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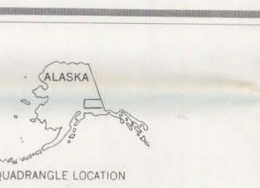
MISCELLANEOUS FIELD STUDIES
MAP MF – 655A

FOLIO OF THE NABESNA QUADRANGLE, ALASKA

BASE BY U.S. GEOLOGICAL SURVEY, 1965



QUADRANGLE LOCATION

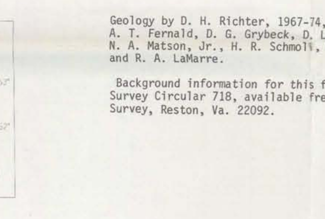
SCALE 1:250 000

5 0 5 10 15 20 25 MILES

5 0 5 10 15 20 25 KILOMETERS

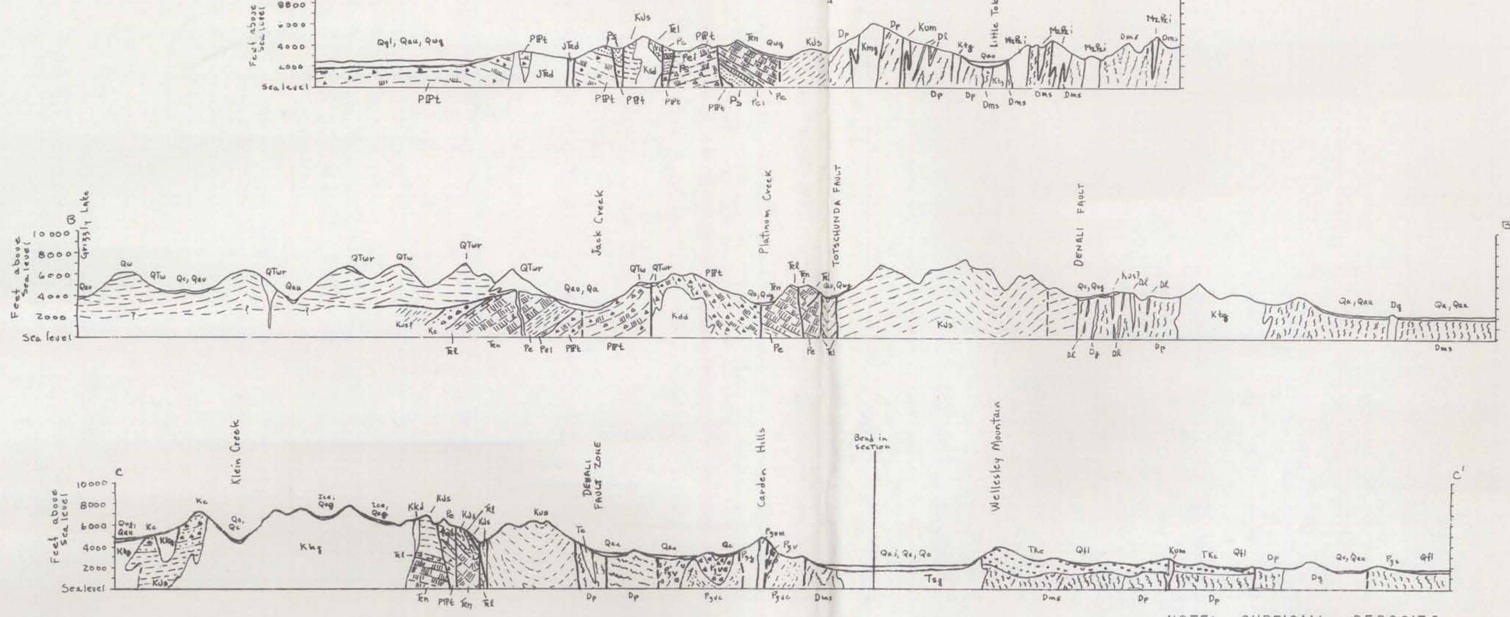
CONTOUR INTERVAL 200 FEET
DATUM IS MEAN SEA LEVEL

LOCATION INDEX



Geology by D. H. Richter, 1967-74, with contributions by A. L. Clark, A. T. Fernald, D. G. Grybeck, D. L. Jones, M. A. Lanphere, P. C. Lowe, N. A. Matson, Jr., H. R. Schmoll, W. N. Sharp, R. L. Smith, D. R. Work and R. A. LaMarre.

Background information for this folio is published as U.S. Geological Survey Circular 718, available free of charge from the U.S. Geological Survey, Reston, Va. 22092.

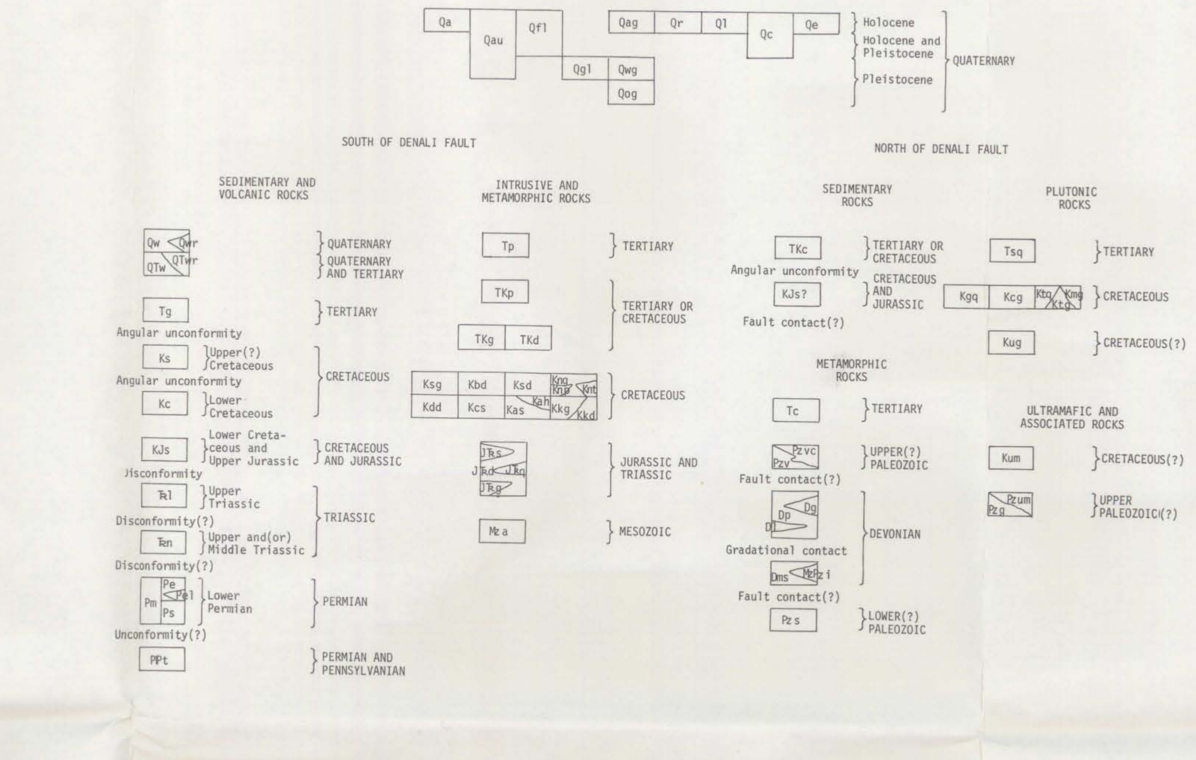


CROSS SECTIONS, NABESNA QUADRANGLE

VERTICAL SCALE 1:125,000 (2X EXAG.)

NOTE: SURFICIAL DEPOSITS SHOWN ONLY WHERE THICK AND EXTENSIVE

CORRELATION OF MAP UNITS



GEOLOGIC MAP OF THE NABESNA QUADRANGLE, ALASKA

BY

D.H. RICHTER

1975

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

ALLUVIAL DEPOSITS

Qa — Alluvium on active flood plains and lowest terraces of major streams, and larger alluvial fans. Chiefly boulders, gravel, and sand

Qau — Alluvium undivided includes older alluvium on higher terraces of major streams, alluvium of smaller streams, alluvial fans, alluvial deposits on broad pediment surfaces, and outwash from both the Alaskan and Wisconsin Glaciations. Broadly gradational with fluviolacustrine deposits (Qfl) and undivided colluvium (Qc), especially in the northwest part of quadrangle. Chiefly boulders, gravel, and sand; locally silt and clay

Qfl — FLUVIOLACUSTRINE DEPOSITS - Lake, pond, and low-gradient stream deposits; locally includes abundant organic matter. Chiefly sand, silt, and clay

Qag — GLACIAL DEPOSITS
Drift of the Alaskan Glaciation. End and lateral moraines left after recession of existing glaciers. Chiefly rubble and diamicton

Qr — ROCK GLACIER DEPOSITS - Includes larger active and recently active rock glaciers and the talus aprons feeding them. Smaller rock glaciers and deposits of old rock glaciers included in undivided colluvium (Qc) or omitted. Chiefly rubble and diamicton

COLLUVIAL DEPOSITS

Ql — Landslide deposits. Chiefly young landslides as evidenced by freshness of form. Older landslide deposits included in undivided colluvium (Qc). Chiefly debris avalanches and block glides

Qc — Undivided colluvium and other deposits on valley walls and hill slopes. In areas of steep slopes chiefly talus and other slope debris but includes alluvium of numerous minor streams, and locally glacial, rock glacier, and mass-wasting deposits. In areas of gentle slopes, especially north of Denali fault, chiefly mixed colluvium and alluvium with reworked eolian material and locally bedrock rubble. Unit includes large solifluction and creep surfaces on high-level low-gradient slopes that are composed chiefly of bedrock rubble but may include older glacial drift deposits (Qog). Chiefly rubble, gravel, sand, silt, and diamicton; generally poorly sorted

Qe — EOLIAN DEPOSITS - Sand dunes and remnant sand dunes, gradational with undivided colluvium (Qc) and locally interlayered with fluviolacustrine deposits (Qfl). Chiefly sand and silt

Qgl — GLACIOLACUSTRINE DEPOSITS - Stratified clay, silt, sand, and minor gravel deposited in extensive glacial lake. Locally includes numerous small post-glacial alluvial and pond deposits

Qwg — DRIFT OF WISCONSIN GLACIATION - Includes end, lateral, and ground moraine, and locally fluvioglacial deposits of both main and late stages of Wisconsin Glaciation and may include some deposits of the Alaskan Glaciation (Qag) in the Wrangell Mountains near the southwest corner of the quadrangle. Unit locally includes post-glacial alluvial and pond deposits especially in the extensive ground moraines of the ancestral Copper, Nabesna, and Chisana glaciers. At higher elevations, deposits merge with and are covered by undifferentiated colluvium (Qc). Chiefly diamicton with minor sand and gravel

Qog — DRIFT OF OLDER GLACIATIONS - Includes glacial deposits with subdued geomorphic expression, probably of Illinoian age, beyond limit of Wisconsin moraines and undifferentiated high-level glacial deposits. Chiefly unconsolidated diamicton and boulder deposits

SOUTH OF DENALI FAULT

SEDIMENTARY AND VOLCANIC ROCKS

WRANGELL LAVA

The name Wrangell Lava (Mendenhall, 1905) is a collective term referring to the rocks of an extensive calc-alkaline volcanic province in the Wrangell Mountains of south-central Alaska. The rocks are largely effusive flows, tuffs and breccias with subordinate shallow intrusive rocks, dikes, and domes that are products of a number of composite stratovolcanoes and large shield volcanoes and many satellitic cones and other small eruptive centers. K-Ar dates suggest that the older part of the Wrangell Lava in the quadrangle has a minimum age of 10 m.y., that is, late Miocene (D. Turner and J. Deininger, unpubl. data); Mount Wrangell, a large shield volcano whose summit caldera lies just beyond the southwest corner of the quadrangle, is still active. The distinction between its younger part (Qw and Qwr) and older part (QTw and QTwr), as used in this report, is based on freshness of volcanic form, degree of alteration of the rocks and a few scattered K-Ar dates mostly in the Mount Jarvis-Icefields Plateau area

Qw — Younger part - Includes andesite flows from Mount Wrangell (T. 4 N., R. 8 and 9 E.), and dacite flows, dacite domes and interbedded breccias and pyroclastic rocks from the Mount Jarvis stratovolcanoes (T. 3, 4 and 5 N., R. 9, 10 and 11 E.), basalt, andesite and dacite flows and palagonitic basaltic lapilli tuff in the Icefields Plateau area (T. 3 and 4 N., R. 12 and 13 E.), an extensive thick dacite flow between Drop Glacier and the Copper River (T. 6, 7 and 8 N., R. 8 and 9 E.), basalt and andesite flows from the small shield volcanoes south of West Glacier (T. 5 N., R. 8 E.) and scattered occurrences, chiefly of basalt and basaltic andesite from numerous small volcanoes, cinder cones, and subice tuff cones. Most rocks are typically porphyritic, with phenocrysts of mafic minerals and plagioclase in a fine-grained intersertal to equigranular groundmass. The andesites and dacites are generally two-pyroxene rocks containing augite and hypersthene; olivine is abundant in the basalts, and olivine, augite and minor hypersthene are generally present in the basaltic andesites. Thickness 0 to more than 2,100 m

Qwr — Rhyolite cinder cone and associated nuée ardente deposits (T. 3 N., R. 10 and 11 E.). Light-buff and cream glassy blocks, scoria, and ash consisting chiefly of hypersthene-bearing rhyolite. Thickness 0 to 180 m

QTw — Older part - Undivided flows, tuffs, and breccias, chiefly of andesite and basaltic andesite composition, dacite domes and flows, and volcano-glacial deposits from a number of poorly defined and locally covered older eruptive centers. Rocks on Tanada Peak (T. 6 N., 10 E.) are chiefly thick (as much as 150 m) andesite and dacitic andesite agglutinate flows. Oldest dated rocks (10 m.y.) are a series of basalt flows, as much as 100 m thick, exposed in the Canyon Creek and Wait Creek valleys (T. 6 and 7 N., R. 12 E.) and north of Jack Creek (T. 8 N., R. 13 E.). Rocks are petrographically similar to the younger lavas (Qw) but are locally altered to chlorite and clay minerals; their vesicles are generally filled with quartz, chlorite, chalcedony, calcite, and zeolite minerals. Thickness 0 to more than 2,000 m

QTwr — Rhyodacite and rhyolite. Includes three large domes and associated flows, nuée ardente and airfall deposits in the Skookum Creek area (T. 7 and 8 N., R. 12 and 13 E.), nuée ardente deposits associated with volcanic mudflow and tillite(?) deposits on Trail Creek (T. 9 N., R. 11 E.), a dome and scattered airfall deposits of pumice lapilli tuff between Chisana and Carl Creek (T. 3 and 4 N., R. 19 and 20 E.), and a number of domes and flows scattered throughout the main part of the volcanic field in the southwest part of the quadrangle. Rocks from the domes and associated pyroclastic deposits range from buff to light tan or gray; flow rocks range from light gray or light pinkish gray to black, depending on the degree of devitrification. Hornblende and locally minor biotite are the principal mafic minerals. Thickness 0 to more than 300 m

Tg — GLACIAL, FLUVIOGLACIAL, AND BOULDER DEPOSITS - Includes weakly consolidated and poorly sorted fluvioglacial deposits capping Gold Hill, south of Glacier Creek (T. 4 N., R. 19 E.), volcanic boulder deposits on Platinum Creek (T. 9 N., R. 13 E.) and many small limited occurrences of tillite underlying the older part of the Wrangell Lava (QTw). Tillite occurrences shown on map are between Carl Creek and Beaver Creek (T. 3 N., R. 20 E.) associated with palagonitic tuffs and along the west side of Nikonda Glacier and both sides of the Nabesna Glacier (T. 3 N., and R. 13 and 14 E.). The fluvioglacial and gravel deposits locally contain fragments of lignitized wood. The Gold Hill deposits contain disseminated native gold (Moffit, 1954) and may be the source of the nearby Bonanza gold placers

Ks — CONTINENTAL SEDIMENTARY ROCKS - Drab brown, buff, and greenish-gray conglomerate, coarse- to fine-grained sandstone, siltstone, and mudstone with subordinate dark-gray shale. Rocks are well consolidated and locally contain volcanic ash, carbonaceous debris, and fragments of petrified wood; exceptionally well preserved leaves and plants occur in strata exposed in Erickson Gulch, south of Chathenda Creek (T. 3 N., R. 19 E). Rocks are relatively flat lying and have not been thermally metamorphosed; clasts include granitic debris apparently derived from the middle Cretaceous Klein Creek and Chisana plutons. Thickness 0 to 90 m

Kc — CHISANA FORMATION (Richter and Jones, 1973a) - A thick unit of marine and subaerial volcanic and volcaniclastic rocks characteristic of a volcanic arc assemblage. Upper part of formation consists of maroon and dark-green andesite and basaltic andesite flows, green-gray to dark-green fragmental volcanic rocks, and subordinate dark-green dense porphyritic andesite, thin-bedded green and maroon conglomerate, grit, sandstone, and light-gray tuff. The fragmental rocks are apparently lahars and avalanche deposits containing rounded to angular fragments of various volcanic rocks associated locally with nonvolcanic clasts, lignitized wood, and other carbonaceous debris. Base of upper part locally marked by thick accumulation of amygdaloidal flows; at most places broadly gradational into lower part
Lower part is chiefly dark-green to gray-green fragmental volcanic rocks in units as much as 100 m thick, with minor dark-green porphyritic flows ranging from dacite to andesite, thin beds of maroon volcanic sandstone and siltstone, and lenses of dark-gray marine sedimentary rocks rarely more than 30 m thick. Fragmental volcanic rocks are similar to those in upper part but generally lack nonvolcanic clasts and contain no carbonaceous debris. The marine sedimentary rocks, apparently confined to the lower 600 m of the formation, consist of dark-gray argillite, thin-bedded graywacke, pebble to cobble conglomerate, and gray-green tuffaceous mudstone. These rocks are locally gradational with underlying mudstones of the informally named Nutzotin Mountains sequence of Late Jurassic and Early Cretaceous age
The pelecypod *Inoceramus* is locally abundant in the interbedded marine-volcanic sequence in the lower part of the formation and the ammonite *Shasticrioceras*, of Barremian age, has been found in the upper part. In the vicinity of the Klein Creek and Chisana plutons (middle Cretaceous), the rocks have been thermally metamorphosed to albite-epidote hornfels and amphibolites; in Monte Cristo Creek (T. 5 N., R. 13 E.) intense hydrothermal alteration has produced a gypsum-quartz-sulfide assemblage in the rocks. Thickness 0 to more than 3,000 m

KJs — MARINE SEDIMENTARY ROCKS - A widespread and thick sequence of predominantly shallow and deep intertonguing marine sedimentary rocks ranging in age from Late Jurassic to Early Cretaceous is informally referred to as the Nutzotin Mountains sequence (Berg and others, 1972). The sequence underlies much of the terrain between the Denali and Totschunda faults; a relatively small outlier crops out south and southeast of the Nabesna mine. Three lithologic units (lower, middle, and upper) are recognized in the main part of the sequence and two units (lower and upper) are recognized in the outlier. None of these units are differentiated on the geologic map. The sequence is largely in fault contact with older rocks, but the top is well exposed in the Chathenda Creek area (T. 4 N., R. 19 and 20 E.) and south of Nabesna (T. 7 and 8 N., R. 13 N.), and the base is exposed south of Noyes Mountain (T. 9 and 10 N., R. 11, 12 and 13 E.) and between the Nabesna River and Cooper Creek (T. 6 N., R. 14 and 15 E.). All units are intruded by middle Cretaceous plutons. Thermal metamorphism has produced dense, cream, light-green and purplish-gray banded hornfels adjacent to the larger intrusive bodies. Thickness of sequence is probably more than 3,000 m
The upper unit in the main part of the sequence consists of about 900 m of dark-gray graded argillite and graywacke overlain by 180 to 450 m of gray mudstone. Tuffaceous mudstone beds near the top are conformably overlain by massive andesite breccias of the Chisana Formation (Kc). Several species of *Buchia* are abundant in the unit and indicate an age of Late Jurassic and Early Cretaceous. In the outlier the upper unit is chiefly non-marine and consists of about 300 m of carbonaceous, thin-bedded, drab-brown and gray sandstone, siltstone and shale with minor grit and conglomerate. No fossils have been collected from this upper unit section
The middle and major unit of the sequence consists of turbidite deposits, chiefly graded beds of gray to dark-gray argillite, siltstone and graywacke that locally alternate with massive beds of pebble to cobble conglomerate, pebbly graywacke, graywacke and argillite. The graded beds are exceptionally well developed and consist of rhythmically alternating units 1 cm to more than 30 cm thick. The conglomerates are polymictic with rounded clasts derived from the terranes both north and south of the Denali fault. Much of the strata have developed a strong slaty cleavage; isoclinal folds, locally overturned, and thrust faults are common structural features. Fossils are extremely rare; but include a few *Buchia* of Late Jurassic age
The lower unit of the sequence near Noyes Mountain consists of about 900 m of dark-gray argillite and minor siltstone, mudstone, graywacke, and impure limestone. Conspicuous clasts of light-gray massive Triassic(?) limestone, ranging in size from cobbles to house-size boulders, occur sporadically through the lowermost part. Sparsely distributed *Buchia* throughout the unit indicate a Late Jurassic age. West of the Totschunda fault the lower unit is about 1500 m thick and consists of massive beds of shallow-water pebble to cobble conglomerate, as much as 40 meters thick, interbedded with dark-gray siltstone and argillite that locally contain fragments of coalified wood and other carbonaceous debris. Clasts in the conglomerate consist of well-rounded volcanic and volcaniclastic rocks, limestone, chert and crystalline igneous rocks derived from underlying strata, and white quartz and metamorphic rocks probably derived from the metamorphic terrane north of the Denali fault. Relatively abundant *Buchia* indicate a Late Jurassic age

Trl — LIMESTONE - Includes an upper unit of thin bedded limestone and a lower unit of massive limestone separated by local angular unconformities. Near intrusive rocks the limestone is thermally metamorphosed to conspicuous white tremolite-bearing marble with garnet-epidote-magnetite tactite
The upper unit consists of dark-gray fine-grained thin-bedded limestone. The beds are a few centimeters to as much as 2 meters thick with thin interbeds of black cherty argillite and dark gray carbonaceous shale. Minor beds of medium- to coarse-grained calcareous sandstone and calcareous grit, as much as 1 meter thick, are scattered through unit. The limestone is chiefly micrite and biomicrite, locally recrystallized and dolomitized, and weathers light gray (micrite) and buff (spiculitic biomicrite). The rocks are fetid and locally contain spheres of coarse calcite as much as 2 cm in diameter. Argillite and shale interbeds contain locally abundant *Monotis subcircularis* Gabb of Late Triassic age. Unit is probably correlative with the lower member of the McCarthy Formation exposed in the southern Wrangell Mountains. Thickness 0 to 120 m
The lower unit is gray to dark gray and fine grained massive-bedded limestone with lenses and nodules of gray and black chert and irregular patchworks of disseminated fine-grained quartz. Bedding is generally not discernible. Chiefly micrite, dismicrite or microsparite, commonly recrystallized or strongly brecciated and veined by coarsely crystalline calcite; locally dolomitized. Weathers light gray. Typically unfossiliferous but contains a few sparsely distributed hydrozoa (*Lovenipora?*) and brachiopods (*Spondylospira*) of Triassic age. Unit is probably correlative with the Chitistone Limestone exposed in the southern Wrangell Mountains. Thickness 20 to more than 250 m

Trn — NIKOLAI GREENSTONE (Rohn, 1900) - Dark-gray-green, dark-brown, reddish-brown and maroon-gray subaerial amygdaloidal basalt flows separated locally by thin beds of reddish-brown nonmarine volcaniclastic rocks. Base generally marked by discontinuous volcanic conglomerate-breccia containing fragments of basalt and underlying sedimentary rock. Predominantly intermixed aa and pahoehoe flows, individual flow units range from 5 cm to more than 15 m thick. Flows are generally porphyritic, containing phenocrysts of saussuritized plagioclase feldspar and subordinate clinopyroxene and relict olivine in an intergranular groundmass of feldspar and pyroxene that have been largely altered to chlorite, epidote, and serpentine. Amygdules consist of quartz, calcite, chlorite, epidote, pumpellyite, prehnite and unidentified zeolite minerals. Native copper occurs locally in flow tops, fracture zones, and amygdules. North of Bear Valley (T. 13 N., R. 9 and 10 E.). Permian limestone (Pel) occurs in the basalt as clasts in basalt-limestone conglomerate, as fragments incorporated in flows, and as large lenses and masses as much as hundreds of meters long that may represent flow-rafted debris. Near Snag Creek (T. 5 N., R. 21, 22 and 23 E.) the basalt includes abundant lenses of Triassic limestone (Trl) apparently structurally emplaced. Only the larger outcrops of these limestone inclusions in the basalt are shown on the map. Dikes and sills of gabbro included in the map unit are probably hypabyssal equivalents of the flows. Near larger intrusive bodies, the basalt has been thermally metamorphosed to massive fine-grained amphibolite. Thickness 150 to 1,800 m, averaging 1500 m. Thinner part of formation observed only northwest of Cooper Pass (T. 6 N., R. 15 E.) may be structural rather than depositional

MANKOMEN GROUP (Mendenhall, 1905; revised by Richter and Dutro, 1975) - A marine sedimentary rock sequence including an upper formation of nonvolcanogenic argillite and limestone (Eagle Creek Formation) and a lower formation consisting chiefly of volcaniclastic rocks (Slana Spur Formation). The Mankomen Group is equivalent to parts of the Cache Creek Group in the adjacent Kluane Ranges in Canada and to parts of the Skolai Group in the southern Wrangell Mountains in the adjoining McCarthy quadrangle

Pe — EAGLE CREEK FORMATION (Richter and Dutro, 1975) - Chiefly dark-gray and greenish-gray thin-bedded argillite and siliceous siltstone with thin interbeds of calcareous siltstone and sandstone, dark-gray silty bioclastic limestone, grit, and pebble-to-cobble intraformational conglomerate. Silicified mudstone concretions, as much as 1 m in diameter, and cone-in-cone structures, locally abundant. Relatively abundant brachiopods, cephalopods, corals, foraminifera, and bryozoan indicate an Early Permian age. Dikes and sills of Triassic(?) gabbro (not shown) are very common and locally may constitute more than 70 percent of the section. Thickness 100 to about 500 m. Locally separating the Eagle Creek Formation from the overlying Nikolai Greenstone are discontinuous and thin (less than 30 m) lenses of carbonaceous shale, calcareous argillite and chert that contain the Middle Triassic pelecypod *Daonella*. These strata are not differentiated on map, but for convenience are mapped with the Eagle Creek Formation; location of known *Daonella* beds are shown by dots

Pel — Light-gray to gray, thin- to thick-bedded fossiliferous limestone; generally fine grained (biosparrudite) but commonly recrystallized. Contains minor nodules of gray chert and base is locally marked by coarse-grained clastic limestone containing abundant volcanic clasts. Limestone generally occurs at base of Eagle Creek Formation but is variable in thickness and locally absent. In the Cross Creek area (T. 3 and 4 N., R. 15 and 16 E.) the limestone is intruded by Triassic(?) gabbro (not shown) and abundant porphyry dikes and sills (Tp). Locally very abundant brachiopods, corals, and foraminifera indicate an Early Permian age. Thickness 0 to 100 m

Ps — SLANA SPUR FORMATION (Richter and Dutro, 1975) - Predominantly dark-green, gray-green and brown volcanic siltstone, sandstone, and conglomerate with subordinate lapilli tuff, volcanic breccia, and impure bioclastic limestone. Finer grained clastic strata, generally thin bedded and locally graded; conglomerates and breccias are massive and thick bedded. Formation apparently thins and intertongues with Tetelna Volcanics (PPt) from west to east; strata not observed east of about R. 10 E. Only Early Permian fossils (brachiopods and corals) collected from Nabesna quadrangle; in the type section 25 km northwest of the northwest corner of quadrangle the formation ranges from Middle Pennsylvanian to Early Permian. Thickness 0 to 300 m

Pm — MANKOMEN GROUP, UNDIVIDED - Shown only in the Slana River valley (T. 12 N., R. 9 and 10 E.), where the rocks have been thermally metamorphosed by diorite of the diorite complex (JTrd) and gabbro and anorthosite (Mza). Rocks consist of light-colored wollastonite-, diopside-, and garnet-bearing marble, calcareous metasiltstone and metasandstone and dark-green-brown pyroxene and hornblende hornfels that is locally biotite-bearing. Weakly foliated

PPt — TETELNA VOLCANICS (Mendenhall, 1905) - Chiefly interbedded dark-green to purplish-gray-green volcanic flows, volcanic mud and debris avalanches, lapilli-pumice tuffs and fine- to coarse-grained volcaniclastic rocks. Flows generally massive porphyritic andesites, commonly amygdaloidal. Volcaniclastic rocks range from mudstone to conglomerate and are locally gradational into volcanic-rich limestone. The conglomerate and volcanic fragmental rocks are massive; the finer grained volcaniclastic rocks are thin bedded and locally graded. Along east side of Nabesna Glacier (T. 4 and 5 N., R. 14 E.) and locally elsewhere between the Nabesna Glacier and Cross Creek, formation includes buff to gray-green massive rocks with conspicuous quartz eyes in a fine-grained dense matrix of quartz, feldspar, white mica, and, locally, sulfides that may represent altered silicic effusive or shallow intrusive rocks. Near the diorite complex (JTrd) in the northwestern part of the quadrangle, the Tetelna has been largely recrystallized to massive fine-grained assemblages of hornblende, epidote, chlorite, and feldspar containing very abundant irregular masses and bands of locally foliated hornblende diorite and quartz monzonite, and amphibolite. All rocks contain chlorite, epidote, and pumpellyite as alteration minerals. These minerals occur both in the matrix of the flows and fragmental rocks and together with quartz and carbonate minerals in veins, fractures and shear zones. The upper part of the Tetelna Volcanics in the Nabesna quadrangle contains Permian brachiopods and cephalopods (Richter and Schmoll, 1973). The lower part is considered Pennsylvanian by correlation with this formation in the general area of its type section 25 km to the northwest (Richter and Dutro, in press)
The Tetelna Volcanics apparently represents vestiges of a late Paleozoic volcanic arc that was built directly upon oceanic crust (Richter and Jones, 1973b). The Tetelna Volcanics is probably equivalent to parts of the Strelna Formation and to the lower part of the Skolai Group, which cropout in the southern Wrangell Mountains. Thickness greater than 1,000 m, but base nowhere exposed

INTRUSIVE AND METAMORPHIC ROCKS

Tp — YOUNGER PORPHYRY - Includes many color, textural, and phenocrystal varieties of hornblende-feldspar and feldspar porphyries ranging in composition from andesite to rhyodacite. Color varies from light gray to dark pinkish brown and groundmass textures are generally fine-grained intergranular or trachytic. Larger irregular bodies generally unaltered; smaller dikes and sills and the complex intrusive bodies in the Cross Creek area (T. 3 and 4 N., R. 15 and 16 E.) generally exhibit varying degrees of deuteric and hydrothermal alteration. K-Ar dates (M. A. Lanphere, unpub. data) indicate ages between 17 m.y. (Monte Cristo Creek, T. 5 N., R. 13 E.) and 39 m.y. (Cross Creek, T. 4 N., R. 16 E.). Porphyries may represent hypabyssal equivalents of the older part of the Wrangell Lava (QTw). Only the larger and more conspicuous intrusive bodies shown; in the Cross Creek porphyry complex, the map unit may include argillite (Pe), limestone (Pel), dikes and sills of Triassic(?) gabbro, and volcanic rocks of the Tetelna Volcanics (PPt)

TKp — OLDER PORPHYRY - Shown only south of Baultoff Creek (T. 4 N., R. 23 E.) and near Chisana (T. 3 N., R. 19 E.). The porphyry near Baultoff Creek is a gray-green massive intrusive rock that cuts strata of the Eagle Creek Formation (Pe). It is highly altered and consists of saussuritized plagioclase phenocrysts in a matrix of chlorite, carbonate minerals, and zoisite. The porphyry near Chisana is a light-gray-green massive andesite porphyry containing conspicuous phenocrysts of plagioclase, as much as 1 cm long, in a fine-grained altered groundmass. Both bodies may be hypabyssal equivalents of flows of the Chisana Formation (Kc)

TKg — GRAPHIC GRANODIORITE - Light-gray medium-grained equigranular hornblende granodiorite containing graphic intergrowths of quartz and potassium feldspar. Exposed only along a steep valley wall south of Cross Creek (T. 3 N., R. 15 and 16 E.). No K-Ar dates available; intrusive may be related to middle Cretaceous plutonic event

TKd — DIORITE, UNDIFFERENTIATED - Includes a number of small complex porphyritic to equigranular granitic intrusives scattered throughout the quadrangle. Predominantly irregular bodies of intimately mixed augite-hornblende porphyritic diorite and fine- to medium-grained equigranular hornblende diorite. Includes medium-grained dark augite-olivine syenodiorite near head of West Fork of Bond Creek (T. 4 N., R. 15 E.) and fine- to medium-grained augite-bearing norite near head of Middle Fork of Bond Creek (T. 4 and 5 N., R. 15 E.). No K-Ar dates available; intrusives may represent small stocks of the middle Cretaceous plutonic event

MIDDLE CRETACEOUS PLUTONS

A middle Cretaceous plutonic event south of the Denali fault is represented in the quadrangle by at least eight complex plutons. In general, the rocks are medium grained and relatively fresh with equigranular to porphyritic hypidiomorphic textures. Most plutons show a wide range in composition, but granodiorite and quartz monzonite predominate; locally abundant phases include quartz diorite, diorite, syenodiorite, monzonite, and trondhjemite. Plutons are generally strongly discordant and locally contain xenoliths in abundance. K-Ar dates on five of the plutons (Nabesna, Klein Creek, Chisana, Antler Creek, and Suslota Pass) indicate emplacement ages of 105-117 m.y. (Richter, Lanphere, and Matson, 1975). The other plutons (Slana, Buck Creek, and Devils Mountain) are assumed to be contemporaneous on the basis of field evidence

Ksg — SLANA PLUTON - Exposed only in the extreme northwest corner of the quadrangle. Chiefly hornblende granodiorite, locally weakly foliated

Kbd — BUCK CREEK PLUTONS - Includes three elongate plutons just south of the Denali fault in the Tok River drainage (T. 11 and 12 N., R. 12 E.). Chiefly hornblende quartz diorite and syenodiorite with subordinate leucocratic hornblende granodiorite. The diorite contains small irregular masses and layers of pyroxene hornblendite and hornblende-mica peridotite. Locally strongly foliated

Ksd — SUSLOTA PASS PLUTON - Small pluton in T. 11 and 12 N., R. 10 E., is chiefly hornblende diorite containing abundant pegmatitelike segregations of very coarse euhedral hornblende crystals in a mesh of finer grained plagioclase

Kng — NABESNA PLUTON - A large complex intrusive consisting chiefly of hornblende-biotite granodiorite but with quartz diorite, diorite and trondhjemite as locally abundant phases. Younger porphyry (Tp) dikes and small stocks common throughout pluton; only larger bodies shown. Large zones of the pluton, especially along its south margin, have been affected by propylitic and argillic alteration (stippled) and contain deposits of disseminated sulfides including chalcopyrite and molybdenite

Knt — Leucocratic medium- to coarse-grained trondhjemite consisting of sodic plagioclase, quartz, and minor biotite

Knp — Small irregular masses of buff to salmon-pink quartz-feldspar porphyry with conspicuous large quartz eyes and altered euhedral plagioclase phenocrysts in a dense aphanitic groundmass of quartz and plagioclase. Relatively abundant near porphyry copper deposit at Orange Hill (T. 5 N., R. 14 E.)

Kdd — DEVILS MOUNTAIN PLUTON - Elongate pluton exposed on both sides of the broad Nabesna River valley. West of the river, the rocks are chiefly hornblende diorite and quartz diorite; east of the river they include both hornblende diorite and hornblende granodiorite. Strongly propylitically altered; most of their original hornblende has been replaced by chlorite and minor epidote and their plagioclase by saussurite

Kcs — CHISANA PLUTON - Gradational from dark clinopyroxene diorite at the exposed west end of the pluton, through a central zone of clinopyroxene syenodiorite, to clinopyroxene-hornblende monzonite along the east margin of the pluton. Biotite occurs sparsely throughout most of the pluton, and magnetite is an abundant accessory mineral, especially in the more mafic rocks, where it may constitute as much as 7 volume percent of the rock

Kas — ANTLER CREEK PLUTON - Chiefly hornblende syenodiorite, locally weakly foliated

Kah — Irregular border zone of Antler Creek pluton consisting of very coarse grained (1-3 cm) hornblendite with minor augite and interstitial plagioclase, quartz, and pyrite

Kkg — KLEIN CREEK PLUTON - Large complex intrusive similar to the Nabesna pluton but with a number of small satellitic stocks and a generally higher potassium feldspar content. Chiefly hornblende-biotite granodiorite and quartz monzonite and subordinate hornblende syenodiorite, biotite gabbro, and mafic hornblende diorite. Zones of strong propylitic and argillic alteration (stippled) are conspicuous throughout the pluton and locally contain deposits of disseminated sulfide minerals, including chalcopyrite and molybdenite

Kkd — Dark medium-grained hornblende-rich diorite. Disseminated pyrite locally abundant. Inclusions and pendants of hornfelsed Nutzotin Mountains sequence of sedimentary rock (KJs) and Chisana Formation (Kc) are common

DIORITE COMPLEX

The term "diorite complex" refers to a diverse and intimately mixed group of synkinematic plutonic rocks and a variety of medium- to high-grade metamorphic rocks. Includes plutonic diorites and quartz diorites, diorite, syenite and monzonite gneiss, amphibolite, quartz-feldspar schist and cataclasite, and possibly granulite. Contacts between plutonic and metamorphic rocks are both structural and apparently gradational. K-Ar dates (Richter, Lanphere, and Matson, 1975), however, indicate a Middle Jurassic age for the plutonic rocks and a Late Triassic age for the principal metamorphic minerals in the metamorphic rocks, suggesting that the diorite complex contains two genetically distinct terranes

JTrd — Heterogeneous hornblende diorite with subordinate hornblende granodiorite, hornblende-biotite quartz monzonite, biotite quartz diorite, and a variety of crystalline gneisses: hornblende diorite gneiss, clinopyroxene-hornblende gneiss, hypersthene-hornblende gneiss, and amphibolite with subordinate syenite-monzonite gneiss. The plutonic rocks, which have well-defined granitic textures and exhibit features of autobrecciation and autointrusion, appear to grade into the crystalline gneisses. The gneisses are wholly recrystallized with a pronounced crystalloblastic fabric; their mineral assemblages indicate extensive amphibolite-grade metamorphism. Hypersthene in cores of hornblende crystals in many of the rocks suggests that the amphibolite facies metamorphism has been superimposed on a higher grade metamorphic fabric

JTrs — Quartz-feldspar schist and cataclasite. Strong deformational fabric with large rotated and crushed feldspar and rare quartz crystals in a fine-grained granoblastic matrix of quartz and minor porphyroblastic garnet with thin laminae of biotite or amphibole

JTrq — Medium- to coarse-grained hornblende quartz diorite, hornblende-biotite quartz diorite, and subordinate leucocratic quartz diorite. Textures range from equigranular to porphyritic with the porphyritic varieties containing conspicuous blue-gray quartz eyes and, locally, concentrations of small white quartz xenocrysts

JTrg — Pink biotite-hornblende syenite-monzonite gneiss with thin interlayers of gray hornblende diorite gneiss and minor dark biotite schist. Small syenite pegmatite dikes, locally corundum-bearing, cut the alkali gneiss

Mza — ANORTHOSITE - Fresh medium- to coarse-grained bytownite anorthosite with hypidiomorphic to allotriomorphic texture. Contains 5 to 10 percent diopsidic pyroxene in poikilitic clusters and crude bands and minor interstitial olivine. Gabbro pegmatite consisting of calcic plagioclase and clinopyroxene occurs throughout the anorthosite. Although mapped as partly intrusive into rocks of the Eagle Creek Formation (Pe), actual contacts have not been observed and hence the anorthosite may be entirely structurally emplaced

NORTH OF DENALI FAULT

SEDIMENTARY ROCKS

TKc — CONGLOMERATE AND SANDSTONE - Green-gray to brown-gray pebble-to-boulder conglomerate, conglomeratic sandstone, and coarse-grained sandstone containing subordinate beds of finer grained clastic rocks. Conglomeratic rocks are massive and thick bedded; finer grained clastics are thin bedded. Clasts are subangular to well rounded and chiefly of greenstone, chert, quartz, phyllite, and crystalline igneous and metamorphic rocks. Exposed on Wellesley Mountain and hills to north along east side of quadrangle. Strata generally dip at low angles to the north and overlie older metamorphic rocks with marked angular unconformity. Locally thermally metamorphosed to dense dark conglomeratic hornfels by the Snag Creek pluton (Tsq) of Tertiary age. No fossils observed. Unit may represent shoreline facies of the Nutzotin Mountains sequence (KJs) south of the Denali fault. Thickness 0 to more than 1,500 m

KJs? — MARINE SEDIMENTARY ROCKS - Dark-gray argillite, greenish-gray graywacke and argillite-siltstone-graywacke beds similar to rocks of the Nutzotin Mountains sequence (KJs) south of the Denali fault. Exposed on four hills just north of the Denali fault (T. 10 N., R. 14, 15 and 16 E.) but largely covered by older glacial deposits and colluvium. Rocks are not regionally metamorphosed but are structurally contorted and are assumed to represent gravity slide blocks off the mountains south of the Denali fault

METAMORPHIC ROCKS

Tc — COMPLEX OF COTTONWOOD CREEK - Heterogeneous assemblage of banded granite and quartz diorite gneiss and biotite- and augite-bearing amphibolite gradational into biotite metagranodiorite and metagranite. Porphyroblasts of garnet locally abundant, especially in the more silicic banded gneisses. Metagranitic rocks range from fine to coarse grained and generally display a granoblastic texture. Exposed only in the Denali fault zone (T. 5 N., R. 22 and 23 E.) enclosed by schist and phyllite (Dp). K-Ar dates (Richter, Lanphere, and Matson, 1975) on metamorphic biotite and amphibole give ages of 17 to 20 m.y.

VOLCANIC AND VOLCANICLASTIC ROCKS

Weakly metamorphosed series of intermediate to mafic volcanic flows and predominantly volcaniclastic rocks and tuffs exposed in the Carden Hills area near the east edge of the quadrangle. May be equivalent to the Tetelna Volcanics (PPt) south of the Denali fault, but may also be a unit within the Devonian terrane (Dp). Low greenschist facies metamorphism

Pzv — Dense, dark-greenish-gray fine-grained to weakly porphyritic andesite and basalt flows with abundant reddish jasperoid breccia fillings and minor interbedded thin-banded red and green cherty mudstone. Flow rocks consist of albitized feldspar in a matrix of actinolite and minor chlorite

Pzvc — Chiefly dark-gray thin-bedded fine- to medium-grained volcanic sandstone, cherty argillite, quartzite, and tuff. Generally contorted and locally strongly foliated

PHYLLITE, LIMESTONE, AND GREENSTONE

A sequence of regionally metamorphosed and isoclinally folded marine sedimentary rocks and massive volcanic greenstones. Low greenschist facies metamorphism

Dp — Chiefly dark- to light-gray phyllite and brownish-gray metaconglomerate containing conspicuous stretched clasts and subordinate quartz mica schist, quartzite, calcareous mica schist, quartz-chlorite schist, and thin marble lenses. Rocks exhibit well-defined axial plane schistosity deformed by a later period of kink-folding. Thermal metamorphism has locally produced cordierite- and andalusite-bearing knotty schists peripheral to the Tok-Tetlin (Ktg, Ktq, Kmg) and Cheslina plutons (Kcg)

Dg — Dark-greenish-gray massive greenstone consisting chiefly of fine-grained epidote, chlorite, and altered feldspar with segregations of actinolite and rare small phenocrysts of clinopyroxene. Includes thin septa of dark-gray phyllite north of Mentasta Pass (T. 14 N., R. 8, 9 and 10 E.). Appears to be extrusive andesite and basalt flows but may be in part intrusive. Crude pillow structures observed in Bartell Creek (T. 14 N., R. 10 E.)

Dl — Gray to dark-gray recrystallized limestone; weathers light gray, and forms conspicuous castles and pinnacles protruding above the generally colluvium-covered phyllite surface. Rugose and tabulate corals from widely scattered localities indicate a Middle Devonian age

MARINE SEDIMENTARY ROCKS AND DIORITE-GABBRO

Similar to phyllite-limestone-greenstone sequence, and probably gradational with it, but lacks massive limestone beds, includes a greater diversity of metasedimentary rock, and locally is intruded by numerous sills and irregular lenses of mafic igneous rocks. Metasedimentary rocks exhibit low greenschist facies metamorphism

Dms — Predominantly dark-gray phyllite, dark-gray to buff quartzite and calcareous quartzite, light-gray porcellanite, buff to light-gray calcareous quartz mica schist, and light-gray marble. Rocks are isoclinally folded with axial-plane schistosity well defined in the phyllite and schist layers, but only locally well developed in the porcellanite and quartzite strata. Unit includes many small diorite-gabbro bodies not shown separately as MzPzi

MzPzi — Dark-greenish-gray, fine- to coarse-grained augite- and hornblende-bearing mafic diorite and gabbro. Rocks have an equigranular hypidiomorphic to ophitic texture consisting principally of ophitic augite, saussuritized calcic plagioclase, and minor hornblende. Chlorite is locally abundant as isolated segregations and as an alteration product of hornblende. The primary plagioclase and the lack of foliation indicate rocks were emplaced after main period of folding and metamorphism

Pzs — QUARTZ MICA SCHIST - Tan, light-gray and light-gray-green quartz-muscovite schist, quartz-muscovite-chlorite schist, dark-gray graphitic schist, and minor calcareous mica schist. Schistosity highly developed, generally obliterating any trace of original bedding. Kink band folds superimposed on schistosity planes. Near contact with Gardiner Creek pluton (Kgq) schists are migmatic and contain abundant layers and lenses of quartz-rich granitic rock. The schists reflect greenschist facies metamorphism

PLUTONIC ROCKS

Tsq — SNAG CREEK PLUTON - Fresh homogeneous medium- to coarse-grained leucocratic biotite quartz monzonite with equigranular hypidiomorphic texture. Exposed mainly on the south flank of Wellesley Mountain (T. 7 N., R. 22 and 23 E.) but apparently underlies most of the alluvial plain between Wellesley Mountain and the Carden Hills. K-Ar dates (Richter, Lanphere, and Matson, 1975) give a minimum age of about 50 m.y.

MIDDLE CRETACEOUS PLUTONS

The middle Cretaceous plutonic event north of the Denali fault is represented by three large plutons that petrographically differ from and are significantly younger than the middle Cretaceous plutons south of the fault. Textures range from equigranular to porphyritic hypidiomorphic; porphyritic varieties predominate. Quartz monzonite is the dominant rock type, although composition varies as widely as in the plutons south of the fault. The plutons also tend to be concordant with the structural grain of the metamorphic terrane, are generally foliated, and lack xenoliths, suggesting that they have been emplaced at somewhat deeper levels in the crust than those south of the fault. K-Ar dates (Richter, Lanphere, and Matson, 1975) indicate emplacement ages of 89 to 94 m.y.

Kgq — GARDINER CREEK PLUTON - Chiefly a coarse-grained leucocratic biotite quartz monzonite that locally contains minor hornblende. Poorly exposed; observed only in roadcuts along the Alaska Highway and at a few localities north of the highway. Pluton is probably coextensive with large granitic terrane to the north in the Tanacross quadrangle and to the east in Yukon Territory

Kcg — CHESLINA PLUTON - Predominantly medium-grained biotite-hornblende granodiorite with a marginal phase of hornblende-biotite quartz diorite and minor hornblende monzonite. Marginal phase is fine grained and locally porphyritic

TOK-TETLIN PLUTON - A large elongate composite pluton consisting of three distinct compositional-textural phases. Contacts between phases range from sharp (Mineral Cairn phase-Tok phase boundary) to gradational (Tok phase-Tetlin phase boundary). All phases yield K-Ar ages within the interval of 92 to 94 m.y.

Ktq — Tetlin phase--Forms the bulk of the pluton; consists predominantly of porphyritic biotite-hornblende quartz monzonite locally gradational to biotite-hornblende granodiorite. Rocks contain abundant and conspicuous twinned phenocrysts of orthoclase, as much as 6 cm long, in a medium- to coarse-grained groundmass

Kmg — Mineral Cairn phase--Includes a long linear body and two segmented extensions on the Denali fault side of the pluton. Rocks characteristically foliated and consist predominantly of porphyritic biotite-hornblende granodiorite and quartz monzonite with minor biotite diorite containing phenocrysts of both plagioclase and orthoclase

Ktg — Tok phase--Chiefly fine- to medium-grained biotite-hornblende granodiorite. Locally porphyritic with small phenocrysts of both plagioclase and orthoclase

Kug — UNDIFFERENTIATED PLUTONIC ROCKS - Includes three small stocks in T. 13 N., R. 11 E. and a linear stock at the eastern end of the Black Hills (T. 11 N., R. 20 E.). No age dates available, but all questionably related to middle Cretaceous plutonic event. Two of the three stocks in northeast part of quadrangle are porphyritic medium-grained biotite-hornblende granodiorite, the third, is a coarse-grained ophitic gabbro containing as much as 15 volume percent magnetite. The Black Hills stock is a medium-grained, weakly foliated biotite-rich granodiorite-diorite

ULTRAMAFIC AND ASSOCIATED ROCKS

Kum — ULTRAMAFIC ROCKS - Alpine-type ultramafic rocks consisting chiefly of serpentinite and serpentinized peridotite (wehrlite) and dunite with subordinate clinopyroxenite. Rocks are exposed in thin elongate bodies at Mentasta Pass (T. 13 and 14 N., R. 9, 10 and 11 E.), near the eastern end of the Black Hills (T. 10 N., R. 21 E.) and south of Mirror Creek (T. 9 N., R. 23 E.). The three bodies, restricted to the Devonian phyllite (Dp) sequence, define a relatively straight linear that may reflect a major, but undetected, structural feature. Rodingite inclusions, locally with thin nephritic rims, occur in the Mentasta Pass body, and massive chromitite occurs as float from the Mirror Creek body. Devonian limestone (Dl) in contact with the ultramafic rocks has been thermally altered to a magnesite-dolomite rock containing minor chrome spinel, a green nickel-bearing kaolinite mineral, and wollastonite suggesting that the ultramafics have been emplaced at moderately high temperatures. Lenses of magnesite-dolomite-silica rock occur within the Mentasta Pass body. The Mirror Creek ultramafic body apparently intrudes the conglomerate and sandstone sequence (TKc) exposed between Wellesley Mountain and Mirror Creek.

ULTRAMAFIC ROCKS, GABBRO AND ANORTHOSITE

An ultramafic body associated with gabbro and anorthosite in a metamorphosed volcanic-volcaniclastic sequence (Pzv, Pzvc) in the Carden Hills (T. 6 N., R. 23 E.) is petrographically distinct from, and possibly older than, the three ultramafic bodies occurring in the phyllite (Dp) of the phyllite-limestone-greenstone sequence to the north

Pzum — Alpine-type ultramafic consisting chiefly of serpentinized peridotite (lherzolite) and dunite

Pzg — Predominantly medium-grained leucocratic gabbro and hornblende gabbro intimately mixed with altered anorthositic rocks. Gabbros have a hypidiomorphic texture and consist of calcic plagioclase, clinopyroxene, and hornblende; anorthositic rocks lack clinopyroxene but locally contain abundant segregations, lenses, and wavy bands of fibrous tremolite-actinolite and minor clinozoisite

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EXPLANATION

Contact. Known, approximate, gradational, and inferred

High-angle fault. Dashed where approximate or inferred; dotted where concealed; heavy where evidence of Holocene movement. U, upthrown side; D, downthrown side. Arrows indicate relative lateral movement

Thrust fault. Dashed where approximate or inferred; dotted where concealed. Sawteeth on upper plate

Sole of inferred gravity slide block. Hachures on block

Folds. Showing trace of axial plane; dotted where concealed. Only larger folds in the terrane south of the Denali fault shown; isoclinal folding in the metamorphic terrane north of the fault is depicted diagrammatically in the cross sections. Smaller folds, many overturned, are common throughout the Nutzotin Mountains sequence (KJs) and in the complex fault zones in the Snag Creek-Baultoff Creek area (cross section C-C'), along Cooper and Notch Creeks, and north of Bear Valley

Anticline

Syncline

Strike and dip of beds or flows

Horizontal

Vertical

50 Inclined

80 Overturned

Strike and dip of foliation. Direction and plunge of lineation, chiefly minor fold axes, shown where measured

Vertical

80 40 Inclined

Daonella beds overlying Eagle Creek Formation (Pe)

K-Ar date locality. Plutonic and metamorphic rock dates described and discussed by Richter, Lanphere, and Matson (1975); dates on the Wrangell Lava shown in 1:63,360-scale Nabesna geologic maps either published or in press (fig. 2, in Richter, Albert, and others, 1975)

Eruptive centers and dikes in Wrangell volcanic field. Queried where inferred

Stratovolcano

Shield volcano

Silicic dome or intrusive root of dome

Cinder cone or small basalt-basaltic andesite volcano

Plug or other small eruptive site not identified by type

Prominent dike

Principal areas of strong propylitic and argillic alteration containing disseminated sulfides

Note: Mines, prospects, and mineral occurrences are shown and briefly described on separate Mineral Resources Map of this folio (MF-655K)

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