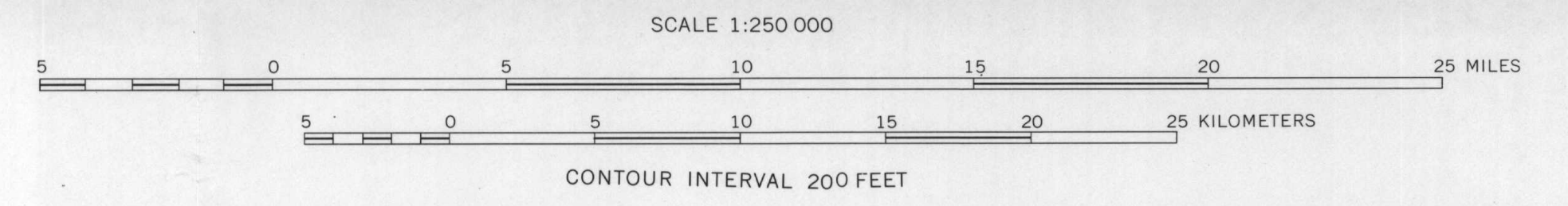
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

FOLIO OF THE SURVEY PASS QUADRANGLE, ALASKA
MISCELLANEOUS FIELD STUDIES
MAP MF — 1176-C
NELSON AND GRYBECK - METAMORPHIC ROCKS

Base from U.S. Geological Survey, 1956



Geology generalized from
Nelson and Grybeck (1980)

Discussion

Petrographic examination of more than 1,400 thin sections of middle to late Paleozoic metasedimentary and metaigneous rocks from the Survey Pass quadrangle in the central Brooks Range of Alaska has resulted in the recognition of three grades of metamorphic rocks that range from very low grade to medium grade, using the terminology of Winkler (1978). The data presented include observations made by the authors and unpublished petrographic observations made by earlier workers (Brosgé, written commun., 1978, 1980).

Mineralogical (Winkler, 1978) and textural criteria used to classify the rocks into these metamorphic grades are:

1) Unmetamorphosed--sedimentary rocks with simple fold style and little or no recrystallization and rare, weakly developed slaty cleavage.

2) Very low grade--presence of pumpellyite and zeolite in mafic volcanic rocks and two metamorphic foliations in phyllite.

3) Low grade--presence of chlorite, muscovite, albite, actinolite, chloritoid, and epidote in metasedimentary rocks; pervasive recrystallization and two to three metamorphic foliations. Note: Plagioclase compositions were determined whenever possible on the U-stage using the a-normal method. However, most alibte grains were untwinned, and composition was based on a combination of mineral relief, chemical staining (Norman, 1974), and, for some samples, microprobe analyses (W. J. Nokleberg, written commun., 1980).

4) Low to medium grade--presence of garnet, biotite, plagioclase, muscovite and amphibole in schist and paragneiss; small discontinuous calc-silicate skarns and local migmatite near the plutons.

The quadrangle can be divided into a central core region containing cataclastic and folded granitic plutons of Middle Devonian age (Nelson and Grybeck, 1978, 1979; Dillon and others, 1979; Silberman and others, 1979) and possible migmatite surrounded by low- to medium-grade or transitional low- to medium-grade schists, marble, and paragneisses. Skarns consist of garnet, amphibole, epidote, diopside, and magnetite and occur as small, discontinuous remnants of the original country rocks that have been preserved as resistant bodies adjacent to the plutons. They were probably more extensive, but have been largely removed structurally during the tectonic emplacement of the plutons (Nelson and Grybeck, 1979).

Texturally, the granitic orthogneisses can be classified as mylonite gneiss and blastomylonite, following the terminology of Higgins (1971). Well-developed, coarse-grained augen (porphyroclasts) of plagioclase are the more spectacular features of these rocks. The distribution of the various cataclastic textures in the orthogneiss (fig. 1) suggests that in rocks from the margin of the Arrigetch Peaks pluton, cataclastic textures predominate over recrystallization textures. The interpretation of the textures in the Mount Igikpak pluton are not so clear but it appears that cataclastic textures also occur in its marginal zone; in addition, the only areas of consistently fine- and medium-grained rocks is in the northeastern lobe of the Mount Igikpak pluton and the satellite bodies to the west. The apparent distribution is modified by displacement along the Reed River fault and the northeastern plunge of the northeastern lobe of the pluton. This distribution would be consistent with a largely tectonic emplacement history.

The metamorphic rocks surrounding the central core region are predominantly low-grade slate, phyllite, and schist. At least two, and locally three, episodes of penetrative deformation are commonly apparent in the field. Isoclinal and recumbent folds, large nappes, and pervasive recrystallization suggest a complex metamorphic history (Mull and Tailleur, 1977; Newman and others, 1977; Nelson and Grybeck, 1979; Grybeck and Nelson, 1981). Rare grains of kyanite that occur in metaquartzite of the Mississippian Kekiktuk Conglomerate were interperted by Nelson and Grybeck (1980) as being detrital on the basis of the following criteria:

(1) Kyanite occurs as rectangular grains (< 5 mm longest dimensions), showing rounded corners. No more than three grains were observed in any thin section.

(2) The metaquartzite is interbedded with rare gray to black phyllite layers less than 1 m thick that contain none of the metamorphic minerals that might be expected in pellitic rocks associated with kyanite-bearing metaquartzite.

(3) Kyanite-bearing schists of Proterozoic(?) age occur in the Wiseman quadrangle to the east (Dillon and others, 1980). Kyanite in these schists constitutes 10-15 percent of the rock. These or equivalent rocks could be the source for the kyanite in the Mississippian rocks.

The Kekiktuk Conglomerate elsewhere in the Brooks Range contains abundant pyrophyllite occurring as a replacement of the original matrix (Reed and Hemley, 1966). This mineral is interpreted to have formed under conditions of low-grade metamorphism where the bulk composition of the rock was relatively rich in alumina and silica. Calculated pressure-temperature curves in the system Al_2O_3-SiO_2-H_2O (Hemley and others, 1980) indicate that kyanite is stable within temperature and pressure limits of low-grade metamorphism. The kyanite in the Kekiktuk therefore may not be detrital, but even if it is metamorphic, the stability data of Hemley and others (1980) and the presence of chloritoid as an associated metamorphic mineral suggest that these rocks may be products of low-grade metamorphic conditions.

The northern third of the quadrangle is underlain by Upper Devonian and Mississippian clastic rocks belonging to the Hunt Fork Shale, Kanayut Conglomerate, and the Kayak Shale. These rocks are characterized by a single episode of penetrative deformation. Locally, recrystallization of the argillaceous groundmass of the sandstones has developed a white mica, but the primary clastic grains, chiefly quartz, chert and plagioclase, are not recrystallized.

An area of very low grade metamorphosed pillow basalts and flows occurs in the Angayucham Mountains and Helpmejack Hills at the extreme south edge of the Survey Pass quadrangle.

The different metamorphic grades in the Survey Pass quadrangle suggest a complex polymetamorphic history. The Angayucham Mountains belt contains evidence for only one post-Triassic metamorphic event. This interpretation is compatible with a tectonic model of the Brooks Range that would assign these rocks to the uppermost thrust sheets (Roeder and Mull, 1978; Patton and others, 1977) involved in the Mesozoic metamorphism. A similar interpretation applies to the largely Upper Devonian unmetamorphosed clastic rocks in the northern part of the quadrangle.

The Ambler schist belt contains possible Proterozoic metamorphic rocks, Devonian and Mississippian marble, Devonian volcanic rocks, and associated ore deposits, and metamorphic minerals have yielded Cretaceous K-Ar dates. Three periods of metamorphism in the schist belt can locally be recognized; however, two metamorphic events are more commonly recognized. Some rocks containing blue amphiboles - supposedly of Proterozoic age - show textures indicative of only one metamorphism. Other blue amphibole-bearing rocks contain chloritoid and, in many samples, pseudomorphs of blue(?) amphibole that suggest the high-pressure zones of low-grade metamorphism with a later retrograding event of lower pressure. The abundant Devonian ages (fossil, U-Pb, and Rb-Sr) on metasedimentary rocks, metavolcanic rocks, and marble are significant and may raise questions as to the accuracy of the Proterozoic dates (see discussion, Turner and others, 1978, 1979). However, pre-Devonian rocks do occur in the Brooks Range and the Survey Pass quadrangle, as indicated by (Proterozoic Z) U-Pb dates on the Ernie Lake pluton (Dillon and others, 1979), and skarns and other intrusive features associated with the Arrigetch Peaks and Mount Igikpak plutons (Nelson and Grybeck, 1978). The most reasonable interpretation of the Ambler schist belt that can accommodate the range in ages is that Proterozoic and Devonian rocks have been tectonically imbricated.

The Noatak-Alatna belt of low-grade rocks record only one period of metamorphism that is probably post-Mississippian. The Schwatka Mountains belt containing higher temperature, transitional, low- to medium-grade metamorphic rocks must record at least two metamorphic episodes. The Devonian anatectic orthogneiss plutons indicate the presence of pre-upper Devonian crust; vestiges of these rocks are now represented by local skarns and xenoliths associated with the plutons. The absence of extensive skarns, discordant metamorphic structures between orthogneiss and the country rocks, and local faulted contacts suggest that the granites were emplaced largely by tectonic movements during the Mesozoic.

Mull and Tailleur (1977) suggest that Mesozoic tectonism culminating in Neocomian time has produced large-scale crustal shortening in the Brooks Range. This event resulted in the accumulation of thrust sheets in the Brooks Range (Roeder and Mull, 1978). The period of crustal shortening was followed by dominantly vertical, basement-involved tectonism (Mull, 1977; Nelson and Grybeck, 1979). Mesozoic regional metamorphism probably began when the present parautochthonous rocks of the southern Brooks Range were deformed by thrusting and buried by successively imbricated and stacked thrust sheets. Tectonism and associated metamorphism ended in the Late Cretaceous, as indicated by K-Ar ages of 80 to 90 m.y. on metamorphic minerals from the southern flank of the Brooks Range (Turner and others, 1979).

The higher-grade metamorphic rocks in the central part of the quadrangle probably are the more deeply buried rocks involved in the Mesozoic tectonism and do not necessarily reflect the intrusive effects of the emplacement of the Middle Devonian orthogneiss. The ages are unresolved for metamorphic events that petrographic and field observations suggest occurred before the Mesozoic metamorphism. The resolution of these events by detailed mapping and isotopic dating should provide significant information on the complex history of the Brooks Range.

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Table 1. List of mineral assemblages in selected metamorphic rocks, Survey Pass quadrangle, Alaska. [1]

Locality no.	Sample no.	Rock description.
1	77ANS112A	Lithic wacke
2	77ADB183A	MU-AB phyllite
3	78AMH140B	Quartz arenite
4	77ADB206A	Semischistose feldspathic wacke
5	77ADB180A	Subfeldspathic lithic wacke
6	77ADG267A	PL-CA-MU-QZ semischist
7	77ADB207A	CL-MU semischistose quartz siltstone
8	77ANS226A	Semischistose calcareous feldspathic wacke
9	78ANS115A	CL-MU-CA-QZ schist
10	78ANS188A	MU-CLT-QZ semischist
11	78ADG40A	CLT-QZ quartzite
12	77ADG145B	KS-GA-HB-BI-QZ gneiss
13	77ANS166A	MU-CA-QZ schist
14	78ADG77A	BI-MU-QZ schist
15	77ADG331A	CL-GA-BI-HB-AB schist
16	78AMH51A	CA-EP-BI-HB-MU-QZ schist
17	73ABe20B	BI+HB+AB+GA+QZ+EP (not in order of abundance)
18	78AMM10C	QZ-MU-AM-CA marble
	78AMM10B	BI-MU-AB-QZ schist
19	77ADG85A	CL-MU-AB-QZ schist
20	77ADG245A	CL-GA-BI-AB-QZ schist
21	78ADG135	CL-AB-MU-QZ schist
22	77ADB150A	CL-CLT-MU-QZ schist
23	77APC31	CL-CLT-MU-QZ schist
24	77ANS150A	ZE-CL greenstone
25	78ADG196A	CL-AB-MU-QZ schist
26	78AMH179A	CA-CL-AB-CLT-GC-MU-QZ schist
27	77ADG257A	CL-PU-AB greenstone
28	78AMH102A	GC-CLT-CL-QZ-MU schist
29	78AMH13A	CA-CL-GC-AB-QZ schist
30	78ANS154	GA-CLT-CL-MU-QZ schist
31	78ADG125	GA-CL-MU-QZ schist

[1] Minerals listed in increasing order of abundance.

Mineral abbreviations are as follows:

MU--muscovite, CL--chlorite, CLT--chloritoid, QZ--quartz, PL--plagioclase, CA--Calcite, BI--biotite, HB--hornblende, AB-albite, KS-potassium feldspar, GA--garnet, GC--glaucophane, EP--epidote, AM--amphibole, PU--pumpellyite, ZE--zeolite.

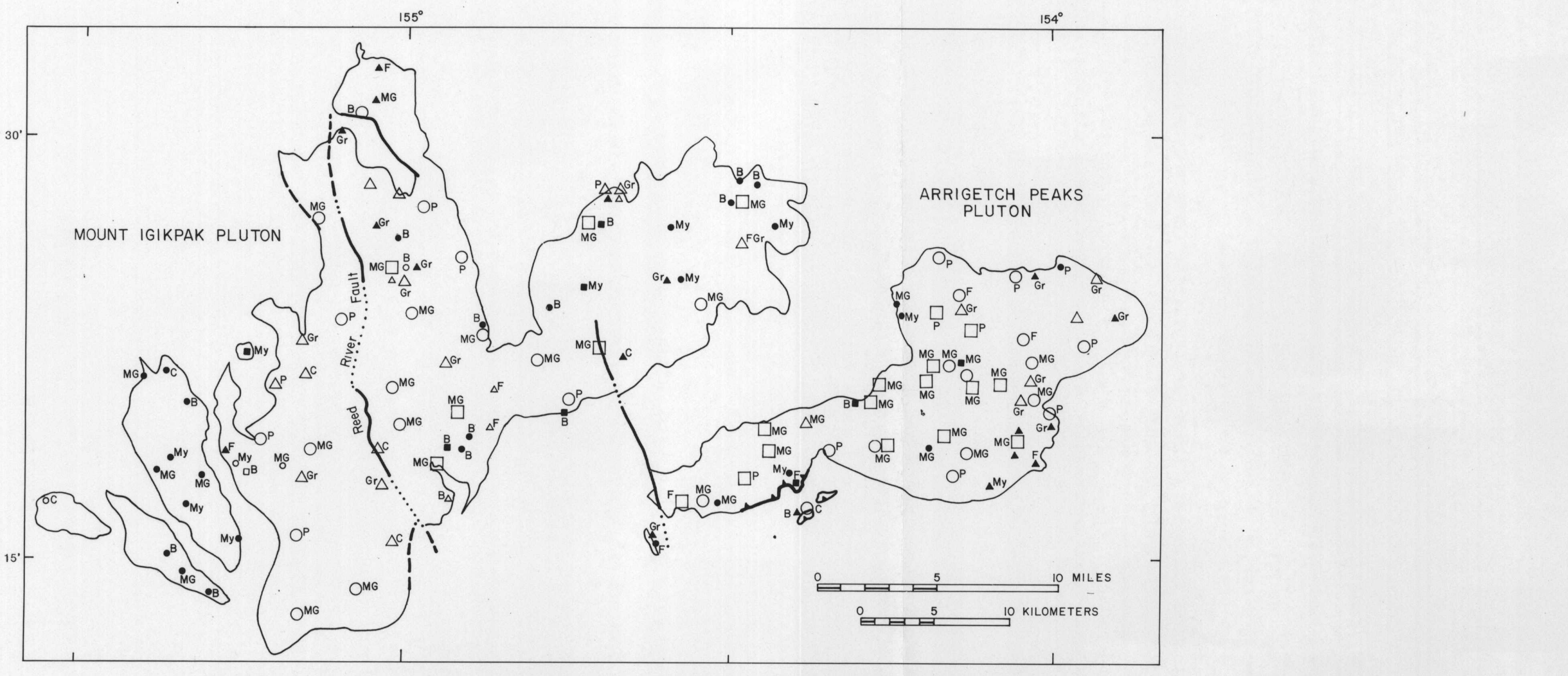


Figure 1. Distribution of textures in the orthogneiss of the Arrigetch Peaks and Igikpak plutons.

Explanation for Figure 1

GRAIN SIZE DISTRIBUTION

>5 mm coarse	1-5 mm medium	<1 mm fine	
△	▲	△	Average grain size of equigranular granite
□	■	□	Average grain size of augen-shaped prophyroclasts
○	●	○	Average grain size of other porphyroclasts

TEXTURAL DEFINITIONS[1/]

F Foliated sample only (hand specimen description)

Gr Granite (minor cataclasis and little or no recrystallization)

Cataclasis > Recrystallization

C Cataclasite (non-foliated)

My Mylonite (foliated)

P Protomylonite (foliated)

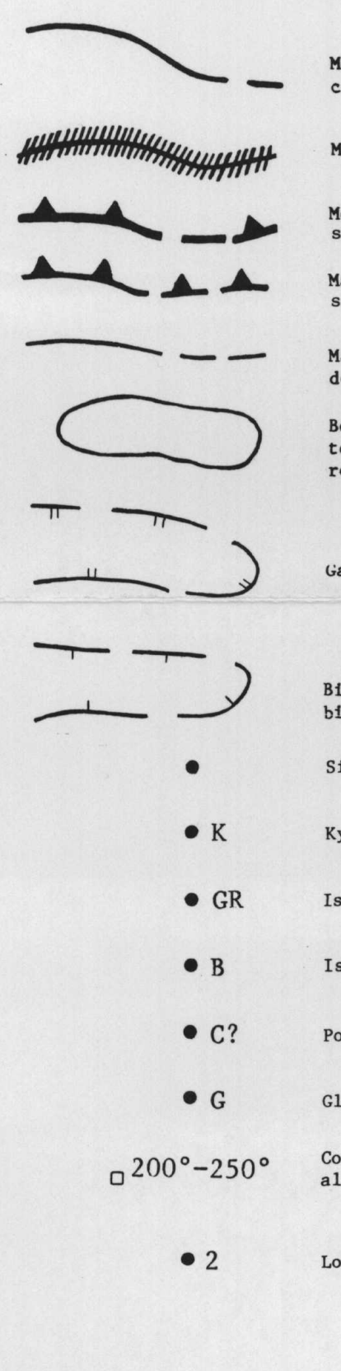
Recrystallization > Cataclasis

MG Mylonite gneiss (foliated)

B Blastomylonite (foliated)

[1/] Terminology of Higgins (1971)

EXPLANATION



Metamorphic grade boundary - Dashed where inferred. Letters indicate the metamorphic grade as noted below

Metamorphic grade boundary that coincides with a high-angle fault

Metamorphic grade boundary that coincides with a thrust fault; sawteeth on upper plate

Major thrust fault separating distinctive metamorphic rock types; sawteeth on upper plate

Major high-angle fault - Dashed where approximately located; dotted where concealed

Boundary of distinctive metamorphic assemblages and undifferentiated metamorphic rock types (schist, metaconglomerate, metaigneous rocks, etc.)

Garnet isograd - Hachures point into region of persistent garnet

Biotite isograd - Hachures point into region of persistent brown biotite

● Site of petrographically examined sample

● K Kyanite locality

● GR Isolated occurrence of garnet

● B Isolated occurrence of brown biotite

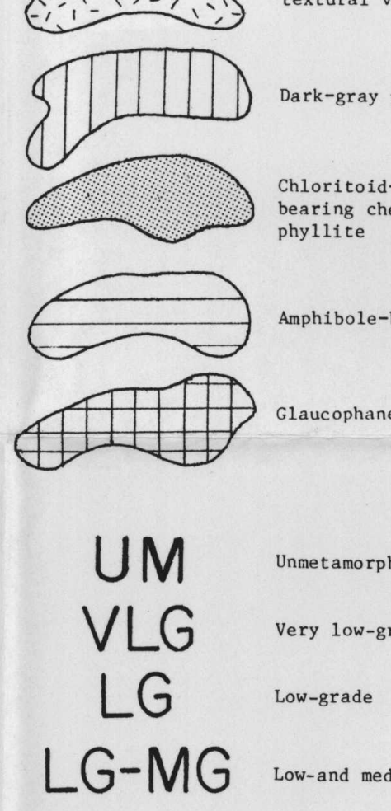
● C? Possible cordierite occurrence

● G Glaucophane occurrence

□ 200°-250° Conodont locality. Temperature (°C) indicated reflects color alteration index in conodonts (Epstein and others, 1977)

● 2 Location of mineral assemblage - Listed in Table 1

SPECIAL ROCK TYPES AND ASSEMBLAGES



Granitic orthogneiss — See Figure 1 for details of the textural variations

Dark-gray phyllitic rocks

Chloritoid-bearing quartz-muscovite schist, chloritoid-bearing chert conglomerate, minor chloritoid-bearing phyllite

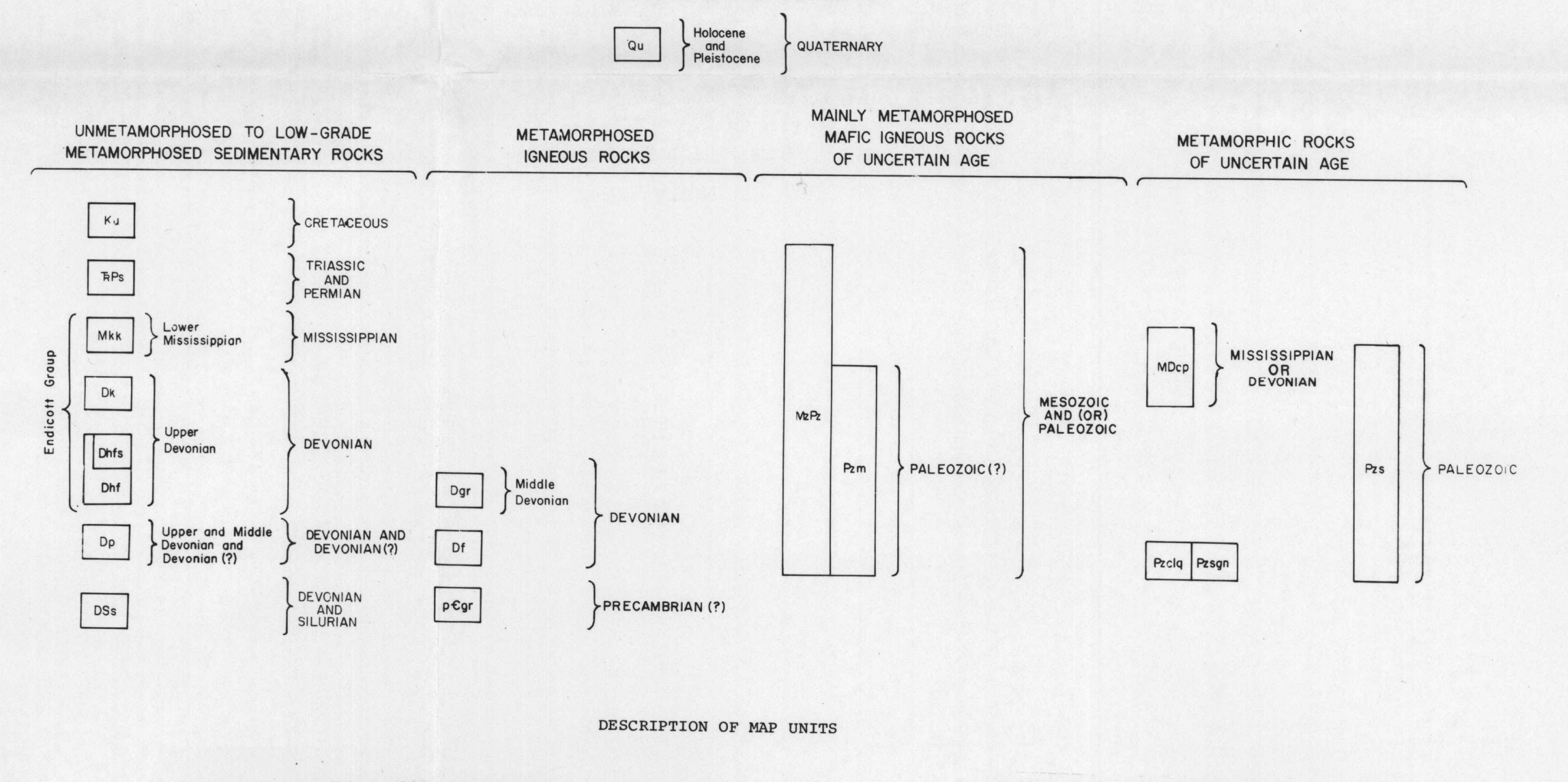
Amphibole-bearing schist

Glaucophane-bearing schist

Metamorphic Grades

UM	Unmetamorphosed, possibly very low-grade
VLG	Very low-grade
LG	Low-grade
LG-MG	Low-and medium-grade or transitional low-to medium-grade

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Unconsolidated Deposits

Qu SURFICIAL DEPOSITS, UNDIVIDED

Unmetamorphosed to Low-Grade Metamorphosed Sedimentary Rocks

Ku UNDIVIDED CONGLOMERATE--Quartz-pebble and igneous-pebble conglomerate; some interbedded volcanic sandstone

TRPs SHUBLIK AND SIKSIKPUK FORMATIONS (Triassic and Permian)--Pink-weathering limestone of Shublik Formation (Triassic) and black slate and chert of Siksikpuk Formation (Permian)

ENDICOTT GROUP (Mississippian and Devonian)--In map area includes:

Mkk KAYAK SHALE AND KEKIKTUK CONGLOMERATE (Lower Mississippian)--As mapped, unit includes related undifferentiated clastic rocks and a few outcrops of limestone in lower (?) part of Lisburne Group

Dk KANAYUT CONGLOMERATE (Upper Devonian)--Nonmarine rusty-weathering quartz sandstone, ferruginous mudstone, and black siltstone, and shale. Prominent, resistant layers of black-lichen-covered light-gray quartzite. Rare conglomerate

Dhf HUNT FORK SHALE (Upper Devonian)--Dark-gray phyllite with minor quartz mudstone and sandstone. Upper part includes:

Dhfs Wacke sandstone member--thick monotonous unit of interbedded rusty-weathering feldspathic sandstone and dark-gray mudstone and shale. Locally includes thin layers of reddish-gray fossiliferous limestone and calcareous sandstone.

Dp GRAY PHYLLITE--Mainly gray, calcareous phyllite and muscovite schist; contains limestone beds up to 20 m thick. Locally consists of lenses of quartz-pebble conglomerate interbedded with orange-weathering, fossiliferous limestone, black siliceous phyllite, or micaceous schist

DSs SKAJIT LIMESTONE (Devonian and Silurian)--Massive white to light-gray granoblastic marble and orange-weathering dolomitic marble. Some interlayered chlorite schist

Metamorphosed Igneous Rocks

Dgr GNEISSIC GRANITE--Medium- to coarse-grained biotite-muscovite orthogneiss ranging in composition from granite to alkali-feldspar granite. Commonly well-developed augens; locally cataclastically deformed

Df METAFELSITE--Mainly quartz-albite-feldspar schist; locally porphyroblastic muscovite-biotite-quartz-albite-feldspar rocks that retain igneous textures

p€gr GRANITIC SCHIST--Medium-grained porphyroblastic gray biotite-quartz-feldspar schist

Mainly Metamorphosed Mafic Igneous Rocks of Uncertain Age

MzPz MAFIC VOLCANIC ROCKS, PHYLLITE, SANDSTONE, AND CHERT--Consists mainly of interbeds and fault slivers of Devonian(?) to Jurassic pillow basalt, greenstone, and diabase, gray phyllite, wacke sandstone, minor Triassic radiolarian chert, Mississippian radiolarian chert, and thin beds of Paleozoic limestone. Weakly metamorphosed to unmetamorphosed

Pzm MAFIC VOLCANIC AND INTRUSIVE ROCKS--Basalt, greenstone, and altered gabbro. Unmetamorphosed to slightly metamorphosed

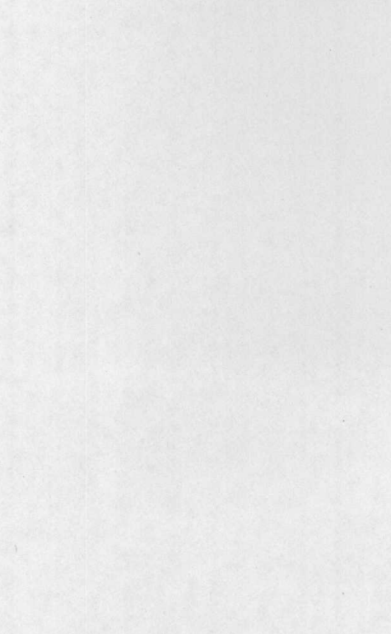
Metamorphic Rocks of Uncertain Age

MDcp CALCAREOUS PHYLLITE--Black calcareous phyllite with thin dark-gray limestone lenses

Pzs LOW-GRADE SCHIST--Chlorotoid-bearing quartz-muscovite schist, calcareous quartz-albite-muscovite schist, quartzite, and rare thin limestone beds. Schist locally contains glaucophane

Pzclq CHLORITIC QUARTZITE--Chlorite quartzite and chloritic quartz schist

Pzsgn LOW- TO MEDIUM-GRADE SCHIST AND GNEISS--Interlayered quartz-muscovite schists and orange-weathering marble. Medium-grade schist and paragneiss with garnet, biotite, and amphibole near plutons



Contact--Dashed where approximately located; dotted where concealed

Fault--Dashed where approximately located or inferred; dotted where concealed; queried where uncertain

Thrust fault--Dashed where approximately located or inferred; dotted where concealed; queried where uncertain. Sawteeth on upper plate

MAP SHOWING DISTRIBUTION OF METAMORPHIC ROCKS IN THE SURVEY PASS QUANDRANGLE, BROOKS RANGE, ALASKA

By

Steven W. Nelson and Donald Grybeck

1981

Interior—Geological Survey, Reston, Va.—1981

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