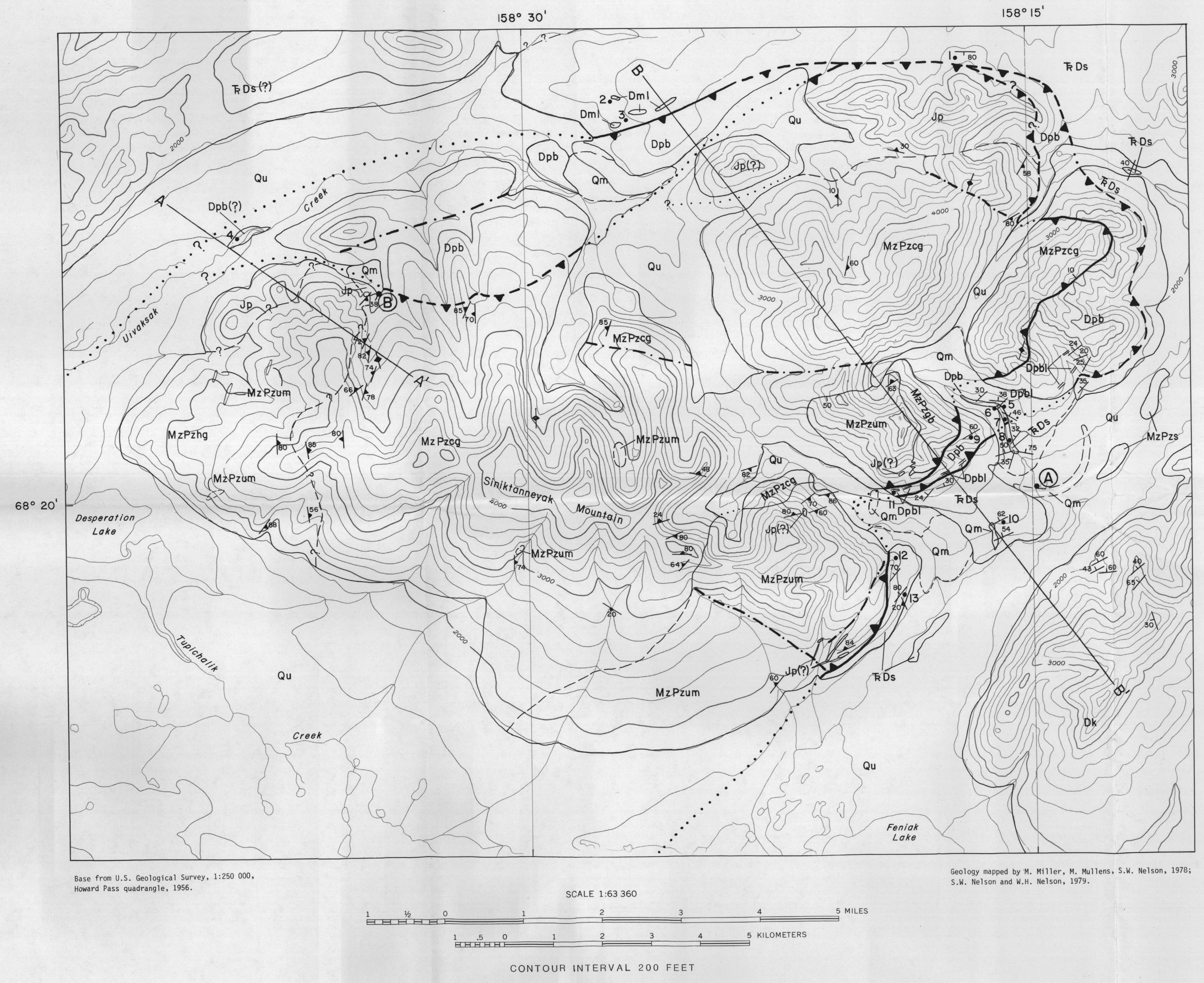
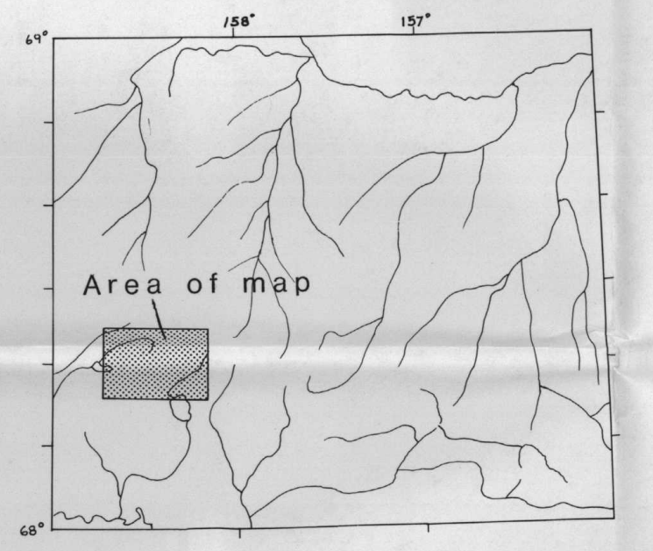
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1441



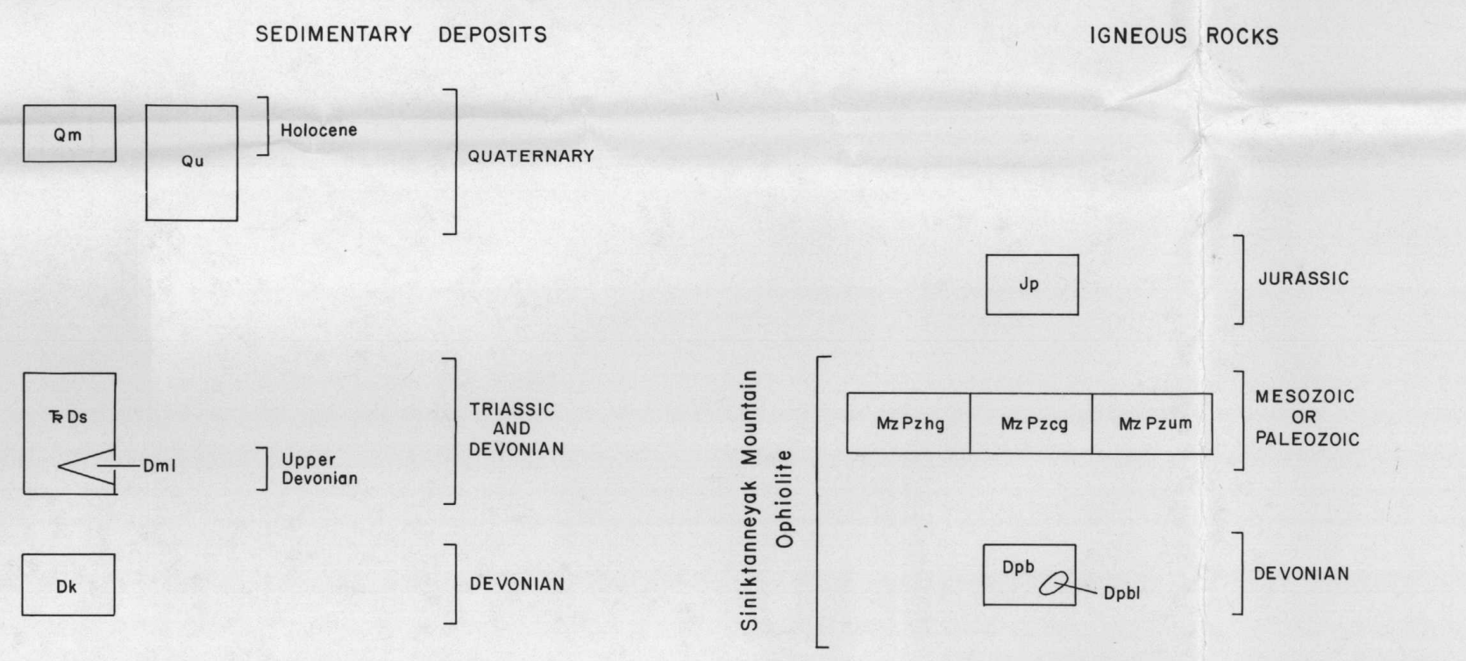
Base from U.S. Geological Survey, 1:250 000, Howard Pass quadrangle, 1956.

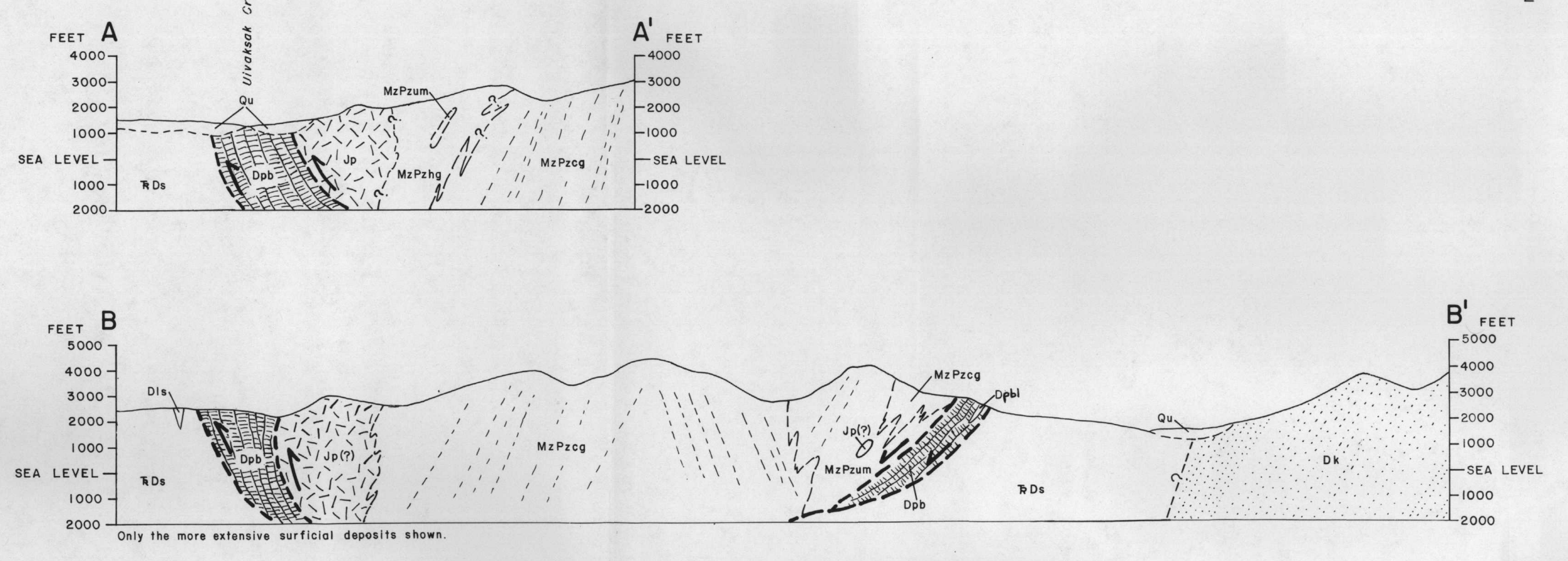
Geology mapped by M. Miller, M. Mullens, S.W. Nelson, 1978; S.W. Nelson and W.H. Nelson, 1979.



Howard Pass quadrangle

CORRELATION OF MAP UNITS





Only the more extensive surficial deposits shown.

GEOLOGY OF THE SINIKTANNEYAK MOUNTAIN OPHIOLITE, HOWARD PASS QUADRANGLE, ALASKA

By
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1982

Introduction

The possible ophiolitic nature of the subsequently named Siniktanneyak Mountain ophiolite was first recognized by Tailleur (1973) and further discussed by Roeder and Mull (1978) and Patton and others (1977). They recognized and described the apparent reverse relation in which the ultramafic to gabbroic part of the complex structurally overlies pillow basalt and discussed the regional tectonic significance of the ophiolite. The complex is composed of two major independent thrust masses - a basaltic unit below and a gabbroic-ultramafic unit above. The thrust masses were assembled during a Mesozoic or Tertiary event of Brooks Range thrusting in the western Brooks Range ophiolite belt (Patton and others, 1977). The ophiolites of this belt are interpreted as erosional remnants of the highest allochthon within an imbricated stack of Devonian to Cretaceous strata in which as many as six separate allochthonous sheets were emplaced by northward thrusting or obduction over a minimum distance of 120 km (Roeder and Mull, 1978). Most previous information and interpretations, however are based on reconnaissance-scale mapping and study, and only the broad features of the ophiolites are known. Little published information is available about their internal structure and petrography. This lack of detailed published information on the western Brooks Range ophiolites has stimulated this and other studies (Zimmerman and Soustek, 1980) of these rocks. This map is the initial part of a detailed study of the Siniktanneyak Mountain ophiolite. Previously there were no published geologic maps, other than generalized sketch maps.

The Siniktanneyak Mountain ophiolite which occupies an outcrop area of 300 km^2, can be defined as a potential ophiolite, on the basis of the criteria listed by Coleman (1977) and Penrose Field Conference Participants (1972). Essential rock types missing are a sheeted dike complex and a major ultramafic tectonite unit. Also, the age of the various rock units is a factor with this complex and and is not clearly addressed by the preceding references. It is generally assumed (Coleman, 1977) that the ultramafic assemblage of an ophiolite may be older, perhaps much older, than the other units, and cross-cutting and intrusive relations in a typical ophiolite indicate that the cumulus gabbroic part solidified before the sheeted dikes and related pillow basalt were emplaced. This assumption suggests that the mafic volcanic part of an ophiolite is usually the youngest part. In the Siniktanneyak Mountain ophiolite, however there is evidence (discussed below) that the pillow basalt member may be older than the ultramafic to mafic part of the complex. Does this mean that the Siniktanneyak Mountain body is not an ophiolite or that it is two partial ophiolites? We believe that the rocks at Siniktanneyak Mountain can be properly termed a partial ophiolite because the use of the term is independent of the supposed origin (and age?) of the distinctive assemblage of mafic to ultramafic rocks exposed at Siniktanneyak Mountain. Roeder and Mull (1978), however, interpret mafic diabasic to porphyritic dikes in the gabbro as the basal part of a sheeted-dike complex. Two problems with their interpretation are that (1) the mafic dikes intrude all the igneous rock types (except the ultramafic rocks) and, as such, seem out of typical sequence, for the sheeted dikes should be in the upper part of an ophiolite and (2) the mafic dikes clearly intrude the Jurassic plutonic rocks and therefore are probably younger than the main part of the ophiolite complex. No conjugate dikes exhibiting asymmetric chilling (Coleman, 1977) were observed. Dikes are chilled against pyroxene gabbro on both sides and have locally metamorphosed it to a banded hornblende plagioclase rock.

Radiometric ages

Only one published isotopic date is available from the Siniktanneyak Mountain ophiolite (Patton and others, 1977) and it is from a hornblende pegmatite dike intruding gabbro. The date on this sample (66ATr76.2) is 151±14 m.y. (Late Jurassic); however, the sample is apparently a float sample collected from stream alluvium (map loc. A) that has cut glacial moraine and is approximately 1.75 km southeast from the nearest gabbro outcrops. Unpublished Late Jurassic K-Ar ages of 153±7.6 m.y. on biotite and 161±8.1 m.y. on hornblende were obtained from near the intermediate to felsic plutonic rock unit on the west side of the complex (map loc. B) (C.F. Mayfield, written commun., 1979).

DESCRIPTION OF MAP UNITS

SEDIMENTARY DEPOSITS

Qm YOUNGER GLACIAL MORAINE DEPOSITS (Holocene)--Includes ground, lateral, and end moraines from Holocene glaciers. End and lateral moraines appear fresh and little modified. Deposits consists of locally derived mafic and ultramafic detritus from the Siniktanneyak Mountain ophiolite

Qu SURFICIAL DEPOSITS, UNDIVIDED (Quaternary)--Includes older (modified) glacial moraine and outwash deposits, alluvium, colluvium in valleys, and gravel terraces at Feniak and Desperation Lakes

ŦRDs SEDIMENTARY ROCKS, UNDIVIDED (Triassic to Devonian) --A sequence of sedimentary rocks consisting of three distinct units that are best exposed north of Feniak Lake. The older unit consists of gray-weathering shale and purple-weathering laminated siltstone interbedded with a distinctive orange- to brown-weathering cream-colored fossiliferous limestone layers that average 20 cm in thickness. Echinoderm, coral, and brachiopod fossils from the limestone beds are Late Devonian and (or) Early Mississippian (nos. 10 and 13 table 1). Stratigraphically(?) between the older unit and the younger unit is a dark-gray interbedded sequence of micaceous wacke sandstone, siltstone, and shale. Dark-gray shale chips, worm trails, and plant remains are abundant in the sandstone and siltstone beds. Rare pelecypods or brachiopod shell fragments have been collected but were not identified. The youngest sedimentary unit consists of interbedded siliceous shale and chert (weathering gray, green, purple, orange and black), minor gray limestone with black chert lenses, and interbeds of calcareous shale that contain a coquina composed of the pelecypod Monotis of Middle Triassic age (table 1, no. 12). Fossils from these rocks are similar to faunas from the limestone member of the Shublik Formation in the central and western parts of the North Slope (N. J. Silberling, written commun., 1979). No contact relation between these units were observed. Fossil ages suggest that these rocks are in part correlative with the Kagvik structural sequence (Churkin, and others, 1979). The Kagvik sequence contains sedimentary rocks of Carboniferous to Triassic age that are juxtaposed by imbricate fault slices; a similar relation may exist here, but it was not observed in the field. No obvious thermal metamorphic effects were developed adjacent to the contact between the sedimentary sequence and the mafic igneous rocks of the ophiolite. However, a few meters above locality 12, a 1- to 2- meter thick zone of brecciated dunite overlies the sedimentary rocks. Locally, unit contains:

Dml Massive limestone -- Light-gray limestone that forms resistant outcrops and is associated with black shale, black-and purple-weathering

Dk KANAYUT CONGLOMERATE (Upper Devonian)--Light-gray- to buff- or orange-weathering quartz arenite and conglomerate. Includes minor resistant ironstone nodules as large as 20 cm and interbedded coal and shale. Minor crossbedding and channel features are locally well developed. In thin section the sandstone consists of angular grains of quartz and fine-grained polycrystalline chert with minor detrital muscovite, calcite, limonite(?), zircon, and brown tourmaline. Average grain size is 0.2 mm. Conglomerate clasts are angular and average 1.5 cm in size. No fossils were observed in the map area, but correlative rocks elsewhere in the Brooks Range contain Late Devonian (Famennian) fossils (J.T. Dutro Jr., written commun., 1978).

IGNEOUS ROCKS

Jp INTERMEDIATE TO FELSIC PLUTONIC ROCKS (Jurassic)-Light-gray medium-grained plutonic rocks ranging from diorite to granite (fig. 1). These rocks crop out in two small stocks: one of about 10 km^2 in the northern part of the complex and the other of less than 2.6 km^2 in the western part of the complex. Small (less than 5 m thick) alaskite dikes intruding the ultramafic rock unit in the southeastern part of the complex are tentatively correlated with the felsic stocks. Rocks composing the two small stocks range in composition from hornblende diorite to biotite-hornblende alaskite. Clinopyroxene partly mantled by brownish-green hornblende is typically seen in thin sections. The freshest rocks and best exposures are found in the smaller pluton in the western part of the complex. Numerous dark-gray mafic dikes intrude the plutonic rocks in this area. K-Ar dates from a sample (loc. B) near this area yield ages of 153 m.y. and 161 m.y. on biotite and hornblende, respectively (C.F. Mayfield, written commun., 1979). Outcrops of the larger stock in the northern part of the complex are poor, rubbly, and more altered than those of the small pluton. Mafic minerals are commonly altered to chlorite and fibrous actinolite. Plagioclase is moderately to strongly altered to sericite and clay(?) minerals. Mafic dikes, as much as 4-5 m thick, are also found in this pluton, and their contacts with the plutonic rocks are sharp. The dikes may make up as much as 10-20 percent of the outcrop. They weather a light brown similar to the weathering color of the pillow basalt unit. Alaskite dikes intruding peridotite and dunite in the southeastern part of the complex contain as much as 5 percent biotite and muscovite. Textures are granitic, graphic, and pegmatitic in the central parts of these dikes. Grain size decreases near the margins of some of the dikes (C.G. Mull, oral commun. 1978). One dike intruding dunite was probably emplaced in an active fracture in the ultramafic rock. The dunite at the contact is a dark gray mylonite and the margin of the alaskite dike is a medium- to coarse-grained porphyroclastic mylonite whereas the central part of the dike has more typical granitic and graphic textures. These alaskites have not been observed to intrude either the structurally underlying undivided sedimentary rock unit or pillow basalt unit.

SINIKTANNEYAK MOUNTAIN OPHIOLITE--Includes:

MzPz hg Hornblende pyroxene gabbro (Mesozoic or Paleozoic)--Approximately 15-km^2 area of mostly rubble outcrop at the west end of the complex. Rocks predominantly light-gray-weathering noncumulus(?) gabbro with well-developed mineral banding. Petrographic observations show that most gabbro is hornblende- and hypersthene-bearing with modal values of hornblende ranging from trace amounts to 37 percent, hypersthene ranging from trace amounts to 6 percent, and clinopyroxene ranging from trace amounts to 40 percent. Color index values range from trace amounts to 60 percent and average about 15 percent. The leucocratic nature of the rocks from this area can be observed in the field. The contact between these rocks and those of the more typical darker cumulus gabbro unit to the east is probably gradational. Orange-weathering peridotite and typical gray-weathering gabbro are rare. It is not known whether the hornblende is primary or formed from metamorphism by intrusion of the adjacent intermediate to felsic plutonic rock unit. The discontinuous hornblende rims on pyroxene and patchy replacement of pyroxene by hornblende suggest the metamorphic effects of the plutonic rocks (Brown and others, 1979) but could also indicate discontinuous reaction processes during late-stage crystallization

MzPz cg Cumulus gabbro (Mesozoic or Paleozoic)--Light-greenish-gray-weathering medium- to coarse-grained gabbro and olivine gabbro. Forms major rock type of the Siniktanneyak Mountain ophiolite with an outcrop area of approximately 77 km^2. Large areas are rubble, and the best outcrops are found along ridge tops and small exposures in cirques. Rocks are well layered with alternating pyroxene-rich and plagioclase-rich layers. Some exposures display small-scale mineral crossbedding and truncated mineral layers that constitute evidence supporting a cumulus origin for the banding. Igneous laminations of plagioclase are present but not pervasive. A granular texture more typical in thin section suggests that the plagioclase and pyroxene simultaneously crystallized. Two large-scale folds wth amplitudes on the order of hundreds of meters were observed on the southeast end of the ridge forming Siniktanneyak Mountain. Determination of tops (based on crossbedding and truncated mineral layers) in cumulus layering suggests that the upward direction is now to the west and that the gabbro has been tilted westward (also noted by Roeder and Mull, 1978). The few eastward directions found for tops probably reflect undetected large-scale folds. The gabbro is usually medium grained with granular, anhedral crystals of olivine, clinopyroxene, and plagioclase. Some olivine is discontinously mantled by clinopyroxene. Numerous small lenses or layers of orange-weathering peridotite belonging to the ultramafic rock unit crop out in the gabbro, but only two of the larger ones are shown on the map. Pink clinozoisite-bearing veins averaging 1-2 cm in thickness cut the gabbro in the vicinity of these peridotite outcrops. The gabbros have been intruded by mafic dikes that have porphyritic to diabasic texture and average a couple meters in thickness. In the western area of outcrop, the dikes constitute about 30 percent of the outcrop. Metamorphism of the gabbro by these dikes has locally produced a banded plagioclase-hornblende rock near the contact zones. Inclusions of amygdaloidal basalt in boulders of gabbro from a drainage on the eastern side of the complex indicate that the gabbro cannot be older than the pillow basalt unit. Basalt in the contact areas, however, shows tectonic deformation and is no higher metamorphic grade than lower greenschist facies

MzPz um Ultramafic rocks (Mesozoic or Paleozoic)--Largely orange-weathering medium-grained dunite, wehrlite, harzburgite, and olivine pyroxinite (fig. 1). By far the major rock type is dunite in which the other rock types occur as cumulus bands, layers, and pods. Conspicuous layering in the dunite is caused by the alternation of layers rich in pyroxene crystals with pyroxene-free layers. Olivine and, to a lesser extent, pyroxene are altered to serpentine minerals, talc, and(or) clear to light-green amphibole. This mineralogy probably reflects hydrous alteration associated with minor serpentinization. Deformational (tectonite) fabrics are not abundant in the samples collected. Olivine deformational lamellae are the most common indication of deformation. Chromite occurs in discontinuous layers, pods, and wispy stringers within dunite and as disseminated grains, along with magnetite. No significant values for platinum-group elements have been detected in any of the rock units from the ophiolite (table 2). Localized zones of brecciation and hydrous mineral alteration (serpentinization) are found near the contact of the ultramafic rocks and the thrust fault in the southeastern part of the complex. Near the southeast edge of the complex, the ultramafic rocks have been intruded (possibly along fractures) by small (less than a few meters thick) dikes of muscovite-biotite granite and alaskite (probably belonging to the intermediate to felsic plutonic rock unit) and plagioclase bronzite(?) veins a few centimeters thick. These dikes and veins are discordant to the layering in the ultramafic rocks. No mafic dikes like those intruding the gabbro were observed intruding the ultramafic rocks. The contact of ultramafic rock with gabbro was observed along the ridge of Siniktanneyak Mountain where tongues of ultramfic and gabbro rock a few centimeters thick and as much as few meters long extend into one another (fig. 2). Layers with concentrations of pyroxene parallel to the tongues extend from the ultramafic rock into the gabbro. This relation seems to indicate concurrent development of cumulus layers in adjacent gabbro and ultramafic rock. The process that led to these intertonguing structures is at present unclear.

Dpb Pillow basalt (Devonian)--Dark-brown- to dark-green-weathering amygdaloidal and vesicular basalt. Unit locally contains interbedded chert, volcaniclastic sedimentary rocks, and associated volcanic breccia, tuff, and massive basalt. To the northwest, pillows were only locally observed. The extent of rubble outcrops in this area, however, may obscure many of the geologic features. Near fossil locality 4 (table 1), Nokleberg (written commun., 1978) describes the outcrops as complex tectonic interlayering of limestone, gabbro, ultramafic, tuff, and pillow basalt. He interprets this area as a complex breccia or melange. This tectonic mixing probably reflects the proximity of the outcrop to the thrust at the base of the ophiolite. Well-developed pillows are best exposed along the northeast side of the ophiolite. Determination of stratigraphic tops by pillow morphology is surprisingly difficult. The attitude of volcanic layers in this area is consistently northwest dipping, and sedimentary structures in the interbedded limestone as well as vesicles concentrated on the upper half of individual pillows, are more conclusive and support the earlier (Tailleur, 1973; Roeder and Mull, 1978) interpretation that stratigraphic top is to the northwest in this area. Locally the basalt is intruded by diabase dikes with a similar mineral content as the basalt. Petrographically the basalts are fine grained. Plagioclase laths enclose anhedral crystals of clinopyroxene. Swallow-tail and belt-buckle crystal forms in plagioclase are common in the finer grained and glassy(?) basalts. Vesicles are filled with calcite and chlorite and are common only in the upper half of the pillow. An unidentified zeolite was observed in one specimen from the northern part of the complex. Three lines of evidence suggest that the basalt sequence was erupted into shallow water: (1) Some of the fossils from locality 6 (table 1) are clasts; however, the laminar stromatoporoids are generally in growth position. In addition, the limestone from this locality contains rounded pebbles of basalt, (2) In the vicinity of localities 4 and 11 (table 1) the presence of, lithic lapilli tuff containing undevitrified to partially devitrified glass and angular fragments of basalt and fossiliferous limestone suggests shallow-water environment, (3) The common presence of conspicuous concentric zones of centimeter-size vesicles in the upper half of pillow forms probably indicates water depths of less than 450 m (Wells and others, 1979; Jones, 1969; Moore, 1965). Locally within the pillow basalt unit intense orange weathering denotes mineralized zones a few meters thick, containing sulfide minerals. Analyses of rocks from some of these zones show anomalous values of Ag, Cu, and Ba (table 2). The host rocks are light cream colored on fresh surfaces and consist of felted and bladed plagioclase cut by sulfide-bearing quartz-filled fractures. Locally unit contains:

Dpbl Limestone (Middle or Upper Devonian)--Massive to thin-bedded light-gray fossiliferous limestone interbedded with pillow basalt unit. Contains fossil corals, brachiopods, stromatoporoids, and conodonts (table 1 locs. 6, 7, 9,11). Beds range in thickness from a few meters to 5 m and contain rounded pebbles of basalt in upper parts.

MAP SYMBOLS

84 ATTITUDE OF MINERAL BANDING--In gabbro and ultramafic rocks

72 ATTITUDE OF BEDDING--In sedimentary rocks and pillow basalt

▲ ?▲... THRUST FAULT--Dashed where approximate or inferred; dotted where concealed; queried where uncertain. Sawteeth on upthrown plate. Direction and degree of dip indicated where known

-.-.-. TREND OF PROMINENT LINEAMENTS--Determined from air photos

— -?-··· CONTACT--Dashed where approximate or inferred; dotted where concealed; queried where uncertain; direction and degree of dip indicated where known

•3 FOSSIL LOCALITY--Number keyed to table 1

•Ⓐ LOCATION OF RADIOMETRICALLY DATED SAMPLE

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Table 1. Location and age of fossil collections from the Siniktanneyak Mountain ophiolite, Howard Pass quadrangle, Alaska.

Map No.	Field No.	Fossil group(s)	Age and(or) Range	Map symbol	Identification By	Remarks	Report No.
1	79ANs2C	Conodonts	---	ŦRDs	A. Harris	None recovered	A-79-36
	79ANs2E	Radiolarians	Pennsylvanian (Morrowan) to Permian (Guadalupian)	ŦRDs	D. Jones		A-80-18M
2	78AMH192A	Conodonts	---	Dml	A. Harris	None recovered	A-78-30
3	79ANs25C	Conodonts	Lower Upper Devonian (Frasnian)	Dml	A. Harris	Host rock reached 100°C[2].	A-79-36
4	78ANk35	Brachiopods	Early Permian[1]	Dpb(?)	J. T. Dutro, Jr.	Melange(?)	A-78-36
5	79ANs41D	Conodonts	---	Dpbl	A. Harris	None recovered	A-79-36
6	79ANs41E	Stromatoporoids Corals	Early Upper Devonian (Frasnian)	Dpbl	W. A. Oliver, Jr.		A-79-36
7	79ANs41C	Conodonts	Upper Devonian	Dpbl	A. Harris	Host rock reached 200°C. Possible exposure to warm or hot fluids[2].	A-79-36
8	79ANs41A	Plants		ŦRDs	J. Wolfe		
9	78ANs205B	Conodonts	Upper Devonian and (or) (middle Famennian) Lower Mississippian (middle Osagian)	Dpb	A. Harris	Host rock reached 200°C[2].	A-78-30
10	78AMH194A	Echinoderms Brachiopods Sponge(?)	Middle Devonian and (or) Lower Mississippian	ŦRDs	J. T. Dutro, Jr.		A-78-29
11	78AMM35C	Corals Brachiopods	Middle to Upper Devonian	Dpbl	J. T. Dutro, Jr.		A-78-29
	78AMM35D	Conodonts	Devonian to Triassic	Dpbl	A. Harris	Host rock reached 120°-150°C[2].	A-78-30
12	79ANs31A	Radiolarians Pelecypods	Upper Triassic (Norian)	ŦRDs ŦRDs	D. Jones Norm Silberling		A-80-18M A-79-36
	79ANs31B	Conodonts	Middle Triassic (Anisian and(or) Ladinian)	ŦRDs	Bruce Wardlaw	Host rock reached 60°-140°C[2].	A-79-36
13	78ANs135B	Echinoderms Corals Brachiopods	Upper Devonian and(or) Lower Mississippian	ŦRDs	J. T. Dutro, Jr.		A-78-29

[1] Fossils are probably in tectonic inclusions. Locality described as melange by W. J. Nokleberg (written commun., 1978).

[2] Temperature values based on conodont color alteration index (Epstein and others, 1977).

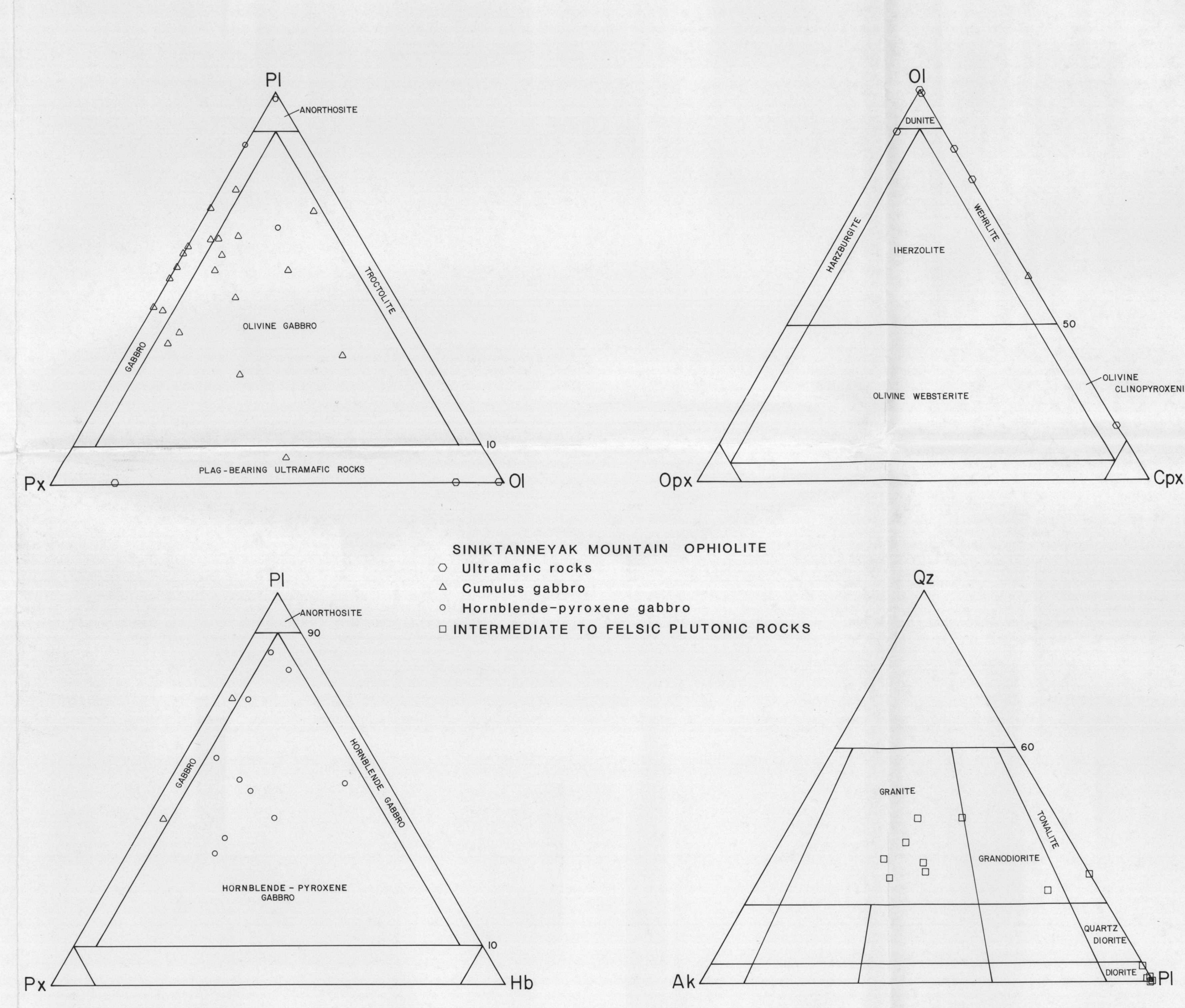

Figure 1. Modal plots of quartz (Qz), alkali-feldspar (Ak), plagioclase (Pl), clinopyroxene (Cpx), orthopyroxene (Opx), hornblende (Hb), and olivine (Ol) from various units of the Siniktanneyak Mountain ophiolite and the intermediate to felsic rock unit (after Streckeisen, 1973). Thin-section modes 500 points per thin section with 1 mm spacing.

Table 2. Semiquantitative spectrographic and fire assay-spectrographic analyses of igneous and sedimentary rocks at Siniktanneyak Mountain [Semiquantitative spectographic analyses by E. Cooley, D. Risoli, J. Hurrell. All data in parts per million (ppm). Concentrations detected but below value shown are indicated by the (<) symbol. Concentrations above procedural detection limits are indicated by the greater than (>) values.]

[Fire assay for Pt-group element by R. Carlson and E. Cooley. N, looked for but not detected. NA, not analyzed.]

Rock unit	Jp					MzPz hg			MzPz cg							
Sample No...	78ANs134A	78ANs202A	78AMm33B	78AMm34A	78AMm34C	78ANs139A	78AMm33A	79ANw18	78ANs137A	78ANs204A	78ANs204C	78ANs206A	78AMH193C	79ANs8A	79ANs10B	79ANs23A
Rocktype....	granite	granodiorite	diorite	granodiorite	diorite	gabbro	gabbro	gabbro	gabbro	gabbro	gabbro	gabbro	gabbro	gabbro	metagabbro	gabbro
Lat.........	68°18'N.	68°23'N.	68°22'N.	68°24'N.	68°24'N.	68°21'N.	68°22'N.	68°21'N.	68°20'N.	68°24'N.	68°24'N.	68°20'N.	68°21'N.	68°21'N.	68°22'N.	68°19'N.
Long........	158°20'W.	158°38'W.	158°35'W.	158°19'W.	158°19'W.	158°41'W.	158°35'W.	158°39'W.	158°22'W.	158°15'W.	158°15'W.	158°24'W.	158°19'W.	158°35'W.	158°35'W.	158°30'W.
Ag.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
As.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Au.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
B........	20	<10	20	30	20	10	20	<10	10	20	15	10	10	<10	<10	N
Ba.......	1500	1000	700	500	1000	50	200	300	50	50	50	<20	20	30	100	N
Be.......	1	1	<20	<20	N	N	N	N	N	N	N	N	N	N	<1	N
Bi.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Cd.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Co.......	<5	<5	70	20	50	70	100	100	50	70	100	100	70	70	50	50
Cr.......	<10	<10	100	20	50	700	500	700	>5000	300	1000	500	2000	1150	1000	1000
Cu.......	<5	<5	150	<5	150	<5	150	50	500	50	500	10	30	200	150	5
La.......	50	50	50	50	50	50	50	N	<20	50	50	50	50	N	<20	N
Mo.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Nb.......	<20	<20	<20	<20	<20	<20	<20	N	<20	<20	<20	<20	<20	N	N	N
Ni.......	20	<5	30	10	20	150	150	200	150	100	150	100	200	150	150	300
Pb.......	20	N	10	10	30	N	10	<10	N	N	N	N	N	<10	N	N
Sb.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Sc.......	5	5	30	20	50	30	50	20	50	30	30	50	50	50	70	30
Sn.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Sr.......	300	200	1000	500	700	500	700	200	700	700	500	200	200	100	500	300
V........	20	100	500	150	500	300	500	300	200	200	200	300	300	1700	1000	200
W........	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Y........	30	50	50	50	50	N	50	<10	N	10	<10	10	<10	N	50	N
Zn.......	N	N	N	N	N	N	<200	<200	N	N	N	<200	N	N	N	N
Zr.......	50	200	50	150	50	N	20	10	N	N	N	<10	N	N	20	N
Pt.......	N	N	N	N	N	.020	.005	NA	N	.005	N	N	.010	NA	NA	NA
Pd.......	N	N	.010	<.001	.005	.005	.002	NA	.002	.010	.010	.001	.015	NA	NA	NA
Rh.......	N	N	N	N	N	N	N	NA	N	N	N	N	N	NA	NA	NA
Ru.......	N	N	N	N	N	N	N	NA	N	N	N	N	N	NA	NA	NA
Ir.......	N	N	N	N	N	N	N	NA	N	N	N	N	N	NA	NA	NA

Table 2 continued--

Rock unit	MzPz um						Dpb						ŦRDs		Dpbl
Sample no..	78ANs136A	78ANs138A	78ANs207B	78AMH193A	78AMH193B	78AMm35B	78ANs202B	78ANs203A	78ANs205A	78AMH192B	78AMm35A	79ANs50B	78ANs135A	78AMH194A	78AMH192A
Rock type....	dunite	dunite	harzburgite	clinopyroxinite	dunite	wehrlite	basalt	basalt	pillow basalt	basalt	lapilli tuff	basalt	siltstone	limestone	marble
Lat.......	68°20'N.	68°20'N.	68°18'N.	68°21'N.	68°21'N.	68°20'N.	68°23'N.	68°24'N.	68°21'N.	68°24'N.	68°20'N.	68°22'N.	68°19'N.	68°20'N.	68°24'N.
Long......	158°20'W.	158°21'W.	158°21'W.	158°19'W.	158°19'W.	158°19'W.	158°38'W.	158°24'W.	158°17'W.	158°28'W.	158°19'W.	158°14'W.	158°18'W.	158°16'W.	158°28'W
Ag.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
As.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Au.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
B........	20	10	10	10	10	10	20	20	20	10	10	<10	300	50	N
Ba.......	5	50	20	20	50	50	700	300	300	150	200	50	700	200	N
Be.......	<1	N	N	N	N	N	N	<1	N	N	2	<1	2	<20	N
Bi.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Cd.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Co.......	100	100	150	100	200	100	50	70	100	70	30	70	20	<5	N
Cr.......	>5000	>5000	5000	5000	5000	3000	20	<10	500	300	50	50	200	100	N
Cu.......	<5	70	5	70	<5	10	100	150	300	50	50	200	30	15	N
La.......	<20	<20	50	<20	<20	<20	50	50	50	<20	70	N	70	50	N
Mo.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Nb.......	<20	<20	<20	N	N	<20	<20	<20	<20	<20	<20	N	<20	<20	N
Ni.......	2000	2000	1500	700	2000	500	<5	<5	100	100	20	100	100	30	N
Pb.......	N	N	N	N	N	N	10	20	10	<10	<10	N	15	50	N
Sb.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Sc.......	N	7	10	50	5	100	30	30	50	50	30	50	20	5	N
Sn.......	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Sr.......	N	N	N	N	N	N	300	500	200	200	200	300	200	300	300
V........	500	50	50	200	10	200	300	500	300	300	100	1000	300	100	20
W........	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Y........	N	N	N	N	N	N	50	50	50	10	100	30	100	20	N
Zn.......	N	N	N	N	N	N	N	N	<200	<200	N	<200	200	<200	N
Zr.......	20	N	N	N	N	N	50	50	200	<10	>1000	50	500	20	N
Pt.......	N	N	N	.070	.020	N	N	N	N	.005	N	NA	N	N	N
Pd.......	.002	.002	.005	.100	.010	.005	N	N	.007	.003	N	NA	N	.001	<.001
Rh.......	N	N	N	N	N	N	N	N	N	N	N	NA	N	N	N
Ru.......	N	N	N	N	N	N	N	N	N	N	N	NA	N	N	N
Ir.......	N	N	N	N	N	N	N	N	N	N	N	NA	N	N	N

Table 2 continued--

Rock unit	Jp (mafic dike)		(mafic dike)			Mineralized (Jp)			Mineralized (Dpb)		
Sample no...	78AMm33C	78AMm34B	78ANs204B	79ANs8B	79ANs10A	79ANs3D	79ANs11B	79ANs12A	78ANs205C	79ANs42A	79ANs50A
Rock type...	basaltic	diabasic	gabbroic	porphyritic	porphyritic	feldspathic	granitic	sulfide zone	pillow basalt	basalt	chert(?)
Lat......	68°22'N.	68°24'N.	68°24'N.	68°21'N.	68°22'N.	68°24'N.	68°22'N.	68°22'N.	68°21'N.	68°20'N.	68°22'N.
Long.....	158°35'W.	158°19'W.	158°15'W.	158°35'W.	158°35'W.	158°19'W.	158°35'W.	158°35'W.	158°17'W.	158°17'W.	158°14'W.
Ag.......	N	N	N	N	N	N	N	7	20	N	.5
As.......	N	N	N	N	N	N	N	N	N	N	N
Au.......	N	N	N	N	N	N	N	N	N	N	N
B........	50	20	20	<10	<10	N	N	<10	20	N	30
Ba.......	200	700	200	<20	70	300	70	20	5000	1500	500
Be.......	N	N	N	N	N	1	<1	N	<1	<1	<1
Bi.......	N	N	N	N	N	N	N	N	N	N	N
Ce.......	N	N	N	N	N	N	N	N	N	N	N
Co.......	70	70	50	70	100	20	100	200	70	<5	7
Cr.......	100	200	300	300	500	10	15	100	500	15	30
Cu.......	200	20	30	300	100	200	1000	3000	300	5	70
La.......	50	50	50	N	N	20	N	N	50	70	N
Mo.......	N	N	N	N	N	N	10	N	N	7	20
Nb.......	<20	<20	<20	N	N	<20	N	N	<20	30	N
Ni.......	30	70	100	150	300	7	5	150	100	5	30
Pb.......	10	<10	20	<10	N	N	N	<10	100	15	15
Sb.......	N	N	N	N	N	N	N	N	N	N	N
Sc.......	50	50	30	50	70	15	10	30	50	<5	20
Sn.......	N	N	N	N	N	N	N	N	N	N	N
Sr.......	500	700	300	500	200	100	700	700	<100	N	100
V........	500	700	300	1500	1000	50	70	700	500	150	1000
W........	N	N	N	N	N	N	N	N	N	N	N
Y........	30	50	10	<10	<10	70	50	<10	50	150	20
Zn.......	N	N	N	N	N	N	N	N	N	N	N
Zr.......	20	30	10	N	N	150	200	<10	200	300	70
Pt.......	N	NA	N	NA	NA	NA	NA	NA	N	NA	NA
Pd.......	.003	NA	.002	NA	NA	NA	NA	NA	.005	NA	NA
Rh.......	N	NA	N	NA	NA	NA	NA	NA	N	NA	NA
Ru.......	N	NA	N	NA	NA	NA	NA	NA	N	NA	NA
Ir.......	N	NA	N	NA	NA	NA	NA	NA	N	NA	NA

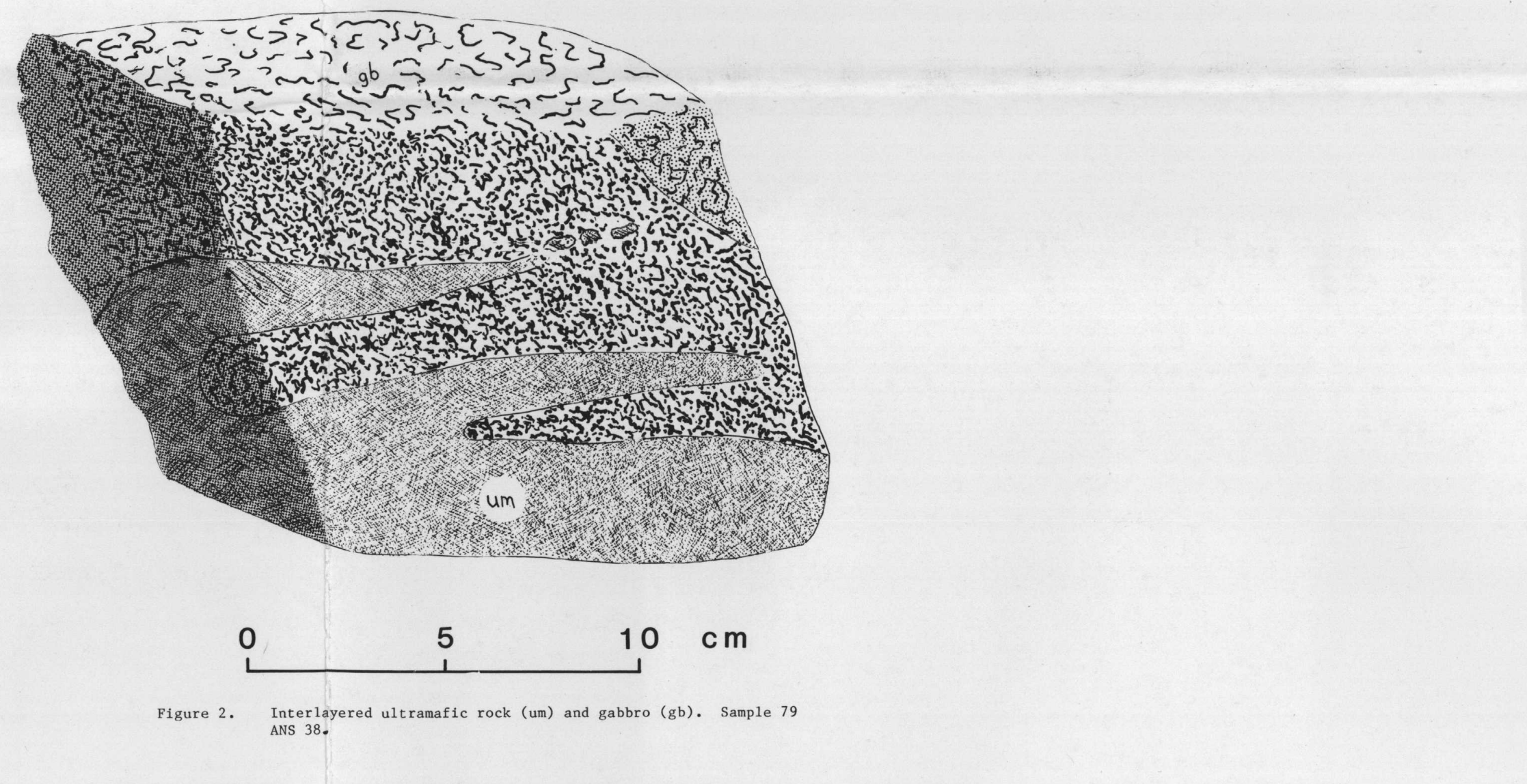

Figure 2. Interlayered ultramafic rock (um) and gabbro (gb). Sample 79 ANS 38.

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