. Fossil collections were studied by R. W. Imlay, J. B. Reeside, Jr., Roland W. Brown, and Teng-chien Yen. Appreciation is herewith expressed to the personnel of the New York-Alaska Gold Dredging Corp., the Awe Mining Co., the Peandori Mining Co., and the Canyon Creek Mining Co. for their assistance, information, and hospitality.

Previous investigations in the Bethel quadrangle were made by Spurr (1900), who described the unconsolidated deposits along the Kuskokwim River, by Maddren (1915), who investigated gold placers in the Tuluksak River-Cripple Creek area, and by Mertie (1938), who mapped on reconnaissance scale in the Tikchik Lakes area. Coonrad (1957) made a reconnaissance

study of the area west of Bethel.

Major structural elements in the Bethel quadrangle trend north-northeastward. Rocks of Early Cretaceous age and older are commonly exposed in geanticlinal tracts and anticlinoria. Rocks of Late Cretaceous age occupy intervening geosynclinal and synclinorial tracts. Strata of Cretaceous age and older are commonly compressed into numerous minor folds of small amplitude. Superimposed upon the small folds are successively larger folds, the largest of which are anticlinorial and synclinorial folds several miles across. Examples of anticlinoria are the Eek Mountains and the large doubly plunging folld northeast of the mouth of Crooked Creek. Both of these structures are strongly asymmetric and, in places, overturned northwestward toward the northeastward-plunging geanticlinal tract between Eek Mountains and Great Ridge. They are flanked southeastward by a synclinal belt that parallels the course of Salmon River and plunges northeastward. Southeast of the synclinorial tract, rocks of the Gemuk group are compressed into two or more broad folds. Near the south edge of the quadrangle, these older rocks are thrust northwestward onto the synclinorium along the Mount Oratio and Fork Creek faults. Near the eastern margin of the map they are thrust southwest-

ward onto a geanticlinal uplift along the Togiak fault. The Mount Oratio and Fork Creek faults are two of the several large reverse faults that have been recognized in the Bethel quadrangle. These two faults and Golden Gate and Tuluksak faults all dip steeply southeastward and are upthrown on the southeast side. Togiak fault dips steeply northwestward and is upthrown on the northwest side. The opposed dip of the reverse faults and the relative movement on them, as well as numerous asymmetric and overturned folds indicate that the geosynclinal tract between Golden Gate and Togiak faults has been compressed between two relatively resistant geanticlinal tracts.

MINERAL RESOURCES AND OCCURRENCES Gold.-Placer gold that contains a minor amount of silver is currently mined on the Tuluksak River and on Canyon Creek. The two mines produce an estimated total of \$500,000 in

gold and silver annually, of which more than 90 percent is dredged from the Tuluksak River and its tributaries. Placer mines on Cripple Creek, Marvel Creek, Granite Creek, and Bear Creek ceased operation within the period 1946 to 1949. The history and description of some

of the mines were given by Maddren (1915, p. 298-360). Prospecting activities show that gold occurs on many streams other than those that have been mined. The location of most of the mines and prospects indicates that mineralization associated with intrusive bodies of granitic and rhyolitic rocks is the primary source of the gold. Secondary reconcentration of glacial gravels may account for some of the placer deposits. Quicksilver.-Cinnabar, ore mineral of mercury, has been identified in placer concentrates from several streams, but no lode deposits have been found in the Bethel quadrangle. The nearest known lode deposit is about a mile south of the quadrangle on Arsenic Creek, a tributary to Rainy Creek, which is a headwater tributary of Eek River. About 2,000 pounds of cinnabar concentrates were recovered from a placer gold mine on Rainy Creek (Rudledge,

Antimony. - Stibnite, an ore mineral of antimony, occurs in a small quartz vein cutting rhyolite on top of Fisher Dome near the head of Fisher Creek. The deposit is probably of no Copper.-Traces of copper minerals were found in andesitic bedrock brought up by a gold

dredge on Tuluksak River, and in green amphibole schist in the fault zone at Golden Gate Falls and about a mile south of the Falls. Float specimens of copper minerals and galena (an ore mineral of lead) are reported from the valley of the Kwethluk River (Maddren, 1915, Tungsten.-Scheelite and wolframite, ore minerals of tungsten, have been identified in

placer concentrates from several streams, but no lode deposits have been found.

Coal.-A bed of soft coal about 8 inches thick crops out in the gorge cut by Eek River through the Great Ridge. The coal is associated with about 10 feet of black carbonaceous hale interbedded with steeply dipping graywacke, conglomerate, and siltstone of Cretaceous ago SUGGESTIONS FOR PROSPECTING Gold, cinnabar, and scheelite are the three minerals most likely to be of interest to the

Platinum, -A very small amount of platinum is recovered with the gold on Tuluksak River.

prospector in the Bethel quadrangle. Systematic search for these minerals should be guided by the fact that gold and tungsten minerals are associated with rhyolitic and granitic intrusive bodies and that quicksilver is almost always associated with bodies of silica-carbonate The currently productive gold deposits are all placers. Placer concentrates of heavy minerals commonly occur on creeks that flow through or head in mineralized source areas asso-

ciated with intrusive rocks. They are generally better developed in areas of low relief where prolonged and undisturbed stream erosion and concentration have taken place. In the Bethel quadrangle, these desirable conditions are found especially in the rolling, mountainous, unglaciated terranes that lie northwest of a line drawn between the Eek Mountains and the northeast corner of the quadrangle. Economic placer deposits are generally more difficult

to find in glaciated areas, as in the southeastern part of the Bethel quadrangle, because the heavy minerals are likely to be disseminated through a large volume of glacial or glaciofluvial deposits. Placer deposits occur in glaciated areas, however, as for example, the one on Canyon Creek. This small, rich gold placer was probably preserved by the high mountains at the head of the creek, which split the ice and kept it out of Canyon Creek valley. Preglacial gravels and placer deposits may also be preserved in narrow preglacial stream valleys that are transverse to the broad major valleys down which large tongues of ice moved. Deposits of this type are likely to be covered by younger surficial deposits, hence difficult to find. Drilling operations in connection with mining activities show that narrow, deep, preglacial stream channels lie beneath surficial deposits in many of the broad valleys. Some of the buried channels may contain valuable placer deposits.

The gold prospector is advised to watch for scheelite, ore mineral of tungsten, because it is commonly associated with gold and may be recovered as a valuable byproduct. Scheelite can easily be identified with an ultraviolet lamp.

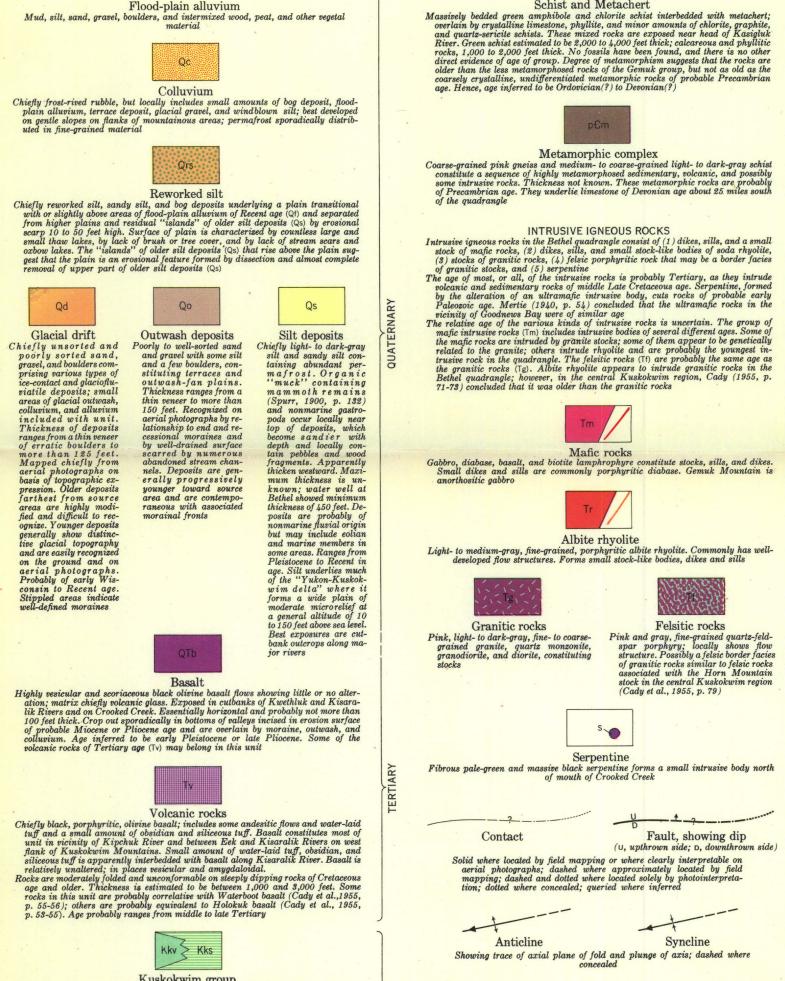
Cinnabar, ore mineral of quicksilver, has been identified in placer concemtrates from several streams in the Bethel quadrangle, but no lode deposits are known. Experience in adjoining areas indicates that quicksilver lodes in the Kuskokwim region are almost always closely associated with bodies of silica-carbonate rock formed by the alteration of mafic dikes and sills. The altered rock is pearl gray on fresh surfaces and weathers a yellow brown, forming the "yellow rock" of the prospector. Few bodies of silica-carbonate rock were found in the Bethel quadrangle, and the chances of finding quicksillver in economic quantities are not very great. Cinnabar lode deposits and bodies of altered mafic intrusive rocks are more common in the adjoining Central Kuskokwim region (Cady et al., 1955, p. 104-116).

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EXPLANATION

BEDDED ROCKS

Kuskokwim group

Andesitic volcanic rocks, Kkv*

Sedimentary rocks, Kkv*

Sedimentary rocks, Kkv

Kuskokwim group consists of a thick sequence of andesitic volcanic rocks (Kkv), and a much thicker sequence of sedimentary rocks, Kks). Fossils of early and middle Late Cretaceous age have been obtained from the volcanic rocks and from the upper part of the sedimentary sequence

Volcanic rocks of Kuskokwim group, Kkv, form a belt of low, rolling hills on west flank of Kuskokwim Mountains from Kwethluk River to beyond north boundary of quadrangle. Similar volcanic rocks are exposed south of Upper Kisaralik River. Rocks comprise massive andesitic and basaltic flows; minor amounts of trachyle, trachy-andesite, and dacite; some interbedded tuffaceous sedimentary rocks; and locally several hundred feet of volcanic breccia at or near the base. Flow rocks are chiefly light to dark gray and greenish gray, porphyritic, highly fractured, and seldom show recognizable flow planes. Volcanic rocks are considerably altered, but original mineral constituents are generally recognizable under the microscope. Both volcanic and sedimentary rocks are recrystallized in narrow contact-metamorphic zones adjacent to some intrusive bodies. Interbedded sedimentary rocks—graywacke, siltstone, impure limestone, and pebble conglomerate—comprise an estimated 25 percent of unit. Relative amounts and distribution of volcanic and sedimentary rocks are variable, but sedimentary rocks appear to be more prevalent along southeast side of belt. Marine fossils obtained from interbedded sedimentary rocks are tarble, but sedimentary rocks appear to be more prevalent along southeast side of belt. Marine fossils obtained from interbedded sedimentary rocks indicate that at least some of rocks are of middle Late Cretaceous age (Cenomanian). May be equivalent to Iditarod basalt in the central Kuskokwim region (Cady et al., 1955, p. 47-50)

Sedimentary rocks of Kuskokwim group, Kks, form a broad belt of high, rolling hills across the east-central part of the qua across the east-central part of the quadrangle. Chiefly interbedded graywacke, silt-stone with lesser amounts of pebble grit and conglomerate, and a small amount of coal. Rocks are well indurated, commonly light to dark gray, and weather brown. Composition varies from volcanic wacke to quartz-chert-feldspar-rich sandstone. Detrital muscovite prevalent in fine-grained rocks. Siltstone commonly has blocky fracture, but slaty cleavage is well developed locally. Shaly bedding-plane parting rare except in abundantly micaceous rocks.

The sedimentary sequence divided into three gross lithologic zones. Rocks of basal zone. The sedimentary sequence divided into three gross lithologic zones. Rocks of basal zone regionally unconformable upon older rocks. At north end of Eek Mountains the basal zone consists of an estimated 3,000 feet of poorly sorted boulder conglomerate. Conglomerate thins rapidly away from this area, and elsewhere basal zone is represented by variable amounts of conglomerate interbedded with several thousand feet of massive graywacke, pebble grit, and siltstone. Commonly graywacke and siltstone comprise alternating beds 20 to 50 feet thick. Second zone predominantly siltstone with very little interbedded graywacke. Thickness estimated to be approximately 5,000 feet. Rocks of second zone are distinct from coarser facies of basal zone, but locally may be gradational into both underlying and overlying stratigraphic zones. Upper zone comprises thinly interbedded fine-grained graywacke and siltstone in about equal amounts: thickness estimated to be 10,000 feet. Fossils collected from about equal amounts; thickness estimated to be 10,000 feet. Fossils collected from rocks of basal zone considered to be of late Early Cretaceous (Albian) age. Fossils from rocks of upper zone considered to be of early and middle Late Cretaceous age

> Gemuk group, KCg Graywacke, siltstone, and conglomerate, KCgg Volcanic rocks, KCgv Limestone and calcareous siltstone and sandstone, KCgl

Limestone and calcareous siltstone and sandstone, KCgl
Chert, siltstone, graywacke, and limestone, KCgl
As originally defined (Cady et al., 1955, p. 27-34) the Gemuk group included rocks
of Triassic and Early Cretaceous age in the central Kuskokwim region and rocks
assigned by Mertie to the Mississippian(?), Permian, and Triassic periods and
Early Cretaceous(?) series in the adjoining Nushagak district (Mertie, 1938, p.
37-59). Rocks of Gemuk group in lower Kuskokwim region have yielded sparse
fossil collections ranging in age from Mississippian(?) to Early Cretaceous. Total
thickness estimated to be 15,000 to 25,000 feet
Gemuk group, undifferentiated, KCg; chiefly massive and thin-bedded, fine-grained,
siliceous rocks, some volcanic rocks, calcareous siltstone, and limestone. Some of the
undifferentiated rocks of the Gemuk group are similar to and probably correlative
with rocks differentiated elsewhere on the geologic map. Fossils of Triassic age have
been obtained from similar rocks both east and south of quadrangle. In Bethel quadrangle most of rocks mapped as Gemuk group, undifferentiated, are probably of
Jurassic, Triassic, and Permian age
Fossil collections and a general knowledge of the stratigraphic sequence have made it
possible to differentiate locally some lithologic units within the Gemuk group in the
Bethel quadrangle
Graywacke and conglomerate, KCgg; massive, fine-to coarse-grained, hard, dark-gray; possible to differentiate locally some lithologic units within the Gemuk group in the Bethel quadrangle
Graywacke and conglomerate, KCgg; massive, fine- to coarse-grained, hard, dark-gray; massive and thin-bedded, light- to dark-gray and green lithic-feldspathic graywacke; massive varicolored argillite; banded slaty siltstone; minor amounts of limestone, calcareous graywacke, andesitic volcanic rocks, chert, and siliceous tuff(?). Much of the graywacke, conglomerate, and siltstone is very similar to rocks in Kuskokwim group (Kks). Silty limestone, calcareous graywacke, and siltstone are more typical-of older (KCgg) sequence. In general, the older rocks are more indurated, and contain much less detrital muscovite mica. Fragments of gneiss and schist are much more prevalent in conglomerate of younger rocks (Kks) than in older rocks (KCgg). Estimated thickness is 5,000 to 10,000 feet. Fossils of Early Cretaceous (Valanginian) and Late Jurassic ages have been collected at several widely spaced localities in Lower Kuskokwim region. Locally these rocks appear to be unconformable on older, more highly deformed rocks of the Gemuk group Volcanic rocks, KCgy, predominantly altered mafic volcanic rocks of Permian age; dark-green to almost black with abundant amygdules, few identifiable phenogrysts. Volcanic breccia, calcareous tuffs, and pillow lava constitute basal beds. Lavas with well-formed pillow structure also occur higher in the unit. Thin-bedded phyllitic calcareous tuff and tuffaceous limestone constitute top of sequence. Marine deposiwell-formed pillow structure also occur higher in the unit. Thin-bedded phyllitic calcareous tuff and tuffaceous limestone constitute top of sequence. Marine deposition suggested by association of limestone and pillow lavas. In Mertie's report (1938, p. 45-46, 74-75) volcanic rocks of Permian age cropping out in the Nushagak district are classified and mapped as greenstone. Thickness of greenstone exposed in area covered by Bethel quadrangle estimated as not more than 2,500 feet. Mertie (1938, p. 46) estimated thickness of at least 4,500 feet in the Nuyakuk Lake area south of Bethel quadrangle Greenstone grades downward through tuffaceous beds into limestone containing fossils of Permian age (Mertie, 1938, p. 43-44, 46). Hence, basal part of greenstone probably is also of Permian age, but its upper part may be Triassic. No data indicating such a range found within area of Bethel quadrangle, but fossils of questionable Triassic age obtained from calcareous zones in greenstone in Eek Mountains a few miles south of Bethel qu.drangle
Limestone and calcareous siltstone and sandstone, KCg!; comprises a belt of calcareous rocks of Permian age stratigraphically beneath but grading up into the volcanic sequence (KCgy). Near Lake Chaekuktuli the rocks are massive and thin-bedded, partly recrystallized, cream-colored limestone, estimated to be 500 to 1,000 feet thick (Mertie, 1938, p. 43). In vicinity of Chikuminuk Lake this belt of rocks consists of interbedded gray silty limestone and calcareous siltstone and sandstone in beds a interbedded gray silty limestone and calcareous siltstone and sandstone in beds a fraction of an inch to several feet thick. Limestone ellipsoids (boudinage?) commonly as much as 12 inches in diameter are characteristic. On north shore of Chikuminuk Lake the calcareous rocks dip about 55° for a distance of approximately 3 miles measured normal to their strike. This suggests a thickness of more than 10,000 feet, but it is probable that the same sequence of rocks is repeated several times by overturned isoclinal folds and/or faults. Collections of invertebrate fossils from limestone near couth end of this helt of rock have been identified as Permina in age (Mertie, 1938.

outh end of this belt of rock have been identified as Permian in age (Mertie, 193) Chert siltstone grannacke, and limestone, KCgc; massive and thin-bedded chert inter vert, sussing, grayware, and timestone; roge, massive that the related that bedded the sitistone and graywacke (generally calcareous), thin-bedded limestone and minor amount of mafic volcanic rocks, all of Mississippian(?) age. Chert is black, white, and gray. No green chert, which is characteristic of younger lithologic units of Gemuk group, was found. Calcareous rocks contain abundant limestone ellipsoids (boudinage?) similar to those associated with calcareous rocks of Permiage (KCgl). Both the siliceous, cherty rocks and the calcareous rocks generally constitute separate zones that are 50 to 500 feet or more thick. Within a single sequence of either calcareous or siliceous rocks, few or none of the other types of rocks was noted. Volcanic rocks are associated with both siliceous and calcareous rocks but are more commonly associated with calcareous rocks. Rocks are intensely deformed; structural complexity precludes an accurate estimate of thickness, but they are probably not less than 3,000 feet thick or more than 8,000 feet thick. Mertie (1938, 1 39-42, 45-46) concluded that there is angular unconformity between these rocks (KCgc and overlying rocks of Permian age (KCgl). The writers think that evidence for unconformity is inconclusive. No fossils have been found in these or definitely correla conformity is inconcustive. No Jossils have even Jound in these or definitely corrective rocks. Rocks are tentatively considered to be of Mississippian age because they are lithologically similar to rocks of Mississippian age elsewhere in Alaska (Mertie, 1938, p. 42) and fossils of Carboniferous(?) age have been collected from possibly correlative rocks near Goodnews Bay about 50 miles south of Bethel quadrantle.

Showing trace of axial plane of fold and plunge of axis; dashed where Strike and dip of Strike and direction of dip of beds based on beds based on field photointerpretation ×90 Strike and dip of Strike of vertical beds based on field overturned beds measurement Strike and dip of foliation Strike of vertical and plunge of lineation Strike and dip of flow cleavage Strike of vertical flow cleavage Placer mine Placer prospect Lode prospect Fossil locality Numbers indicate collection number LITHOLOGIC SYMBOLS Volcanic breccia 0000000 Conglomerate Lava flows Limestone

NOTE: Since the map was submitted for publication, fossils of Middle Jurassic age have been recognized from the volcanic rocks previously thought to be of Late Cretaceous age, Kkv. The volcanic rocks are now considered to be Jurassic in age and not part of the Kuskokwim group. New fossil collections from Great Ridge indicate that the rocks mapped as Gemuk group, KCgg, on Great Ridge should be mapped as Kuskokwim

FOSSIL COLLECTIONS numbers coll. no. 46AHr59 20715 Cretaceous Late Cretaceous (Coniacian 46AHr64 20716 46AHr91 Late Cretaceous (Coniacian) 46AHr101 20718 Late Cretaceous (Cenomanian? 47AHr1 Late Cretaceous (Cenomanian?) 47AHr36 Early Cretaceous (Albian?) 48AHr50A Early Cretaceous (Valanginian) 48AHr50B Early Cretaceous (Valanginian) 48AHr56 Early Cretaceous (Valanginian) 48AHr91 Early Cretaceous (Albian) 48AHr263 Late Cretaceous (Coniacian) 50AHr302 23167 Early Cretaceous (Valanginian) 35AMt23

Base map by Topographic Division U. S. Geological Survey, 1950, with GEOLOGY OF THE BETHEL QUADRANGLE, ALASKA

J. M. Hoare and W. L. Coonrad Scale 1:250 000

Contour intervals 200 and 1000 feet Datum is mean sea level 1957 magnetic declination at south edge of sheet varies from 18°00' to 20°15' east 1959

INTERIOR-GEOLOGICAL SURVEY, WASHINGTON, D. C., MR 6072 Geology by J. M. Hoare and W. L. Coonrad assisted by P. C. Tremel, S. P. Brown, V. E Swanson, G. E. Wermund, R. P. Nickelsen, L. A. Brubaker, Jr., and B. Mears, Jr. Surveyed 1946 to 1950 and 1953