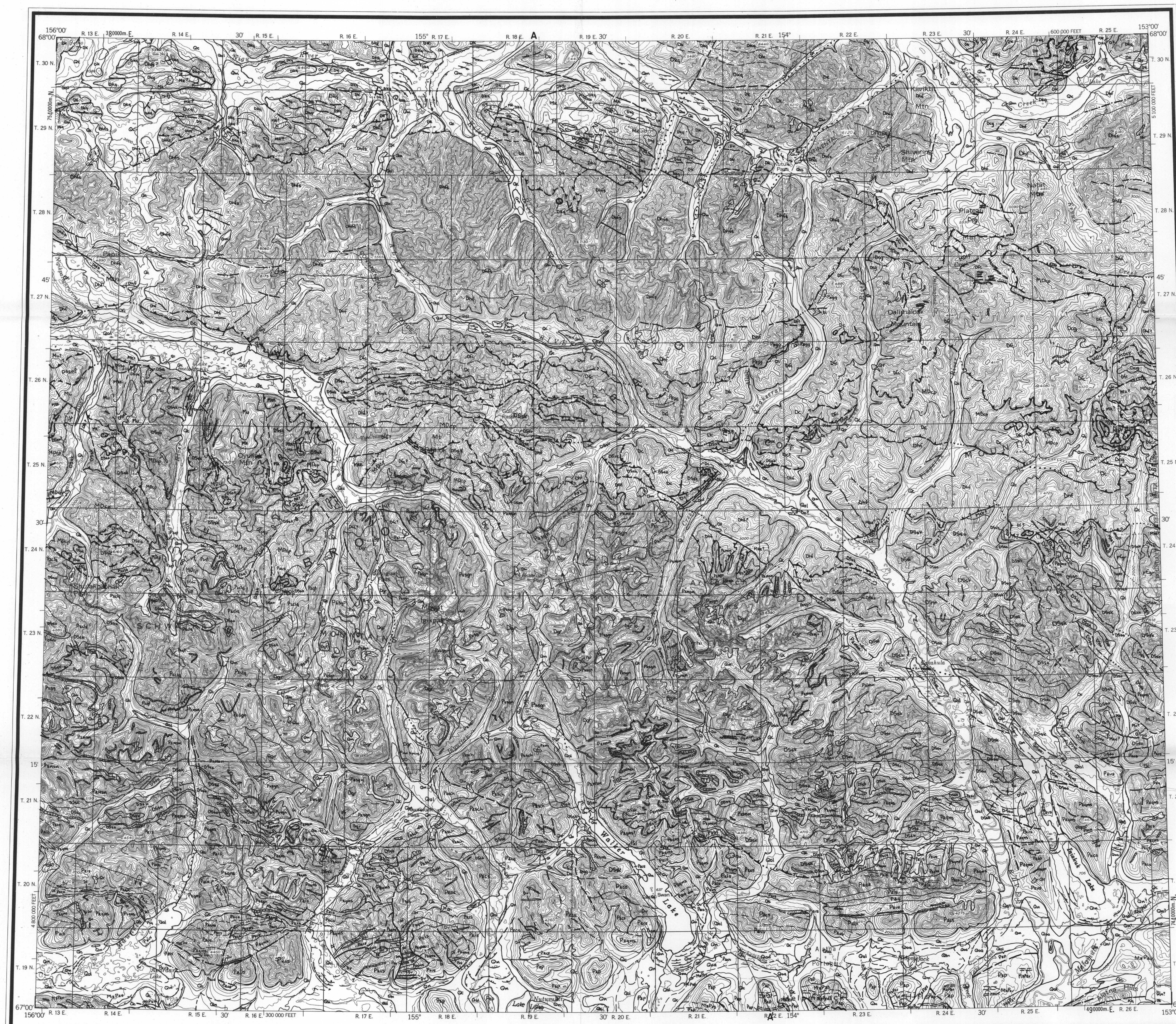
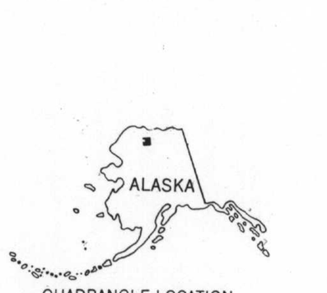
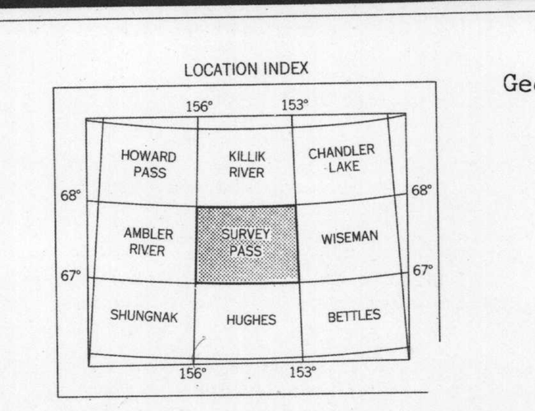


Base from U.S. Geological Survey, 1956

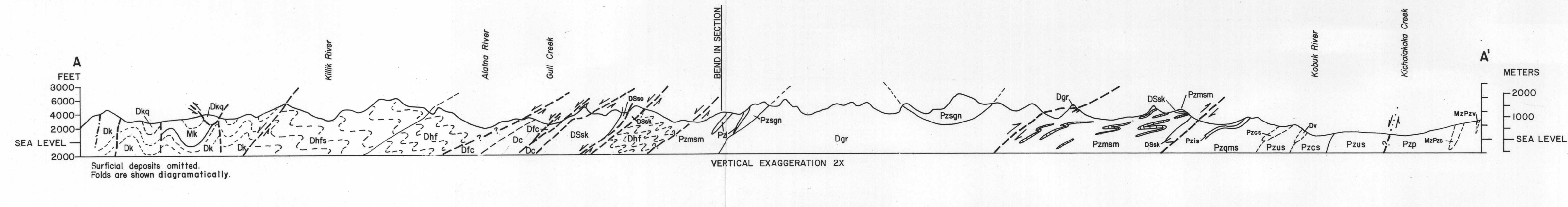
SCALE 1:250 000

CONTOUR INTERVAL 200 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929





Geology by P. S. Smith and J. B. Mertie, Jr., 1924; W. W. Patton, Jr., H. D. Mangus, and W. P. Brosgé, 1951; W. W. Patton, Jr., 1953; W. P. Brosgé and H. N. Reiser, 1959, 1962, 1966; C. E. Fritts and R. E. Garland, 1971; C. E. Fritts, R. E. Garland, G. R. Eakins, and G. H. Pessel, 1972; I. L. Tailleur, G. H. Pessel, R. E. Garland, and W. P. Brosgé, 1973; D. Grybeck, S. W. Nelson, D. A. Brew, P. J. Coney, and M. Toth, 1977; D. Grybeck, S. W. Nelson, D. A. Brew, M. Miller-Hoare, and M. Mullen, 1978.



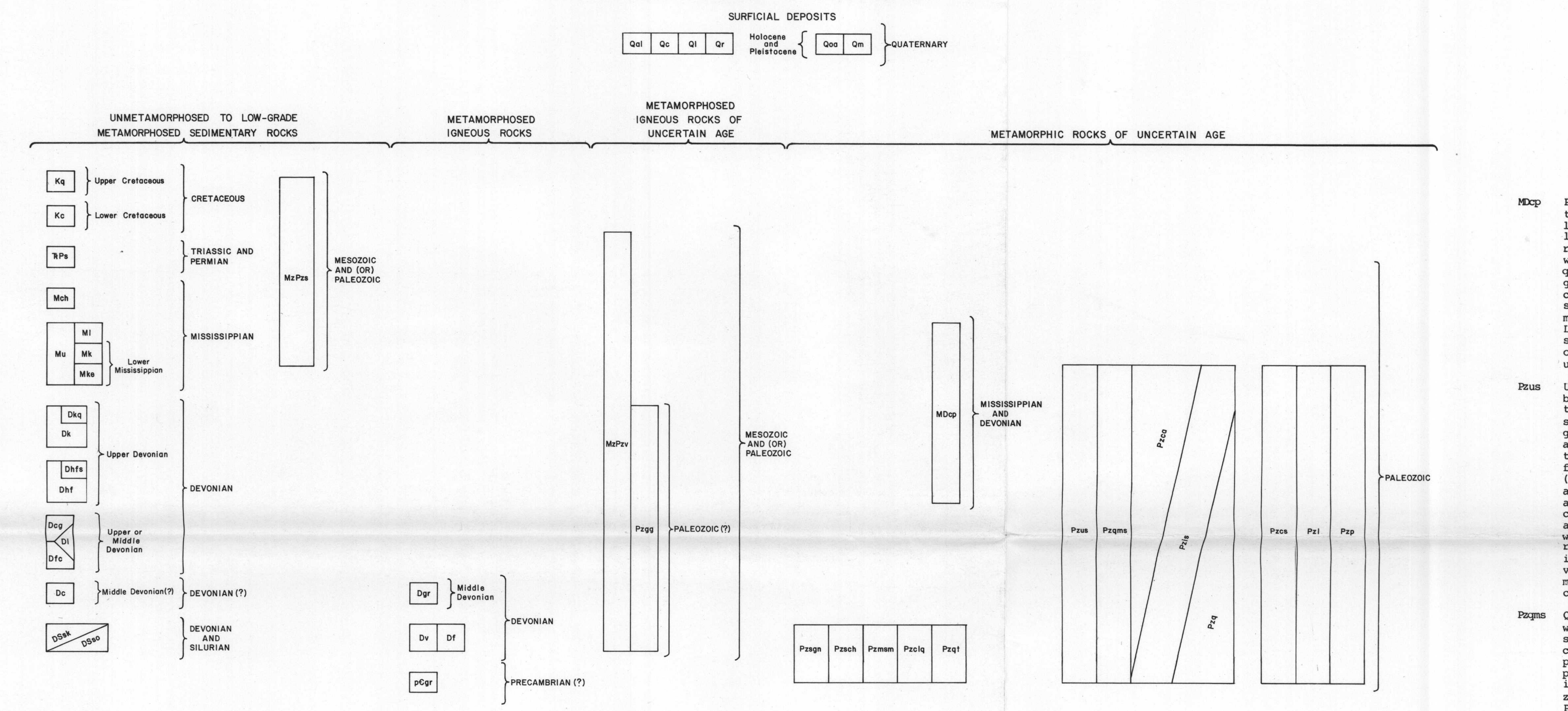
Surficial deposits omitted.
Folds are shown diagramatically.

GEOLOGIC MAP OF THE SURVEY PASS QUADRANGLE, BROOKS RANGE, ALASKA

By
Steven W. Nelson and Donald Grybeck

1980

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Qal ALLUVIUM (Quaternary)--Primarily alluvium on active flood plains. Includes fluvial deposits along isolated river meanders on the larger rivers, minor swamp and bog deposits, and minor reworked glacial deposits and colluvium. Consists chiefly of boulders, gravel, and sand with local areas of silt and clay

Qc COLLUVIUM (Quaternary)--Primarily outcrop rubble and talus on glaciated valley walls and tundra covered areas. Consists primarily of angular boulders and gravel with minor silt- and sand-size material. Includes active alluvium of small streams, many well-developed talus cones in granitic orthogneiss (Dgr) (especially in T. 23 N., R. 19 E.), and numerous recent mud-slides

Ql LANDSLIDE DEPOSITS (Quaternary)--Chiefly debris avalanche material. Coarsest debris observed in a slide, located in T. 22 N., R. 13 E., consists of angular blocks of greenstone as large as 2 x 4 m at toe of slide. Most landslides occur in slate and phyllite of Hunt Fork Shale (Dhf) and consist of debris averaging 25 cm in maximum dimension

Qr ROCK GLACIERS (Quaternary)--Active and inactive rock glaciers and associated talus aprons consisting chiefly of angular rubble; only larger deposits shown. Rock glaciers are well developed in wacke sandstone member of the Hunt Fork Shale (Dhfs)

Qoa OLDER ALLUVIUM (Holocene and Pleistocene)--Predominantly, partly dissected, terraced outwash deposits along Kichaiakaka and Helpmejack Creeks (T. 19 N., R. 22, 23, and 24 E.). Consists of orange-weathering silt, sand, and gravel that form small resistant hills

Qm UNDIFFERENTIATED GLACIAL MORAINE (Holocene and Pleistocene)--Includes ground, lateral, and end moraines from Holocene and Pleistocene glaciers. Moraines predominantly represent deposits formed during the late Pleistocene Itkillik Glaciation (Hamilton, 1977). Large, well-developed moraines are prominent at south ends of Walker and Iniakuk Lakes as well as at head of Alatna River. Morainal debris in Arrigetch Peaks and Mount Igikpak area is commonly ice cored

UNMETAMORPHOSED TO LOW-GRADE METAMORPHOSED SEDIMENTARY ROCKS

Kq QUARTZ CONGLOMERATE (Upper Cretaceous)--Weakly foliated quartz-pebble conglomerate containing well-rounded white quartz clasts, gray lenticular micaceous phyllite clasts, and minor gray foliated quartz clasts in a sand and silt matrix composed of quartz and muscovite. Unit exposed only in southeastern corner of quadrangle

Kc IGNEOUS PEBBLE CONGLOMERATE (Lower Cretaceous)--Interbedded brownish-gray poorly sorted volcanic sandstone and conglomerate containing well-rounded clasts of green chert and diabase that are 3-4 cm in diameter. Beds average 1-2 m in thickness. Unit is exposed only in southeastern corner of quadrangle. Poorly preserved plant fossils indicate Early Cretaceous (Albian) age (Patton and Miller, 1966; Patton and others, 1968). Probable maximum thickness of units Kq and Kc is 900 m (Patton and Miller, 1966)

MzPzs SANDSTONE (Mesozoic and (or) Paleozoic)--Light-gray to brown- and purple-weathering wacke sandstone; average thickness of well stratified beds is about 1 m. Ripple marks, crossbedding, and flute casts occur locally. Rocks have weakly developed foliation and microfolds; they contain minor secondary fine-grained sericite(?), chlorite, and calcite. Angular grains of quartz, plagioclase, and lithic fragments characterize sandstone, and lesser amounts of detrital grains of muscovite, biotite, zircon, and tourmaline have been observed. Contacts with units Pzp and MzPzv are poorly exposed and the spatial association with cherts, phyllite, limestone, and mafic volcanic rocks of Paleozoic and Mesozoic age suggests fault contacts (Plafker and others, 1978)

TRPs SHUBLIK FORMATION (Triassic) AND SIKSIKPUK FORMATION (Permian), UNDIVIDED--Shublik Formation; pink-weathering limestone. Siksikpuk Formation; black slate and orange-weathering black chert. Best exposures are found in core of a faulted syncline located in T. 29 N., R. 19 E. Maximum thickness is about 300 m

Mch CHERT (Mississippian)--Dark-gray to black well-bedded chert containing Mississippian radiolarians and intruded by dark-green diabase (MzPzv) in southwest corner (T. 19 N., R. 14 E.) of quadrangle. Thickness is unknown but is probably less than 50 m

Mu UNDIVIDED MISSISSIPPIAN SEDIMENTARY ROCKS--Undivided sedimentary rocks consisting primarily of interbedded dark-gray phyllite, red- and green-weathering phyllite, quartz semischist, and minor quartz conglomerate with a combined thickness of 2000 m near Oyukak Mountain (T. 25 N., R. 15 E.). Also includes limestone and marble of Lisburne Group (Ml), Kayak Shale (Mk), and Kekiktuk Conglomerate (Mke) where these units are too small to show at map scale

Ml LISBURNE GROUP (Mississippian)--Gray limestone and gray nodular chert and bedded chert. Limestone usually contains abundant, coarse crinoid and brachiopod fossils but is locally unfossiliferous and metamorphosed to marble. About 100 m thick along north edge of quadrangle

Mk KAYAK SHALE (Lower Mississippian)--Occurs in three areas: 1) faulted folds in Kanayut Conglomerate in northern part of quadrangle, 2) south of Noatak River in western part of quadrangle where it unconformably overlies Skajit Limestone, and 3) in scattered areas along eastern boundary of quadrangle where it either unconformably overlies Skajit Limestone or is thrust over Middle or Upper Devonian calcareous schist (Dfc). In northern part of quadrangle, Kayak Shale is black phyllite or slate and is interlayered with brown- and locally orange-weathering fossiliferous siltstone and sandstone. South of Noatak River it is black to dark-gray locally red- and green-weathering slaty phyllite and argillite with minor semischistose quartz-rich siltstone and marble. In eastern part of quadrangle, Kayak Shale is similar to that south of Noatak River, but interlayered marble is rare. In many places, unit is sheared and isoclinally folded and exhibits crenulation cleavage. Maximum thickness of 300 m is exposed, much of which is probably repeated by folding. Early Mississippian fossils are abundant in siltstone and sandstone in the northern part of the quadrangle, and conodonts have provided age control for the marbles interbedded with black phyllite (table 1)

Mke KEKIKTUK CONGLOMERATE (Lower Mississippian)--Consists of three low-grade metasedimentary rock units not differentiated on map; units are, in part, interbedded.

Unit 1. Semischistose chlorite-muscovite-quartz metasandstone and metaconglomerate. Augen porphyroclasts of quartz in conglomerate are as large as 2 cm and are strained and fractured and display various stages of recrystallization. Dark-gray quartz-rich micaceous lithic fragments are foliated and commonly smaller than 2 mm. Detrital accessory minerals observed include blue-green and brown tourmaline, zircon, and kyanite. Locally are interlayered with thin (<2 m thick) layers of gray-, green- or red-weathering phyllite

Unit 2. Chloritoid-bearing semischistose metaquartzite and quartz mylonite. Consists of very fine- to medium-grained quartz with fine-grained, post-tectonic, radiating clusters of chloritoid that have grown across foliation. Abundant fiberous opaque minerals altered to limonite(?) locally give weathered rock a reddish or green color. Rocks have well-developed deformation texture, in part cataclastic, and two moderately to well-developed foliations. Rare accessory tourmaline is present but can be observed only in thin section

Unit 3. Calcareous and feldspathic chlorite-muscovite-quartz semi-schistose metasandstone and metaconglomerate. Rocks are very fine- to coarse-grained and contain porphyroclasts of quartz and plagioclase (less than 10 percent); the plagioclase commonly shows poorly developed compositional zoning. Iron-stained calcite imparts reddish color to weathered surfaces. Lithic fragments are dark gray and very fine grained and contain muscovite and quartz

Presence of trace amounts of detrital kyanite in quartz-rich metaconglomerate (unit 1, above) spatially associated with black phyllite suggests that rocks previously mapped in quadrangle as chloritic quartzite and conglomerate by Brosgé and Pessel (1977) are Kekiktuk Conglomerate. Maximum thickness of Kekiktuk Conglomerate is probably 200 m although stratigraphic markers are missing

Dk KANAYUT CONGLOMERATE (Upper Devonian)--Interbedded quartz wacke, subfeldspathic lithic wacke, feldspathic wacke, and black to dark-gray phyllite and siltstone. May include unrecognized Kayak Shale (Mk). Conglomerate is rare in Survey Pass quadrangle. Thickness is uncertain, and exposed rocks are probably repeated by folding and faulting. Upper part includes:

Dkq Quartz arenite and quartzwacke member--Quartz arenite and quartz wacke in massive resistant beds as thick as 200 m, but more commonly 10-20 m thick. Outcrops usually covered by distinctive black lichen and weather to a light orange where lichen is absent. Locally, contains reddish-brown ferruginous mudstone interbeds as thick as 0.3 m. Distinguished from wacke sandstone member of Hunt Fork Shale (Dhfs) by higher degree of sorting, coarser grain size, absence of plagioclase, and fewer lithic grains other than chert. Rare quartz clasts show quartz overgrowths on well-rounded cores. Quartz overgrowths are probably not authegenic but instead reflect quartz grains with overgrowths inherited from preexisting sedimentary rocks. This interpretation is suggested by rarity of quartz overgrowths in rocks composed mostly of quartz grains and absence of overgrowths on chert grains, which are at least as abundant as quartz grains. Metamorphic fabric is not pervasive, but semischistose and mylonitic textures were locally observed. Incipient metamorphic(?) muscovite and chlorite formed at expense of detrital muscovite are the only mineralogical indications of metamorphism. Indeterminate plant and marine fossils (table 1) indicate fluvial to littoral environment of deposition and suggest a Late Devonian age (J. T. Dutro, Jr., written commun., 1978)

Dhf HUNT FORK SHALE (Upper Devonian)--Dark-gray to black slate and phyllite. Generally forms subdued, tundra-covered topography. Minerals recognizable in thin section are chlorite, muscovite, quartz, and albite. Unit is more than 600 m thick and locally contains well-developed pyrite cubes. Upper part includes:

Dhfs Wacke sandstone member--Interbedded dark-gray, brown-weathering feldspathic and subfeldspathic lithic wacke, dark-gray, brown- to tan-weathering siliceous siltstone, and dark-gray to black phyllite. Poorly to moderately well sorted sandstone consists of angular to subrounded grains, averaging 0.4 mm in size, composed of quartz and gray to black chert or other lithic fragments. Rare pebble conglomerate consists of dark-gray rounded shale chips in wacke sandstone matrix. Approximately 80 percent of sandstone consists of quartz and microcrystalline chert grains. Plagioclase feldspar ranges up to 15 percent with an average abundance of about 5 percent. Lithic fragments other than chert may range up to 20 percent and are dark gray to black (rich in opaque minerals), microcrystalline, foliated, and micaceous. Detrital muscovite is commonly altered (metamorphosed?) to chlorite. Original argillaceous material between grains has been largely recrystallized to fine-grained white mica. Iron oxides, blue-green and brown tourmaline, and zircon are found in trace amounts but may have a combined abundance of as much as 5 percent of the rock. Abundant fossils are widespread in this unit and occur almost entirely in dark orange-weathering impure limestone and calcareous sandstone beds that are generally less than 2 m thick. Fossils include poorly to moderately well preserved brachiopods, gastropods, pelecypods, and echinoderms (table 1). Feeding tracks and trails are also common. Many fossils indicate Late Devonian (Famennian) age. Metamorphic fabric not well developed or pervasive in the sandstone; however, weakly to moderately well developed semischistose texture is locally found in rocks from both northern and southern contacts of unit. In contrast, phyllite has well-developed metamorphic fabric and, in many places, well-developed slip cleavage that has been deformed by later crenulations. Unit is greater than 1000 m thick and is probably repeated by folding and faulting

Dcg METACONGLOMERATE (Upper or Middle Devonian)--Dark-gray to black chlorite-chloritoid-muscovite-chert-quartz metaconglomerate and metawacke sandstone with minor interlayered gray chloritoid-bearing phyllite, purple phyllite, and green chlorite-bearing phyllite. Chloritoid occurs as both radial crystals and stubby prisms. Metaconglomerate occurs in resistant layers as thick as 10 m. Maximum size of white quartz and gray chert clasts is 2 cm. Best exposures of unit are at Plateau Mountain (T. 28 N., R. 24 E.) and peak 5930 (T. 27 N., R. 25 E.). Middle to Late Devonian fossils from interbedded limestone (Dl) (table 1) indicate a Middle or Late Devonian age for the metaconglomerate

Dl LIMESTONE (Upper or Middle Devonian)--Dark-gray- to orange-weathering limestone that occurs as interbeds with metaconglomerate (Dcg) or ferruginous calcareous metasedimentary rocks (Dfc). Limestone is locally carbonaceous and isoclinally to disharmonically folded. Average thickness of beds is 30 mm. Limestone contains Middle to Late Devonian fossils

Dfc FERRUGINOUS, CALCAREOUS METASEDIMENTARY ROCKS (Upper or Middle Devonian)--Light-brown and orange-weathering, gray calcareous micaceous schist, phyllite, and metasiltstone. Outcrops are commonly coated with a white effervescent powder, which Mayfield and Tailleur (1978) reported in Ambler River quadrangle as being dolomite and the soluble salts, epsomite and hexahydrite. Maximum observed thickness north of Noatak River is 300 m and north of Dalimaloak Mountain (T. 27 N., R. 23 E.) is about 700 m; the total thickness is uncertain because of tectonic thickening in recumbent isoclinal folds and faulting

Dc CHLORITE AND CHLORITOID-BEARING PHYLLITE AND SEMISCHIST (Middle Devonian?)--Light-green-weathering chloritic phyllite and chloritoid-bearing muscovite-chlorite-quartz semischist. Includes minor gray phyllite and slate and, locally, mylonite schist. Chloritoid-bearing rocks are similar to some units in undivided Mississippian sedimentary rocks (Mu) but contain probable Devonian fossils (table 1)

DSsk SKAJIT LIMESTONE (Devonian and Silurian)--Massive light-gray-weathering cream to very light gray fine- to medium-grained granoblastic marble. Includes minor muscovite- and quartz-bearing marble. Marble has well-developed metamorphic layering and is complexly deformed. Minor calc-silicate skarns have been developed near Arrigetch pluton. More than 1000 m of marble is exposed along the Alatna and Kugrak Rivers. Large-scale knappelike folds are well developed east of Alatna River. Locally marble is interlayered with chlorite schist. Marble is sparsely fossiliferous but is reported to contain corals of Silurian to Devonian age (Oliver and others, 1975). In Survey Pass quadrangle, fossils range in age from Middle Ordovician to Middle Devonian (table 1)

DSso ORANGE DOLOMITIC MARBLE (Devonian and Silurian)--Orange-weathering medium to coarse-grained granoblastic chlorite-muscovite-quartz-dolomite(?) marble. Chlorite is commonly apple green. Marble contains interlayered chlorite schist, calcareous muscovite schist, and gray marble (DSsk) and in T. 22 N., R. 25 E. includes carbonate-pebble conglomerate in dolomitic matrix that is interbedded or infolded with quartz schist (W. P. Brosgé, written commun., 1979). Unit locally occurs along fault zones where it is brecciated and may be structural rather than depositional unit

METAMORPHOSED IGNEOUS ROCKS

Dgr GRANITIC ORTHOGNEISS (Middle Devonian)--Metamorphosed intrusive rocks that are predominantly muscovite-biotite granite ranging in composition from alkali-feldspar granite to tonalite (fig. 1, sheet 2). According to classification of Higgins, 1971, the rocks are porphyroclastic mylonite gneiss and blastomylonite. Coarse-grained augen gneiss and granitic-textured granite occur locally within Arrigetch Peaks and Mount Igikpak plutons. Previously determined K/Ar ages suggested that granitic rocks were Cretaceous (Turner and others, 1978); however, recent U/Pb zircon ages and preliminary whole-rock Rb/Sr isochron now indicate Middle Devonian age (Dillon and others, 1979; Silberman and others, 1979). Contact relations between granitic orthogneiss and the surrounding metamorphic rocks not definitive. In most places contact is quite sharp and parallel to compositional layering and foliation in adjacent metasedimentary rocks. Intrusive nature (Nelson and Grybeck, 1979) of at least parts of contact is established by (1) presence of large xenolithic blocks of metasedimentary rocks as large as 5 x 10 m, (2) dikes and sills of orthogneiss cutting metasedimentary rocks, and (3) narrow, discontinuous contact metamorphic zones containing amphibolite, and calc-silicate skarns. However, tectonic (faulted) contacts also exist, best exposures of which are northeast of Walker Lake (T. 22 N., R. 20 E.). In this area granitic orthogneiss caps a ridge. Contact is horizontal and parallel to foliation in underlying metamorphic rocks. Lower meter of orthogneiss is well-developed mylonite gneiss and is interpreted as a fault contact which can be traced to the north. Although underlying metasedimentary rocks in this area are of medium (amphibolite) grade, this grade is believed to represent effects of Mesozoic metamorphism and not necessarily intrusive effects of emplacement of orthogneiss (Nelson and Grybeck, 1979). No evidence for sedimentary (nonconformable) contacts was observed in Survey Pass quadrangle. Future workers in this area should be aware of complex nature of the contact between orthogneiss and surrounding metasedimentary rocks. Most workers will agree that region has undergone Mesozoic metamorphism and tectonism as well as an earlier (Devonian?) tectonic event (Mull and Tailleur, 1977). Variation of major oxides with silica is shown in figure 2 (sheet 2). These trends are similar to chemical variation trends in the Sierra Nevada batholith (Bateman and others, 1963) and reflect crystallization from a magma. Apparent initial $^{87}Sr/^{86}Sr$ ratios are high, about 0.715, and suggest that magmas were formed from melting of crustal material

Dv MAFIC METAVOLCANIC ROCKS (Devonian)--Dark-green to dark-gray massive metabasalt, greenstone, and greenschist. Locally includes well-developed pillow basalt and greenstone with ophitic and porphyritic textures. Plagioclase is usually altered to brownish clay(?) minerals. Clinopyroxene is usually altered to chlorite and actinolite with minor calcite and epidote. Greenschist and greenstone contain low-grade (greenschist) metamorphic assemblages that include porphyroblastic albite, actinolite and garnet, rare glaucophane, chlorite, muscovite, and epidote. Age is based on fossils from limestone and marble (Pzl) in southwestern part of quadrangle (No. 78, table 1) that is closely associated with volcanogenic sequence and U-Pb dates of zircons from felsic schist (Df) at Arctic Camp (30 km to the northwest) with magmatic crystallization age of 360 Mu Y. (Turner and others, 1978)

Df FELSIC SCHIST (Devonian)--Very light gray to brownish-red-weathering resistant schistose felsic volcanic rocks. Includes muscovite quartzite and is associated with mafic metavolcanic rocks (Dv). Unit locally contains coarse-grained porphyroclasts of albite and potassium feldspar as long as 5 cm. Felsic schists are associated with volcanogenic, massive sulfide Cu-Zn-Pb-Ag deposits. A recently completed preliminary whole-rock Rb/Sr isochron suggests a Triassic age (M. L. Silberman, oral commun., 1979) for samples from near Picnic Creek (T. 19 N., R. 17 E.); this age contradicts Paleozoic age based on Pb isotopes from stratiform sulfide deposits to the west in Ambler River quadrangle (Smith and others, 1978) that are associated with a correlative volcanogenic sequence, Devonian U-Pb dates (mentioned in unit Dv), and fossil evidence from limestone in Survey Pass quadrangle (No. 78, table 1). Possible older (Precambrian) ages for metavolcanic rocks and associated schist have been suggested on the basis of K-Ar dates (Turner and others, 1978); however this age is believed to be tenuous because of problems with inherited argon (Dillon and others, 1979)

p€gr ERNIE LAKE PLUTON (Precambrian?)--Gray-weathering biotite-muscovite granite mylonite orthogenesis and mylonite orthoschist. Porphyroblasts of albite as large as 1 cm occur in very fine grained "mat" of muscovite. Although U/Pb radiometric dates on zircons from this pluton just east of the quadrangle boundary have yielded Precambrian ages (Dillon and others, 1979). Dillon (oral commun., Nov. 1979) points out that because of problems with inherited (older) zircons from these rocks as well as a Pb-loss factor, these rocks may be younger. Near Ernie Lake structure is complex and contact relations are contradictory. According to Dillon and others (1979), part of Ernie Lake pluton is nonconformably overlain by Paleozoic, Devonian(?) marble unit, whereas elsewhere pluton apparently intrudes thin marble roof pendant

METAMORPHOSED IGNEOUS ROCKS OF UNCERTAIN AGE

MzPzv MAFIC VOLCANIC ROCKS (Mesozoic and (or) Paleozoic)--Very low grade to low-grade metamorphosed massive dark-gray to dark-green volcanic rocks; mostly basaltic in composition but may contain minor, more felsic units. Poorly developed pillows occur in Helpmejack Hills, and well-developed pillows occur locally in southwestern part of quadrangle (T. 19 N., R. 13 E.). Pillows range in diameter from 30 cm to 1 m. Unit commonly consists of flows, dikes, and sills as thick as 20 m. Volcanic rocks may be in complex fault and intrusive relation with each other and are probably interlayered with Devonian limestone. Mississippian chert (Mch), Triassic chert and Paleozoic and (or) Mesozoic sandstone (MzPzs). All contacts are poorly exposed. Plagioclase phenocrysts occur as well-developed laths as long as 2 mm, whereas groundmass plagioclase is usually less than 0.5 mm long. In most samples, plagioclase has been altered to brown mass of clay(?) minerals. Mafic minerals include clinopyroxene, commonly altered to chlorite and (or) actinolite and calcite. One sample contained possible olivine. In many samples, patches (pseudomorphs?) of chlorite suggest former presence of mafic minerals. Altered volcanic glass(?) is very dark and clouded in appearance and contains delicate sheaflike crystals of feldspar. Presence of pumpellyite, albite, and chlorite in thin veins and patches suggests metamorphism to very low grade (Winkler, 1976). Zeolite(?) observed in some samples. No penetrative deformation fabric was observed. Local breccia zones were probably developed as primary feature during emplacement or deposition. Age is uncertain. Ordovician to Devonian microfossils have been found in limestone possibly conformable with pillow basalt (No. 80, table 1); Patton and Miller (1966) correlate volcanic rocks with similar rocks of Jurassic age in eastern Brooks Range. Contains Triassic (D. L. Jones, written commun., 1978, 1979), Permian (Dillon and Pessel, 1977), and Mississippian (No. 81, table 1) radiolarians from interlayered(?) chert. Recent preliminary Rb/Sr dating on felsic schist (Df) from the "schist belt" indicate a Triassic age (M. L. Silberman, written commun., 1979) and suggest that both Paleozoic and Mesozoic volcanic rocks occur in southern quarter of quadrangle

Pzgg GREENSTONE AND GREENSCHIST (Paleozoic?)--Massive dark greenstone commonly composed of albite, actinolite, epidote, and chlorite, and greenschist composed of albite, chlorite, and minor magnetite. Locally greenstone appears to be altered gabbro that has intruded metasedimentary rocks. At one locality (T. 26 N., R. 22 E.), Devonian sedimentary rocks have been metamorphosed to dark hornfels within 2 m of altered gabbro. Largest area of greenstone, in western part of quadrangle (T. 22 N., R. 13 E.), was previously mapped as biotite schist and possibly metamorphosed granodiorite by Brosgé and Pessel (1977), but is more likely metamorphosed volcanic sequence. Poorly developed pillows in compositionally layered biotite-quartz-chlorite schist and semischist, garnet-epidote-albite-amphibolite, and feldspathic biotite-epidote-quartz gneiss with lenticular chloritic patches suggest that these are metamorphosed volcanic rocks of various types. Age of these rocks is uncertain. Intrusive relation discussed above indicates that, in part, they are post-Devonian; some, however, could be older. A Cretaceous K/Ar date (No. 64, table 1) from western part of quadrangle probably reflects widespread Mesozoic metamorphic event(s) in the southern Brooks Range

METAMORPHIC ROCKS OF UNCERTAIN AGE

MDcp PHYLLITE (Mississippian and Devonian)--Interlayered dark-gray to black phyllite and calcareous phyllite. Phyllites are locally siliceous and, although well foliated, resemble argillites. Dark-gray- to orange-weathering marble or dolomite ranging in thickness from 2 cm to 50 m is locally interlayered with phyllite. Siliceous phyllite contains as much as 70 percent quartz with minor muscovite and quartz. Abundant very fine grained opaque minerals give rock characteristic dark-gray color. Metamorphic fabric is typically phyllitic, but semi-schistose and blastomylonitic textures occur locally. Unit is more siliceous than either Early Mississippian Kayak Shale or Late Devonian Hunt Fork Shale although it is lithologically similar to both. No fossils were recovered from samples of interlayered marble. At present, these rocks are considered undivided Kayak and Hunt Fork Shales

Pzus UNDIFFERENTIATED SCHIST--Mostly quartz-muscovite schist (Pzqms) but includes minor undifferentiated units equivalent to chloritoid-bearing schist (Pzcs), calcareous schist (Pzca), felsic schist (Df), mafic metavolcanic rocks (Dv), greenstone and greenschist (Pzgg), quartzite (Pzq), iron-stained schist (Pzis), and limestone and marble (Pzl). Assigned a Paleozoic age on the basis of Middle Devonian to Early Mississippian fossils from limestone and marble (Pzl) interlayered in unit Pzqms (table 1). It is important to point out in any discussion of ages of units Dv, Df, Pzus, Pzqms, Pzca, Pzis, Pzq, Pzl, Pzcs, and Pzp in "schist belt" that age assignments are based on close spatial association with units that have limited fossil and radiometric control. Tenuous nature of Precambrian dates was discussed above, but cannot be ruled out; however, various radiometric methods tend to support middle Paleozoic dates indicated by fossils. Until structural relation between various units in "schist belt" are more clearly understood and more dates obtained, Early Mississippian and older (?) range cannot be better refined

Pzqms QUARTZ-MUSCOVITE SCHIST (Paleozoic)--Predominantly light-gray-weathering chlorite-quartz-muscovite schist and phyllitic schist and dark-gray to dark-gray-green porphyroblastic albite-chlorite-quartz-muscovite schist. Albite occurs in conspicuous porphyroblasts as large as 2 mm that show multiple periods of post-tectonic and syntectonic growth. Minor minerals observed in thin section include garnet, zoned brown tourmaline, sphene, zircon, and apatite. Locally differentiated into units Pzca, Pzis, and Pzq

Pzca CALCAREOUS SCHIST (Paleozoic)--Brown-weathering calcareous quartz-albite-muscovite schist. This schist contains 15-25 percent calcite but is otherwise similar to quartz-muscovite schist (Pzqms)

Pzis IRON-STAINED SCHIST (Paleozoic)--Brown- to orange-weathering iron-stained schist probably equivalent to quartz-muscovite schist (Pzqms) or chloritoid-bearing schist (Pzcs)

Pzq QUARTZITE (Paleozoic)--Dark-gray to black albite-muscovite quartzite and graphitic quartzite. Forms resistant outcrops and locally is interlayered with felsic schist (Df). Maximum thickness is about 30 m

Pzcs CHLORITOID-BEARING SCHIST (Paleozoic)--Predominantly gray-weathering fine- to medium-grained chloritoid-bearing quartz-muscovite schist. Chloritoid commonly occurs as very dark green, stubby, lath-shaped crystals as long as 2 mm. In hand specimen, dark-green (almost black) chloritoid may be mistaken for biotite. Schist locally contains glaucophane, which occurs as anhedral, ragged crystals altered to dark-gray chloritic(?) mineral and as idioblastic crystals enclosed in chloritoid

Pzl LIMESTONE AND MARBLE (Paleozoic)--Mostly light-gray, medium-grained, granoblastic marble, impure quartz-muscovite marble, and minor limestone. Possibly includes carbonate rocks of different ages. Locally contains possible Middle Devonian to Early Mississippian fossils (table 1)

Pzp PHYLLITE (Paleozoic)--Light- to dark-gray phyllite and slate; commonly sericitic. Phyllite may be in part gradational into chloritoid-bearing schist (Pzcs) and quartz-muscovite schist (Pzqms). Cut by locally folded white-quartz veins and quartz segregations that have iron-stained margins. Because of poor exposures, phyllite may contain unrecognized mafic volcanic rocks (MzPzv). Evidence of two deformations observed near resistant outcrops of mafic volcanic rocks may indicate local intrusion or tectonic deformations

Pzsgn UNDIFFERENTIATED SCHIST AND PARAGNEISS (Paleozoic)--Medium-grade schist and gneiss near margins of Mount Igikpak pluton. Common metamorphic minerals (in approximate increasing order of abundance) include garnet, biotite, muscovite, amphibole, feldspar, and quartz. Locally contains minor interlayered marble of unit Pzl. Schistose textures predominate over gneissic textures; however, gneissic textures are more common adjacent to plutons and between main pluton and satellitic bodies such as in T. 23 N., R. 16 E. Contact relations with granitic orthogneiss (Dgr) suggest that unit has been intruded by orthogneiss and is therefore in part Middle Devonian or older

Pzsch SCHIST (Paleozoic)--Predominantly very light gray- to gray-weathering garnet-biotite-albite-muscovite-quartz schist. Schist includes minor tan-weathering muscovite quartzite and gray quartz-muscovite schist and is interlayered with marble (Pzl and DSsk) and greenstone (Pzgg). Intrusion(?) by small satellitic bodies of orthogneiss (Dgr) in T. 21 N., R. 18 E., and T. 22 N., R. 19 E. suggests a Middle Devonian or older age. Unit may be higher metamorphic grade equivalent to metamorphic rocks (Pzqms) in "schist belt" to south

Pzmsm MIXED SCHIST AND MARBLE (Paleozoic)--Interlayered gray marble, orange dolomitic marble, magnetite-bearing chlorite schist, and garnet-biotite-quartz schist with small calc-silicate skarns containing amphibole near the Arrigetch pluton. Typically isoclinally folded with horizontal or subhorizontal axial planes. Resistant ledge-forming marble (Pzl) gives unit bedded appearance. Marble typically weathers gray or orange, and schist weathers dark gray and green. Intermediate amount of interlayered marble distinguishes these rocks from marble unit, DSso (more marble), and the schist unit, Pzsch (less marble); however, they may be equivalent in age

Pzclq CHLORITE QUARTZITE AND CHLORITIC QUARTZ SCHIST (Paleozoic)--Monotonous sequence of light-greenish-gray-weathering rocks that form rugged topography in area of Ivik Creek (T. 23 N., R. 14 E.). Rocks are predominantly quartz with lesser amounts of chlorite, muscovite, biotite, and plagioclase. Near Mt. Chitiok (T. 24 N., R. 16 E.) unit includes light-greenish-gray metaconglomerate with angular clasts ranging in width from 0.5 cm to 3 cm. Clasts are composed of polycrystalline quartz and apple-green chlorite with 1-2 percent calcite. Locally metaconglomerate contains large pyrite cubes as large as 2 cm. Assigned Paleozoic age on basis of possible intrusion by granitic orthogneiss (Dgr)

Pzqt QUARTZITE (Paleozoic)--Orange-weathering white- to cream quartzite, quartz conglomerate, and schistose conglomerate. Locally quartzite contains abundant pyrite and is interbedded with minor calcareous, muscovite quartzite, and yellow-weathering gray laminated calcareous phyllite. Outcrops commonly display well-developed chevron-style folds with amplitudes as large as 25 cm. Apparently intruded by granitic orthogneiss (Dgr) in T. 23 N., R. 16 E.

Map Symbols

30 — Contact--Dashed where approximate or inferred; queried where uncertain; dotted where concealed. Number indicates dip of orthogneiss contact

40 — Fault--Dashed where approximate or inferred; queried where uncertain; dotted where concealed. Number indicates dip of fault east of the Reed River

Thrust or high-angle reverse fault--Dashed where approximate or inferred; queried where uncertain; dotted where concealed. Sawteeth on upthrown plate. Arrows in cross section indicate relative movement

Prominant lineament observed on aerial photographs

Anticlinal fold showing direction of plunge - dashed where approximate

Synclinal fold

Overturned anticline

Undifferentiated limestone and marble--Devonian and Mississippian in age

End and lateral moraine

Medial moraine

Pingo

Interior—Geological Survey, Reston, Va.—1980
For sale by Distribution Section, U.S. Geological Survey, Federal Bldg., Box 12, 101 Twelfth Avenue, Fairbanks, AK 99701, and Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225