STUDIES RELATED TO WILDERNESS

WILDERNESS AREAS

# GRANITE FIORDS, ALASKA

GEOLOGICAL SURVEY BULLETIN 1403

# MINERAL RESOURCES OF THE GRANITE FIORDS WILDERNESS STUDY AREA, ALASKA

Rugged, glacier-dominated alpine terrain, northeastern Granite Fiords. Unnamed peak to left is 2,252 metres (7,390 ft) in elevation, the second highest peak in the study area. Through Glacier in foreground; Chickamin Glacier in distance.

# Mineral Resources of the Granite Fiords Wilderness Study Area, Alaska

*By* HENRY C. BERG, RAYMOND L. ELLIOTT, *and* JAMES G. SMITH,
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## STUDIES RELATED TO WILDERNESS

# WILDERNESS AREAS

In accordance with the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, the U.S. Geological Survey and U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Studies and reports of all primitive areas have been completed. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provides that areas under consideration for wilderness designation be studied for suitability for incorporation into the wilderness system. The mineral surveys constitute one aspect of the suitability studies. This bulletin reports the results of a mineral survey of some national forest lands in the Granite Fiords wilderness study area, Alaska, that is being considered for wilderness designation. The area studied is about 56 kilometres northeast of the town of Ketchikan in southeastern Alaska.

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STUDIES RELATED TO WILDERNESS—WILDERNESS AREAS

# MINERAL RESOURCES OF THE GRANITE FIORDS WILDERNESS STUDY AREA, ALASKA

By HENRY C. BERG, RAYMOND L. ELLIOTT, and JAMES G. SMITH, U.S. GEOLOGICAL SURVEY, and TOM L. PITTMAN and ARTHUR L. KIMBALL, U.S. BUREAU of MINES

## SUMMARY

The Granite Fiords wilderness study area in southern southeastern Alaska is entirely within the Tongass National Forest and encompasses about 2,600 $km^2$ (591,000 acres). In 1971, 1972, and 1973 the U.S. Geological Survey and the U.S. Bureau of Mines conducted a survey of the mineral resources of this area. An aeromagnetic survey was also made by the U.S. Geological Survey in 1972.

About 17 man-months were spent in field investigations. Fieldwork consisted of coastline traverses using skiffs and reconnaissance traverses of inland areas using a helicopter. In 1972 and 1973 the field parties were based on the 37- m U.S. Geological Survey Research Vessel *Don J. Miller II*.

The mineral survey consisted of reconnaissance geological mapping and intensive geochemical sampling. Stream-sediment samples were collected from the major rivers and their tributaries. Rock samples were collected from iron-stained and hydrothermally altered zones, from veins, contacts, joints, fractures, and shear zones, and from any other material that showed any indication of mineralization. In addition, common rock types were sampled to determine their background metal content. The Geological Survey collected and analyzed 1,502 geochemical samples (625 stream sediment, 877 rock and mineral), and the Bureau of Mines submitted 426 samples for analysis, making a grand total of 1,928 samples analyzed for the mineral survey.

Bureau of Mines field investigations included detailed examinations and sampling of mining claims and prospect workings, of altered zones and related mineral occurrences discovered during the geological mapping, and of many of the localities at which geochemically anomalous rock samples were collected.

The landscape of Granite Fiords is dominated by bold, ice-sculpted features carved by glaciers during the Pleistocene Great Ice Age. Typical scenes include deep fiords, U-shaped valleys, rounded ridge crests, sheer cliffs, and Matterhorn-like peaks. About 80 percent of the study area was covered by ice as recently as 10,000 years ago, the time of maximum glacial advance. Today, small permanent snowfields and ice tongues dot the mountains throughout the study area, and the northern reaches are still in the grip of glacial ice.

Granite Fiords wilderness study area lies mainly within the Coast Range batholithic complex, a terrane of predominantly Mesozoic and Cenozoic plutonic and metamorphic rocks that underlies the Coast Mountains of Alaska and British Columbia for more than 1,600 km. Other rocks in the study area include Mesozoic strata that crop out

near the northeastern boundary and Quaternary lava flows that underlie small areas near the southwestern boundary.

The main structural features in the study area include a major lineament along Behm Canal, a platelike terrane of metamorphic rocks in the central region, and a postulated zone of large-scale overthrust faulting in the northeastern sector. Smaller scale structures include minor lineaments, joints, folds, and steep faults and shear zones.

The mineral resources known in Granite Fiords consist of metalliferous lodes containing small amounts of gold, silver, molybdenum, copper, lead, and zinc. Traces of these and other metals were also detected in the geochemical samples. No ore deposits were found during the investigation, but the anomalous amounts of gold, silver, molybdenum, copper, lead, and zinc that occur in the geochemical samples, especially of the paragneiss, Hazelton(?) Group, and Hyder Quartz Monzonite and other Tertiary plutons, suggest that low-grade metalliferous resources may exist.

At present, there are no active mines in the study area or adjacent parts of southeastern Alaska, although the large Granduc mine is just across the international boundary in British Columbia.

Nineteen lodes are known to have been prospected within the proposed boundaries of the study area. Sixteen of them are in the remote northern part of Granite Fiords. The other three are near tidewater: one near the mouth of the Chickamin River and two at Walker Cove. Most of the lodes were originally staked in the early 1900's; about half a dozen were being prospected in 1972. Except for a 1-ton test shipment in 1925, there is no record of any mineral production.

The lodes in northeastern Granite Fiords are sulfide-bearing quartz-fissure veins and stringer lodes, massive sulfide stringers, or disseminated sulfide deposits. Their sulfide minerals include arsenopyrite. chalcopyrite, galena, molybdenite, pyrite, pyrrhotite, sphalerite, and tetrahedrite. The lodes are mainly in metamorphic rocks questionably assigned to the Hazelton Group and in the Texas Creek Granodiorite, both of which have been intruded by quartz monzonite and granodiorite. The information obtained during this investigation suggests that any lode mines that may be developed in the northeastern part of the study area probably would be underground operations mining less than 500 tons per day from veins or aggregates of veins.

The lode near the mouth of the Chickamin is in quartz diorite and consists of a quartz vein that contains pyrite and a little molybdenite. The principal lode at Walker Cove is a 25-m-wide zone of iron-stained paragneiss containing disseminated pyrite and chalcopyrite. Samples of this lode showed 0.3 to 1.5 percent copper and small amounts of zinc, gold, and silver. Similar deposits may occur elsewhere in the paragneiss unit.

Analyses of geochemical samples showed that the only valuable metals present in greater than background amounts are gold, silver, molybdenum, copper, lead, and zinc. Fifty-seven rock and mineral samples and 80 stream-sediment samples contained anomalously high amounts of one or more of these metals. However, most anomalous values were at or near the threshold level, and only about 25 percent of them were as much as two or three steps above it. Of the 137 anomalous samples, 110 contained only 1 metal in threshold or greater amounts, and only 7 contained 3 or more metals.

The distribution of anomalous geochemical samples corresponds closely to the outcrop areas of the Hazelton(?) Group, Texas Creek Granodiorite, paragneiss, and Hyder Quartz Monzonite and other Tertiary plutons. The correlation between anomalous metal values and the two metamorphic terranes suggests that the metals were largely original constituents of the sedimentary and volcanic parent rocks of the paragneiss and Hazelton(?) Group. The lode occurrences within these units probably formed during subsequent metamorphism and plutonism, but there is little evidence that these later events produced major concentrations of metals anywhere within the study area.

No mineral fuels, radioactive fuels, or nonmetallic minerals (other than sand and gravel) were found during the mineral survey.

The Punchbowl area very likely has a relatively high thermal gradient, as indicated by the presence of an uneroded cinder cone and other young volcanic rocks. However, further investigations, including drilling, will be necessary to determine if there is any potential for geothermal resources.

## INTRODUCTION

This report describes the mineral resources of the Granite Fiords wilderness study area. The investigation was undertaken in accordance with the provisions of the Wilderness Act (Public Law 88–577, Sept. 3, 1964). The names "Granite Fiords wilderness study area" and "Granite Fiords" are used synonymously in this report.

Granite Fiords wilderness study area is in southern southeastern Alaska, about 56 km northeast of the town of Ketchikan (population 7,000) (fig. 1). The study area includes parts of the U.S. Geological Survey Ketchikan and Bradfield Canal 1:250,000-scale topographic sheets. About 29 km of the northern border is the international boundary between Alaska and British Columbia. The area is entirely within the Tongass National Forest and encompasses about 2,600 $km^2$ (591,000 acres) of remote, nearly virgin wilderness.

There are no roads or well-developed trails in the study area. A short U.S. Forest Service trail leads from Punchbowl Cove to Punchbowl Lake, but it has been partly destroyed by landslides. Another trail leads from Rudyerd Bay to Nooya Lake, but it too has not been maintained for many years. There is a Forest Service cabin at Big Goat Lake and a log shelter at Nooya Lake.

The part of the area that borders Behm Canal is accessible by boat. Elsewhere, access is by foot and helicopter, and by float-equipped airplanes that can land on Walker, Leduc, and several of the smaller lakes. The northeastern area can also be reached by glacier and cross-country trek from the head of an old, partly obliterated trail that leads from the village of Hyder to Texas Lake at the eastern boundary of the study area. Several private cabins at the mouth of the Chickamin River were occupied and in good condition in July 1973.

The scenery in Granite Fiords is dominated by glacially sculpted features such as deep fiords and broad U-shaped valleys walled by sheer cliffs more than a kilometre high (fig. 2). Most of the area was completely overridden by glacial ice, resulting in broad, rounded ridge crests (fig. 3). In the northern reaches, however, the mountains locally stood above the highest level of the ice and are characterized by Matterhorns and knife-edged ridges, punctuated by spires and pinnacles (fig. 4).

Small permanent snowfields and ice tongues dot the mountains throughout the study area, but in the northern reaches the land is still in the grip of glacial ice. There, only isolated spires and razor-backed ridges of bedrock penetrate the massive icefields and coalescing valley glaciers.

The average elevation of the rounded ridges is about 1,050 m.

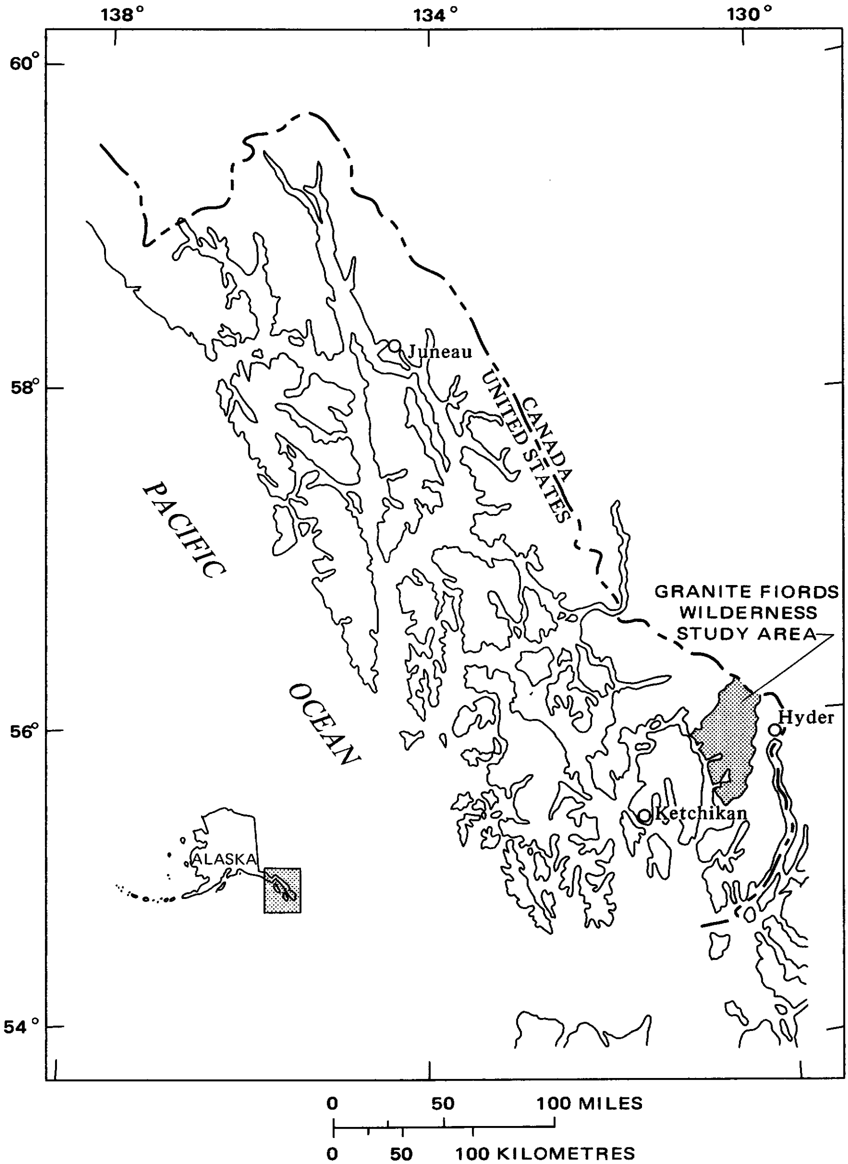



FIGURE 1.—Location of Granite Fiords wilderness study area.

FIGURE 2.—The work of ice in Granite Fiords wilderness study area. Sheer, glacier-carved cliff or jointed granodiorite about 1,050 m high bordering Punchbowl Cove, a 250-m deep fiord.

FIGURE 3.—Rolling uplands, western Granite Fiords, where once-rugged mountains more than 1,200 m high were overridden by Pleistocene ice, resulting in rounded ridge crests.

FIGURE 4.—The bleak, icebound landscape of northern Granite Fiords is dominated by rugged peaks and knife-edged ridges that rise above crevassed icefields and coalescing valley glaciers. This unnamed range near the northeastern boundary of the study area stood above the highest level of the Pleistocene glaciers and thus was not subdued by the abrasive ice.

Along the deep fiords that indent the western part of the study area, these ridges rise directly from sea level, resulting in spectacular halfdomes and buttresses closely resembling those in Yosemite Valley, Calif. The highest peaks in Granite Fiords are along and near the northern boundary. At 2,286 m (7,499 ft), Mount John Jay on the international boundary is the highest, and at least half a dozen other nearby peaks exceed 2,000 m.

The climate is characterized by heavy precipitation, probably equivalent to more than 250 cm of rainfall per year. Vegetation consists of dense, nearly impenetrable rain forest at low elevations, and brush, moss, and lichen at higher levels. Significant forest cover is restricted to the area near Behm Canal and along the major river valleys.

## PREVIOUS INVESTIGATIONS

Until the present investigation, most of Granite Fiords was not geologically mapped. Published geologic descriptions of parts of the study area include U.S. Geological Survey reports by Buddington (1929) and Buddington and Chapin (1929). Fieldwork for these reports was done in 1925 and consisted of geologic reconnaissances of the coastline of Behm Canal and of the Chickamin River, and investigations of mineral deposits near Banded Mountain.

In 1968–70, J. G. Smith (1976) mapped the geology of the Hyder–Texas Creek region and carried his investigations as far as the northeastern part of Granite Fiords wilderness study area. His findings within the study area are incorporated in the present report.

## PRESENT INVESTIGATIONS

Field studies for this report were made during the summer months of 1971–73. In 1971, T. L. Pittman and S. A. Stewart of the U.S. Bureau of Mines spent a month in the study area. In 1972 and 1973, Pittman and A. L. Kimball of the Bureau of Mines joined U.S. Geological Survey geologists H. C. Berg, R. L. Elliott, and J. G. Smith for a total of 3 months of fieldwork. During this time, both field parties were based on the 37-m U.S. Geological Survey Research Vessel *Don J. Miller II* and were closely supported by a jet helicopter. An aeromagnetic survey of the study area and adjacent lands was made in 1972.

Topographic base maps for the geologic studies included parts or all of ten U.S.G.S. 1:63,360-scale quadrangles, including Ketchikan B–2, B–3, C–2, C–3, D–2, D–3, and D–4; and Bradfield Canal A–1, A–2, and A–3.

The geological fieldwork included detailed traverses of the coastlines using outboard-powered skiffs and reconnaissance traverses of inland areas using a helicopter. In addition to the geological mapping, the mineral survey included intensive geochemical sampling. We collected stream-sediment samples from the major rivers and their tributaries and rock samples from iron-stained and hydrothermally altered zones, from veins, and from all known occurrences of sulfide minerals. In addition, we sampled the common rock types on a broad scale for information on their background metal content. A total of 1,502 geochemical samples (625 stream-sediment, 877 rock and mineral) were collected and analyzed. Analytical work was done under the direction of A. L. Meier at the U.S. Geological Survey field laboratory in Anchorage, Alaska, and D. L. Grimes at the Survey's main laboratory in Denver, Colo.

Bureau of Mines work included examination of relevant literature on mineral deposits and mining activity in and near the study area and a search for mining claim locations. The field investigations included detailed examinations and sampling of previously known mining claims and lode prospects, and of altered zones, related mineral occurrences, and many rock geochemical anomaly sites discovered during the present investigation. Analyses of the 426 samples collected by Bureau of Mines personnel were done by the Geological Survey and by the Bureau of Mines laboratory in Reno, Nev.

All measurements (except ounces per ton) in this report are in metric units. All dimensional measurements were taken in English units and converted to metric equivalents. In certain measurements, such as specific peak elevations and contour values, we have used both units, so that the reader can compare these values directly with the topographic map. We retained ounces per ton partly for readers' convenience but mainly because many of these values are quoted (directly or indirectly) from published sources.

## ACKNOWLEDGMENTS

We thank Robert Stacey, Edgar Magalhaes, and Eugene Kuehn, master, engineer, and cook-seaman, respectively, of the R/V *Don J. Miller II*, for making their vessel a comfortable and efficient base of operations for the field parties during 1972 and 1973. We are also grateful to Allen L. Clark, U.S. Geological Survey, who joined the field party for 10 days in June, 1972, for his contributions to the early geologic mapping and guidance of the geochemical sampling program. The Survey geologists were ably assisted in the field by Philip Frame, Steven Erickson, Michael Rymer, and Eduardo Rodriguez. The Bureau of Mines field team was aided by Frank Smith, Robert Doler, and Donald Keill. We also thank Kenneth Eichner for showing us the locations of several prospects in the Banded Mountain area.

## GEOLOGY

### SETTING

Granite Fiords wilderness study area lies mainly within the Coast Range batholithic complex, a terrane of plutonic and high-grade metamorphic rocks that underlies the Coast Mountains of Alaska and British Columbia for more than 1,600 km. Other rocks in the study area include Mesozoic bedded rocks that crop out near the northeastern boundary and Quaternary lava flows that underlie small areas near the southwestern boundary.

In Granite Fiords, two-thirds of the batholithic complex is plutonic rocks—chiefly quartz diorite, granodiorite, and quartz monzonite—that range in structure from strongly gneissoid to massive and nonfoliated. The plutons are progressively more silicic and massive northeastward across the batholith. The remaining third of the complex consists of banded paragneiss derived mainly from sedimentary rocks and minor amphibolite that originally was intermediate to mafic igneous rock. In some places, the paragneiss grades imperceptibly into the adjacent granitic plutons; in others it occurs in striking, sometimes even bizaare patterns of angular, elongate, and swirled inclusions of dark rock in the lighter granite (fig. 5). The paragneiss is regionally metamorphosed in the amphibolite facies throughout the study area.

The geologic history of the batholithic complex is as yet incompletely known. Radiometric dates from comparable rocks in areas adjacent to Granite Fiords indicate that the plutons range in age from about 200 to 45 to 50 m.y. (million years) (Grove, 1971, p. 71; J. G. Smith, unpub. data). The youngest isotope-dated pluton in the immediate area is a gabbro stock about 23 m.y. old (J. G. Smith, unpub. data). Regional geologic studies, supported by a few isotope dates, suggest that the paragneiss underwent sillimanite-grade regional metamorphism and local granitization between 50 and 90 m.y. ago (Forbes and Engels, 1970; Berg, 1972, p. 1; J. G. Smith, unpub. data). The premetamorphic age of the strata that were metamorphosed to paragneiss, however, is speculative. No fossils have been found in the paragneiss. Some geologists (Roddick and Hutchison, 1972, p. 7) believe that the paragneiss is derived from strata as old as Precambrian. Others (Monger and Ross, 1971; Monger and others, 1972) argue that its maximum age is not greater than late Paleozoic. The late(?) Paleozoic or Mesozoic premetamorphic age assigned to the paragneiss in this report is based on evidence from regional studies in neighboring areas (Berg and others, 1972).

The bedded rocks near the northeastern boundary of the study area are the southwesternmost fringe of an intermontane basinal terrane

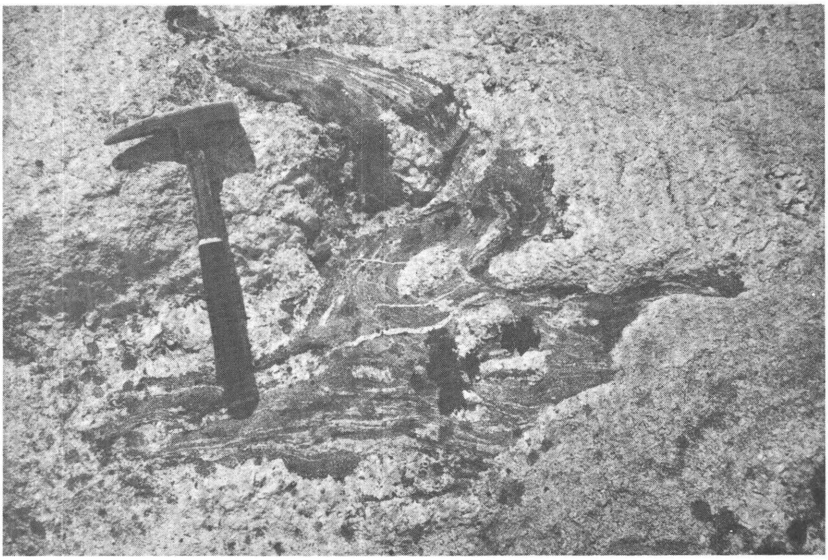


FIGURE 5.—Swirled inclusion of dark paragneiss in massive Hyder Quartz Monzonite, east-central Granite Fiords.

of Mesozoic sedimentary and igneous rocks whose main outcrop area is in British Columbia (Monger and others, 1972, p. 578–579). In Granite Fiords, these rocks consist of slightly to moderately metamorphosed andesite, graywacke, siltstone, and argillite. Fossils have not been found in these strata in the study area, but the rocks are lithically identical to, and nearly continuous with rocks mapped by Grove (1971) as Hazelton Group, of Jurassic age, in British Columbia. These bedded rocks, herein designated the Hazelton(?) Group, are intruded by 45- to 50-m.y.-old (Eocene) plutonic rocks and by the approximately 200-m.y.-old Texas Creek Granodiorite, part of which may be contemporaneous with the Hazelton(?).

The youngest consolidated rocks mapped in Granite Fiords are Quaternary lava flows and associated volcaniclastic rocks that crop out in isolated small patches, mainly in the southwestern part of the study area. These rocks are part of a field of mainly postglacial lava flows, volcanoes, and cinder cones that dot a region encompassing thousands of square kilometres in Alaska and British Columbia (Souther, 1970). The main occurrence in Granite Fiords is at Punchbowl Cove, where columnar lava flows form picturesque cliffs accented by threadlike waterfalls 30 m or more high. The existence of glacial valleys partly filled with lava flows, and of at least one partially breached but otherwise uneroded cinder cone near Punchbowl

Lake, shows that these volcanic rocks are younger than the Pleistocene glaciers that carved the main features of the Coast Mountains. On the other hand, one flow along Behm Canal shows striae and grooves that might have been produced by glacial action. It thus might have erupted during or even before the Great Ice Age.

## UPPER(?) PALEOZOIC OR MESOZOIC ROCKS

### PARAGNEISS AND AMPHIBOLITE

The presumed oldest rocks known in the study area (see "Setting") consist of banded high-grade gneisses derived from sedimentary and volcanic strata. About 98 percnet of these rocks are treated as a single map unit, designated "paraneiss," that consists mainly of pelitic (biotite-rich) gneiss but also contains significant amounts of other rock types. The remaining 2 percent is amphibolite.

The main outcrop of the paragneiss (pl. 1) is a broad, nearly continuous north-northwest-trending belt, about 20 km wide, that runs the length of the study area 3 to 10 km inland from Behm Canal. A subsidiary belt, roughly parallel to the main one, crops out along Behm Canal, where it forms a narrow, discontinuous coastal strip that tapers from a width of 3 km on the south to one-half km or less on the north. Numerous isolated outcrops of the unit occur in all but the northern sector of the study area.

In general, the lithology of the paragneiss is characterized by rusty-brown-weathering pelitic gneiss and schist containing conspicuous biotite. Such rocks make up about 66 percent of the unit. The remainder, on the basis of the number of samples of different rock types collected, includes migmatite (16 percent), gneissic plutonic rocks (7 percent), marble and calc-silicate gneiss (4 percent), pegmatite (3 percent), quartzite (2 percent), amphibolite (1 percent), and aplite (1 percent).

The paragneiss typically consists of alternating light- and dark-gray layers, averaging 15 cm in thickness, with about 50 percent oligoclase and andesine, 25 percent quartz, and 15 percent biotite. Accessory minerals, in amounts up to about 10 percent, include potassium feldspar, garnet, sillimanite, and muscovite. The paragneiss commonly also contains traces of one or more of the following minerals: apatite, clinopyroxene, orthopyroxene, graphite, hornblende, magnetite, pyrite, sphene, and zircon. Secondary minerals, the result of widespread incipient retrograde metamorphism, include small amounts of actinolite, albite(?), chlorite, epidote, and sericite.

Relations between the paragneiss and adjacent rock units are complex. In most places, the paragneiss grades imperceptibly downward and laterally into gneissic granodiorite. In some localities, however, it is in sharp contact with plutonic rocks or passes gradually into them through a zone of migmatite, a complex mixture in which inclusions of dark-gray gneiss stand out in contrast—often in striking fashion on glacially polished outcrops—against a light-gray background of granitic rock (fig. 6). Contacts between the paragneiss and amphibolite are marked by a zone, up to 10 m wide, of alternating bands of pelitic gneiss and amphibolite or a transitional rock type containing approximately equal amounts of biotite and hornblende.

The lithology and the relict textures inherited from original bedded deposits indicate that the forerunners of the paragneiss sequence were deposited in a marine environment and consisted of argillaceous clastic sediments and minor amounts of limestone, chert, and felsic to intermediate or mafic volcanic rocks.

The main outcrop of amphibolite is in a discontinuous coastal strip up to one-half km wide along Behm Canal between Walker Cove and Rudyerd Bay. Four other small outcrop areas were also mapped: one along Behm Canal northwest of the mouth of the Chickamin River, one on the north shore of the inlet at the mouth of the Chickamin River, one on the west bank of lower Barrier Creek, and one about 8 km south of the intersection of Barrier Creek and South Fork of the Chickamin River.

The unit commonly is strongly banded and consists of layers of greenish-black gneiss that alternate in striking contrast with layers

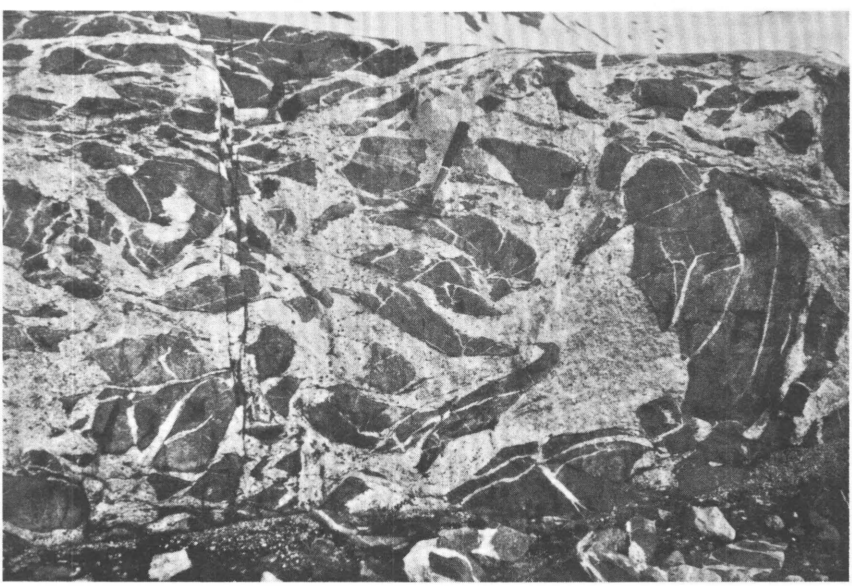


FIGURE 6.—Angular inclusions of dark-gray paragneiss in foliated Hyder Quartz Monzonite, northern Granite Fiords.

of light-gray gneiss. The composition layering ranges in thickness from paper-thin laminae to bands about 30 cm thick; their average thickness is about 10 cm. Local variation in the relative proportions of mafic and felsic components results in outcrops that range from nearly pure hornblende schist to relatively uniform dark-gray gneiss containing approximately equal amounts of mafic and felsic minerals.

Under the microscope, representative specimens show fine- to medium-grained granoblastic and schistose aggregates of about 45 percent plagioclase feldspar (oligoclase and andesine), 30 percent hornblende, 15 percent biotite, and 5 percent quartz. The remainder of the rock consists of up to 5 percent accessory apatite, clinopyroxene, garnet, magnetite, pyrite, and sphene, and secondary chlorite and epidote.

The intertonguing and gradational contact between the amphibolite and paragneiss units has already been described. Like the paragneiss, the amphibolite may be in gradational, abrupt, or migmatitic contact with adjacent plutonic rocks. Conspicuous in the amphibolite are locally abundant white quartz-feldspar veins, which contrast strikingly with their greenish-black host.

### UNDIVIDED METAMORPHIC ROCKS

An area of about 20 $km^2$ west of the Leduc River in the northern part of Granite Fiords is underlain by an assemblage of metamorphosed bedded rocks that includes amphibolite, pelitic gneiss, schist, phyllite, and hornfels. These rocks are intruded by massive to gneissoid granodiorite and quartz monzonite plutons, some of which occur as sills parallel to the foliation of the recrystallized strata.

The unit comprises about equal parts of gneiss and schist, and subordinate phyllite and hornfels. Some of the rocks identified in the field as "phyllite" and "hornfels" actually are very fine grained schist. However, these rocks show fairly well defined relict structure suggestive of bedding, and we retain their field names to distinguish them from the gneiss and schist, which have no relict structure.

Despite their diverse lithology, the undivided metamorphic rocks have fairly simple mineralogy; the different rock types vary mainly in grain size and relative proportions of minerals. The essential minerals in nearly every specimen examined in thin section are, in decreasing order of abundance, andesine, quartz, hornblende, biotite, and augite. The rocks commonly contain one or more of the accessory minerals apatite, calcite, magnetite, potassium feldspar, pyrite, and sphene, and such secondary minerals as actinolite, albite(?), chlorite, epidote, and prehnite(?). In some samples, especially near plutonic contacts, porphyroblasts of biotite and amphibole overprint an earlier schistosity.

The metamorphic minerals and textures indicate up to amphibolite-grade regional metamorphism and hornblende-hornfels-grade contact metamorphism. Where both types occur together, as near plutonic contacts, the contact metamorphism is the younger of the two. The secondary minerals are sparse and indicate incipient low-grade retrograde metamorphism or hydrothermal alteration.

The age and correlation of the undivided metamorphic rocks are largely speculative. Some of the rocks consist of paragneiss lithologically indistinguishable from parts of the amphibolite and paragneiss units; others are fine-grained schist, phyllite, and hornfels identical to parts of the Hazelton(?) Group. From this evidence, we infer that the undivided unit includes rocks from all three of these units. However, we were not able to map them separately, partly because of lack of time and partly because of heavy snow cover.

## JURASSIC OR OLDER ROCKS

### HAZELTON(?) GROUP

A sequence of recrystallized andesitic fragmental rocks, graywacke, siltstone, argillite, and minor limestone is exposed in the northeastern part of Granite Fiords and extends eastward beyond the boundary of the study area. Although we found no fossils in the sequence within the study area, we assign it questionably to the Hazelton Group because it crops out almost continuously with lithically and structurally identical rocks assigned to the Hazelton Group near Hyder, Alaska, by Buddington (1929) and to the Hazelton assemblage near Stewart, British Colubmia, by Grove (1971). In its type area, near Hazelton, British Columbia, the Hazelton Group is dated on the basis of fossils as Early and Middle Jurassic (H. W. Tipper, oral commun., 1973). In Granite Fiords, we believe the Hazelton(?), as mapped, is Jurassic or older because it is intruded by the Late Triassic or Early Jurassic Texas Creek Granodiorite.

Neither the base nor the top of the sequence is exposed in the study area; its minimum structural thickness, on the basis of exposures in cliffs, is about 750 m. Near Chickamin and Through Glaciers, and in the headwaters of Texas Creek, the sequence forms the erosional remnants of an arched roof over the Texas Creek Granodiorite.

The sequence has been subjected to low-grade regional metamorphism and to local contact metamorphism caused by the intrusion of the Texas Creek Granodiorite and Tertiary plutons. In some places, the rocks are tightly to isoclinally folded with steep axial planes; in other places, they are deformed into nearly recumbent folds with gently to moderately northeastward dipping axial planes. A postulated zone of large-scale overthrusting, parallel to the semirecumbent structures, is described under "Structure."

Outcrops of the Hazelton(?) Group are smooth and rounded where recently uncovered by retreating glaciers. Elsewhere they are angular and jagged owing to weathering along numerous intersecting joint and foliation surfaces. Weathered surfaces are mostly gray to black, although near intrusions weathered surfaces are often iron stained from weathering of pyrite. On freshly broken surfaces the coarser grained rocks are dull shades of green or less often purple, reddish brown, or gray. Finer grained rocks are gray to black.

The dominant rocks in the Hazelton(?) Group are interbedded andesitic tuff-breccia, volcanic graywacke, siltstone, and argillite. Less common rocks include coarse volcanic conglomerate, possible broken-pillow breccia, and dark-blue-gray marble. Nonvolcanic detritus is rare. Pillow lavas or flows were not seen.

The tuff-breccia is massive and usually ½ to 4 m or more thick; the argillite and graywacke are interlaminated on a centimetre scale. Graded bedding, load casts, and flame structures are common.

Representative samples of the tuff-breccia contain 5 to 50 percent poorly sorted angular to subrounded lapilli, set in an unsorted and unstratified volcanic graywacke matrix. Phenocrysts of euhedral, zoned plagioclase from 1 mm to 1 cm long constitute 5 to 20 percent of the lapilli. They have largely recrystallized to albite or oligoclase and clinozoisite-epidote, but those that survive metamorphism retain their original andesine composition. Phenocrysts of mafic minerals are much less common than plagioclase; most lapilli contain none at all. Mafic minerals present are strongly pleochroic euhedral green or brown hornblende and, less commonly, colorless subcalcic augite. Olivine is absent. Most mafic phenocrysts have recrystallized to masses of actinolite, chlorite, and opaque minerals. Vesicles are rare, and pumiceous lapilli are absent. The groundmass of the lapilli is mostly a recrystallized, nearly submicroscopic aggregate of albite-quartz-chlorite-epidote and opaque minerals, although shapes suggestive of microlites are still visible in some specimens.

The graywacke matrix of the tuff-breccia consists of sand-sized, angular mineral fragments identical to the phenocrysts in the lapilli and a pasty filling that before metamorphic recrystallization was probably tiny crystal fragments and glass particles.

Thin sections of the volcanic graywacke show angular grains of plagioclase, hornblende, and volcanic rock fragments. More than 95 percent of the grains are of volcanic derivation. They are set in a recrystallized, almost submicroscopic mosaic of metamorphic albite, chlorite, epidote, quartz, sericite, calcite, and opaque minerals. Volcanic rock fragments are mashed and molded around other grains, further obscuring original textures. Many crystal clasts show angular broken outlines in contrast to the euhedral phenocrysts in the tuff-breccia.

Most if not all the rocks in this unit were probably deposited in seawater. Direct evidence for marine deposition consists of the presence of fine-grained volcaniclastic rocks with graded bedding and load casts, and interbedded limestones. These features are not found in subaerial deposits and are rare in freshwater deposits. The absence of pumiceous lapilli also furnishes indirect support for marine deposition.

The high content of hornblende and intermediate plagioclase, the small amount of pyroxene, and the absence of olivine indicate that most of the volcanic debris is andeisitc in composition.

The volcanic composition of all the clasts and the abundance of angular lapilli and plagioclase and hornblende crystals indicate that the debris was transported only a short distance from nearby volcanic sources, probably underwater vents. The massive tuff-breccias are pictured as large underwater debris flows that originated on the flanks of nearby vents. The finer grained interlaminated graywacke and argillite represent a mixture of turbidity-current deposits and layers that formed as the finer debris from the underwater eruptions settled to the ocean floor.

## TRIASSIC OR JURASSIC ROCKS

### TEXAS CREEK GRANODIORITE

The Texas Creek Granodiorite in the study area is the westernmost part of a batholith that crops out mainly in the Hyder–Texas Creek area northeast of Granite Fiords (Buddington, 1929, p. 22–29) and is well exposed along Chickamin and Through Glaciers. It probably underlies much of the Hazelton(?) Group at shallow depth. Although its total outcrop area within Granite Fiords is only about 4 $km^2$, the Texas Creek is important because of its close spatial association with most of the known mineral deposits (pls. 1, 2).

Most Texas Creek outcrops are mottled shades of dark green and are rather angular. Their distinctive color and shape are caused by preferential breaking along closely spaced chlorite- and epidote-filled joints and shears.

The Texas Creek Granodiorite consists mainly of recrystallized, cataclastically deformed granodiorite and minor quartz diorite. Hand specimens typically have a greasy green look with cloudy feldspars and indistinct grain boundaries. Representative thin sections show a medium-grained hypidiomorphic granular aggregate of essential andesine or oligoclase, quartz, and potassium feldspar; accessory sphene, green hornblende, and green biotite; and secondary albite, muscovite, clinozoisite-epidote, actinolite, chlorite, calcite, and opaque minerals. In many specimens, euhedral crystals of potassium feldspar and hornblende up to 2 cm long impart a distinct (and characteristic) porphyritic texture.

In general, the Texas Creek Granodiorite is relatively massive and lacks pronounced metamorphic foliation. Instead, most of it is characterized by cataclastic textures, including bent and broken crystals, milled and rounded grain boundaries, and crush trails of finely milled rock and mineral particles. The intensity of the cataclasis generally is low, but locally the granodiorite is converted to mylonite, a banded, flinty rock produced by extreme mechanical deformation.

In addition to widespread incipient cataclasis, the Texas Creek Granodiorite was affected by one or more episodes of low-grade regional metamorphism and up to hornblende-hornfels-grade thermal metamorphism. The regional metamorphism partly obliterated original textures and produced mineral assemblages typical of the greenschist facies. Intrusion of the younger Coast Range plutons produced thermal aureoles up to 2 km wide along their contacts with the batholith. The chronology of these events has not been fully established, but the available evidence suggests that the regional metamorphism and at least some of the cataclasis predate the thermal metamorphism.

The Texas Creek Granodiorite is one of the oldest intrusive rocks known in the Coast Range batholithic complex. It intrudes bedded rocks assigned to the Hazelton(?) Group and in turn is cut by the 45- to 50-m.y.-old Hyder Quartz Monzonite and other middle Tertiary plutons. Its age relative to the foliated and schlieren granodiorite units, which also are intruded by middle Tertiary plutons, is unknown.

Potassium-argon dates on hornblende from the Texas Creek Granodiorite range from about 206 to 200 m.y. (Grove, 1971, p. 71; J. G. Smith, unpub. data). These radiometric data suggest a latest time of emplacement of Late Triassic or Early Jurassic.

## CRETACEOUS OR TERTIARY ROCKS

### QUARTZ DIORITE

Quartz diorite, together with minor amounts of other rocks, occurs exclusively in the western half of the study area. It forms a discontinuous belt about 10 km wide along and near Behm Canal and scattered outlying bodies 15 to 25 km from Behm Canal that are alined roughly parallel to the main belt.

About 60 percent of the map unit is dark-gray-weathering uniformly foliated to gneissose quartz diorite; the rest consists of paragneiss (21 percent), granodiorite (11 percent), and minor migmatite, amphibolite, pegmatite, and quartz monzonite. The quartz diorite everywhere is at least weakly foliated. Planar fabric ranges from a barely discernible alinement of mafic minerals to marked gneissic banding. The strongly gneissose variants are diffucult to distinguish from some of the paragneiss.

Thin sections of representative samples of the quartz diorite show medium-grained granular to planar aggregates of andesine (54 percent), quartz (18 percent), hornblende (13 percent), biotite (12 percent), and accessory apatite, augite, garnet, magnetite, muscovite, potassium feldspar, and sphene. Slight retrograde metamorphism, marked by epidote, chlorite, and saussuritized plagioclase, is nearly ubiquitous. Some of the quartz diorite is intensely iron stained near faults or hydrothermally altered zones. Much of it also shows cataclastic textures, including undulatory extinction in the quartz and incipient granulation at the boundaries of mineral grains.

Contacts between the quartz diorite and adjacent map units are largely inferred from the regional distribution of the major rock types. Most commonly, the quartz diorite grades imperceptibly into foliated granodiorite by increase in potassium feldspar, and into paragneiss either by increase in gneissic banding of the quartz diorite or by increase in abundance of paragneiss inclusions.

The Cretaceous or Tertiary age assigned to the quartz diorite in this report is based on the assumption that it was formed (emplaced) between 50 and 90 m.y. ago, more or less synchronously with the high-grade regional metamorphism of the Coast Range batholithic complex (see "Setting").

### FOLIATED GRANODIORITE

A composite pluton, mostly of foliated and gneissic granodiorite but containing a wide variety of other rock types, is exposed throughout the western half of the study area. Its approximately 1,000-km$^2$ outcrop trends irregularly north-northwest, and geologic relations indicate that it probably also underlies most of the paragneiss map unit.

On the basis of samples collected, the pluton consists mainly of granodiorite (51 percent), quartz monzonite (14 percent), and quartz diorite (13 percent) but locally includes such metamorphic components as hornfels, marble, paragneiss, and unassigned gneiss (18 percent). About 2 percent of the unit is migmatite. The remaining 2 percent includes aplite, diorite, granite, hornblendite, lamprophyre, and one occurrence of pyroxenite. In this report, this heterogeneous assemblage is treated as a single pluton of foliated granodiorite. Additional geologic mapping, however, probably would disclose several distinct plutons.

The mineralogy of the pluton, reflecting the diversity of constituent rock types, is variable. The average of 50 modal (point count) analyses of medium-grained foliated and gneissic granodiorite considered to be representative of the unit shows 50 percent plagioclase (oligoclase and andesine), 21 percent quartz, 15 percent potassium feldspar, 8 percent hornblende, and 7 percent biotite. The rock commonly also contains less than 1 percent of one or more of the accessory minerals apatite, garnet, magnetite, muscovite, pyrite, and sphene. Widespread incipient retrograde metamorphism has produced traces of albite(?), chlorite, epidote, iron oxide, and sericite, one or more of which may be present in much larger amounts near presumed faults and hydrothermally altered zones.

Euhedral crystals of potassium feldspar as much as 2.5 cm in maximum dimension are an important mineralogical feature of the granodiorite. These crystals, called megacrysts because they contrast so markedly in size with the rest of the minerals, commonly weather in relief and stud the surfaces of many outcrops. Our petrographic studies suggest that the megacrysts have formed by replacement of the other felsic minerals.

Contacts between the foliated granodiorite and adjacent units are complex. On plate 1, they are drawn partly on the basis of geologic relations and partly on the basis of the regional distribution of the major rock types. Contact relations between the granodiorite and the quartz diorite and paragneiss units are summarized in the descriptions of those units. The granodiorite grades imperceptibly into schlieren granodiorite by an increase in the number of gneiss inclusions. The relations between the foliated granodiorite and Hyder Quartz Monzonite, however, are somewhat ambiguous. As mapped, the granodiorite contains significant amounts of quartz monzonite, and the Hyder contains appreciable granodiorite. Near their contact, the two units locally are texturally and compositionally transitional. For these reasons, it is not always possible to distinguish between them at any single outcrop. In general, we distinguish the foliated granodiorite from the Hyder according to the following criteria:

1. The granodiorite is markedly foliated and gneissic throughout; the Hyder has a gneissic border zone but generally is relatively weakly foliated,
2. The granodiorite contains more hornblende than biotite; the Hyder contains more biotite than hornblende, and
3. The granodiorite contains less potassium feldspar than the Hyder but is richer in potassium feldspar megacrysts.

In the east-central part of the study area, the regional distribution of the major rock types indicates that the foliated granodiorite unit is intruded by stocklike bodies of quartz monzonite, which we interpret as tongues of the Hyder Quartz Monzonite. In this report, we assign the foliated granodiorite an age of Cretaceous or Tertiary. The reasons for this assignment are summarized under "Quartz Diorite" and "Setting."

### SCHLIEREN GRANODIORITE

Schlieren granodiorite forms three northwest-trending bodies along the eastern boundary of Granite Fiords. The largest is broadly crescent shaped and underlies about 90 $km^2$ of the study area. Two of the bodies continue beyond the boundary to the east and south.

The most consistent characteristic of the pluton and the one that distinguishes it from the other plutons is its inhomogeneity at all scales. Locally it may be foliated, irregularly banded, gneissoid, or migmatitic; combinations of several of these features may occur in a small area. Internal planar and linear structures are ubiquitous, although their exact patterns are unknown. Dark inclusions range from nearly absent to abundant. They are mostly gneiss and amphibolite that have retained their metamorphic layering. The larger inclusions generally are stretched, twisted, bent, or broken. Along strike, individual blocks become ghostlike and finally lose their identity entirely as they blend imperceptibly into indistinct streaks.

The most conspicuous feature of the plutonic rock, and the one from which it takes its name, is its ubiquitous, often contorted elongate dark streaks or schlieren. These are irregular bands, alternately rich and poor in dark (mafic) minerals, that swirl across outcrops, thicken and thin, and in distances measured in metres or millimetres blend into surrounding layers. In addition to the dark inclusions, there are discontinuous, irregular zones of migmatite throughout the pluton.

Outcrops of schlieren granodiorite are massive and smooth where glacially polished and blocky and deeply weathered at lower elevations where covered by vegetation. At a distance, outcrops of this pluton cannot be distinguished from those of other granitic units, despite its distinctive planar features.

The pluton consists of granodiorite and subordinate quartz monzonite. Despite its heterogeneity, the mineralogy is relatively simple, albeit with large ranges in abundance of individual minerals. The essential minerals, in decreasing order of average abundance, are intermediate to sodic plagioclase (oligoclase-andesine), quartz, potassium feldspar, hornblende, and biotite. Ubiquitous accessories are sphene, apatite, magnetite, and pyrite. Secondary minerals include chlorite, muscovite, epidote, and calcite. Rock textures range from equigranular and medium grained to finely schistose. Locally, the unit contains megacrysts of potassium feldspar as much as 1 cm long.

The schlieren granodiorite is gradational with the foliated granodiorite and, like that unit, is intruded by the Hyder Quartz Monzonite. In this report, we assign the schlieren granodiorite a Cretaceous or Tertiary age on the assumption that it formed, along with the foliated granodiorite, between 50 and 90 m.y. ago in conjunction with the high-grade regional metamorphism of the Coast Range batholithic complex.

## TERTIARY ROCKS

### HYDER QUARTZ MONZONITE

The Hyder Quartz Monzonite is a large composite pluton that averages quartz monzonite in composition but includes significant amounts of granodiorite and a variety of other subordinate rock types. The map unit covers about 800 $km^2$ in the northeastern part of the study area and extends eastward and northward beyond the boundary. The stocklike tongue of Hyder Quartz Monzonite within the foliated granodiorite in east-central Granite Fiords suggests that it also underlies parts of that unit.

The Hyder Quartz Monzonite was first named and described by Buddington (1929, p. 29–32) for exposures at and north of the town of Hyder, Alaska. Within the present study area, it is predominantly a medium- to coarse-grained biotite quartz monzonite with lesser amounts of medium-grained biotite-hornblende granodiorite. Inclusions are generally uncommon, and foliation is typically subtle or even absent, except in contact zones and along internal phase boundaries.

About 65 percent of our Hyder samples are quartz monzonite and about 20 percent granodiorite. The remainder include various gneisses (12 percent), minor quartz diorite (2 percent), amphibolite (1 percent), pegmatite (1 percent), and aplite (1 percent). Although this report treats it as a single map unit, a more detailed study would no doubt reveal that the Hyder Quartz Monzonite comprises several separable phases or distinct plutons. Detailed mapping would also disclose other smaller gneiss inclusions or pendants within the Hyder, in addition to the few represented on the map.

The average of 25 modal (point count) analyses of typical granitic rocks from the Hyder Quartz Monzonite shows 44 percent plagioclase (oligoclase and sodic andesine), 26 percent potassium feldspar, 24 percent quartz, 4 percent biotite, and 1 percent hornblende. Accessory sphene, apatite, zircon, opaque minerals and rare muscovite constitute less than 1 percent of the rock. Chlorite and epidote-clinozoisite are widespread, but generally sparse, alteration products. Potassium feldspar megacrysts are uncommon in the Hyder and confined mostly to the mafic phases.

Contacts between the Hyder Quartz Monzonite and the foliated granodiorite to the west are broadly gradational. In general, we distinguished these units by the criteria listed under the description of the foliated granodiorite. The contact between the Hyder and the unnamed massive granodiorite to the northeast is also gradational; the distinction between these two units is primarily mineralogical because both are relatively structureless.

Buddington (1929, pl. 2) included the Hyder Quartz Monzonite in his "Coast Range intrusives," which he considered Jurassic or Cretaceous. The Hyder Quartz Monzonite in the study area is reassigned a Tertiary age because it is in continuous outcrop with type Hyder Quartz Monzonite in the Hyder area, where its biotite has been dated by potassium-argon methods at 45 to 50 m.y. (Grove, 1971, p. 71; J. G. Smith, unpub. data).

### UNNAMED QUARTZ MONZONITE

An area of about 25 $km^2$ at the northernmost tip of the Granite Fiords study area is underlain by an unnamed body of quartz monzonite. This unit extends northward and eastward beyond the international boundary into British Columbia and also westward beyond the study area; consequently, its full form and extent are unknown.

Most samples from this unit are biotite-hornblende quartz monzonite, but a few are granodiorite and leucocratic quartz monzonite. The rock is commonly massive or only weakly foliated, and inclusions are generally rare.

Thin sections and modal analyses of stained slabs show average compositions of about 45 percent plagioclase (oligoclase and sodic andesine), 23 percent potassium feldspar, 22 percent quartz, 6 percent biotite, and 4 percent hornblende. The minor accessories include opaque minerals, apatite, sphene, and zircon. Alteration products are represented by traces of epidote-clinozoisite and chlorite.

The quartz monzonite intrudes the Hazelton(?) Group along contacts that are relatively sharp and easily delineated where exposures are adequate. However, contacts with a massive granodiorite pluton to the south are apparently gradational, and an inferred contact has been drawn that separates a predominantly quartz monzonite terrane from a predominantly granodiorite terrane.

The unnamed quartz monzonite is assigned a Tertiary age because of its lithologic and structural similarities to the Hyder Quartz Monzonite.

### GRANODIORITE

Granodiorite underlies about 100 $km^2$ in the upper Leduc River drainage near the northern boundary of the study area. The outcrop has an irregular oval outline within the study area but extends beyond the map boundaries at two locations.

About 58 percent of the samples from this unit are medium-grained biotite-hornblende granodiorite. Other lithologies include quartz diorite and diorite (16 percent), quartz monzonite (10 percent), and diverse gneiss and schist (14 percent). The pluton typically is massive or very weakly foliated. Commonly, even where an obscure foliation is noted in outcrop, no corresponding planar fabric can be identified in the hand specimen.

The mineralogy of the map unit, determined from thin sections and from modal analyses of stained slabs, averages that of a typical granodiorite: 51 percent plagioclase (oligoclase to andesine), 14 percent potassium feldspar, 18 percent quartz, 9 percent biotite, and 7 percent hornblende. The accessory minerals are apatite, sphene, opaque minerals, and, in many samples, zircon and monazite(?). The deuteric(?) alteration products epidote-clinozoisite, chlorite, and saussurite are ubiquitous but generally only in trace amounts.

The granodiorite intrudes both the Hazelton(?) and the undivided metamorphic units west of the upper Leduc River, where it forms sills parallel to the metamorphic foliation. These contacts are sharp and easily mapped in areas of good exposure. In contrast, contacts between the granodiorite, the Hyder Quartz Monzonite, and the unnamed quartz monzonite to the north apparently are gradational and difficult to map. On plate 1, therefore, we have drawn contacts of the granodiorite on the basis of average lithology in order to distinguish this pluton from two others chiefly of quartz monzonite.

The unnamed granodiorite is assigned a Tertiary age because of its apparently transitional relationship with the Hyder Quartz Monzonite.

### GABBRO

A gabbro stock, the first reported occurrence of this rock type in the Coast Range batholithic complex near Ketchikan, crops out about a kilometre south of the study area. Although outside the proposed boundary of Granite Fiords, the stock and adjacent country rocks are shown on plate 1 because the gabbro is unusual and because it contains enough magnetic minerals to produce a large aeromagnetic anomaly (see "Interpretation of Aeromagnetic Data"). The gabbro has a roughly circular outcrop area of about 10 $km^2$.

Outcrops of the gabbro are massive and weather a distinctive uniform dark brownish gray which clearly sets it apart from the enclosing banded, rusty-brown-weathering paragneiss. The gabbro is not discernibly foliated; the only visible structures are joints, exfoliation domes, and, locally, a crude cleavage that probably is parallel to the exfoliation.

Our reconnaissance investigation of the stock suggests that it may be mineralogically and texturally zoned. The central part consists of uniform, predominantly subophitic fine-grained gabbro containing labradorite and "late" oligoclase (65 percent), augite (10 percent), biotite (10 percent), hypersthene (5 percent), green hornblende (5 percent), magnetite (5 percent), and apatite. Specimens from one locality near the periphery are medium-grained and hypidiomorphic-granular and consist of poorly defined layers up to about 2 cm thick of rock alternately rich in hornblende and pyroxene. These specimens also contain augite, hypersthene, magnetite, apatite, and green hornblende but differ from the rocks in the core in containing somewhat more calcic labradorite and about 10 percent brown hornblende.

Except for minor granulation and for local hydrothermal alteration that has produced traces of chlorite, prehnite(?), and bastite serpentine, the gabbro is undeformed and fresh.

The gabbro intrudes, but does not significantly metamorphose, the paragneiss and quartz diorite units. These contact relations and the absence of metamorphic textures in the gabbro indicate that it is younger than the Cretaceous or early Tertiary regional metamorphism that so profoundly affected the older units. Preliminary potassium-argon studies on biotite from the gabbro indicate an age of about 23 m.y. (J.G. Smith, unpub. data). It therefore is younger than the 45- to 50-m.y.-old Tertiary plutons in the northeastern part of the study area. The gabbro, in turn, is intruded by the Tertiary lamprophyre dikes described below.

### LAMPROPHYRE DIKES

Hundreds of alined lamprophyre dikes occur throughout the study area. They are part of a dike swarm province whose full extent is unknown but which is larger than 15,500 km$^2$ (Smith, 1973). Most of the dikes are between ½ and 3 m thick; their extreme range is from a few centimetres to more than 15 m. Although the dikes are individually too small to show at the scale of our geologic map, we describe them here because they are an important geologic and scenic feature.

Individual dikes are remarkably uniform over long distances; they rarely branch or change thickness or direction. On bare, steep fiord and valley walls, dikes only a metre or so thick can be traced as ribbonlike bands up the cliffs for hundreds of metres. They strike across the glaciated uplands and ridges forming deep narrow furrows.

Fewer dikes were seen in areas underlain by metamorphic rocks than in areas of granitic rocks. Perhaps fewer dikes intruded the metamorphic rocks, but just as likely the dark lamprophyres were more easily overlooked in the similarly colored metamorphic rocks.

Differential erosion strongly emphasizes the dikes, especially in areas of granitic rock. Closely spaced longitudinal and cross joints make them easily eroded, and many dikes have been completely carved away. They are marked along the shores of the fiords only by deep mossy clefts with parallel walls. On the floors of the clefts are swift streams and abundant lamprophyre cobbles.

Attitudes of dike swarms and individual dikes are remarkably uniform. Most of the dikes dip within 10° of vertical and strike between N. 35° E. and N. 80° E. across the main structural grain of the area. Most of the fiords and large rivers parallel this trend for much of their lengths.

The lithology and distribution of the lamprophyre dikes in the study area and nearby parts of southeastern Alaska were described by Smith (1973).

The lamprophyres were emplaced between early Miocene and Pleistocene time. They cut the 23-m.y.-old gabbro stock and other Tertiary plutons in and near the study area and in turn are cut by feeders of Quaternary lava flows and grooved as a result of Pleistocene glaciation.

## QUATERNARY

### VOLCANIC ROCKS

Postglacial volcanic rocks crop out in three areas in Granite Fiords. The largest occurrence is at Punchbowl Cove and Punchbowl Lake. It has an irregular outcrop area of about 25 $km^2$ and consists of horizontal lava flows totaling several hundred metres thick and at least one cinder cone. The picturesque tablelands atop the flows, bounded by columnar-jointed vertical cliffs, are one of the main scenic features in the Punchbowl area.

The other two occurrences are smaller and less conspicuous. One is a 3-km-long tongue of flat-lying flows, about 100 m thick, that have partly filled a glacial valley at the head of Granite Creek. The other is less than 2 $km^2$ in area and consists of at least one rubbly lava flow on the coast of Behm Canal about 10 km north of the mouth of Rudyerd Bay.

Thin-section and chemical analyses of the volcanic rocks show that they are alkaline, ranging in composition from alkali olivine basalt to trachyandesite. The rocks commonly are dark brown or dark green, with numerous vesicles and calcite-filled amygdules. They generally are porphyritic or microporphyritic with fine trachytic, subophitic, and intergranular groundmasses. In some specimens, part of the groundmass is cryptocrystalline material too fine grained to resolve under the microscope.

The largest phenocrysts are centimetre-long rhombic tablets of intermediate plagioclase. The smaller phenocrysts range in size from half a centimetre to microphenocrysts a fraction of a millimetre long and include plagioclase, olivine, clinopyroxene and orthopyroxene, and hornblende. Potassium feldspar, in amounts up to several percent, forms a few microphenocrysts but generally is restricted to the cryptocrystalline groundmass. Other groundmass constituents include plagioclase microlites, olivine, pyroxene, opaque minerals, and cloudy submicroscopic material that probably is partly devitrified glass.

### SEDIMENTARY DEPOSITS

Sedimentary deposits of alluvium, moraine, and talus play an important role in the scenic beauty and wildlife habitat of Granite Fiords wilderness study area (fig. 7). Outstanding examples of such deposits are the broad alluvial flats along the Chickamin and Leduc Rivers, which drain the northern two-thirds of Granite Fiords. These flats locally form marshy nesting areas for birds and are sparsely populated by beavers, wolves, and other animals. They also are the only practical means of foot or pack-animal access from Behm Canal to the interior of the region.

Alluvial deposits of silt, sand, and gravel are present in all but the steepest river valleys and at the heads of coves and inlets, where the streams have built tidal flats. The largest alluvial deposits are in the Chickamin valley (fig. 7*A*), where river flats as much as 2 km wide are underlain by alluvium estimated to be up to hundreds of metres thick. Partial sections through the alluvium along some of the steep riverbanks show striking patterns of cross stratification that record the intricate postglacial history of the river.

The morainal deposits are virtually unsorted accumulations of unconsolidated sediments ranging from clay-size particles to blocks as large as houses. They occur in two principal settings: in valleys immediately below the snouts of glaciers; and atop glaciers as sinuous, locally merging trains of debris. The rushing glacial streams quickly rework the valley moraine, which merges downstream with alluvium.

The talus comprises blocky, angular deposits of loose rock and soil that mantle the valley slopes at the base of the cliffs (fig. 7*B*). The deposits are produced by weathering and mass wasting of the cliffs above, and they merge with the alluvium below. In addition, much of the talus is swept down by avalanches of rock and snow.

Our geologic reconnaissance precluded separate mapping of the various sedimentary deposits, and they therefore appear on plate 1 as a single map unit.

## STRUCTURE

The geologic structures of Granite Fiords fall into two main subdivisions on the basis of their size and significance:

1. Regional structures, encompassing hundreds of square kilometres.

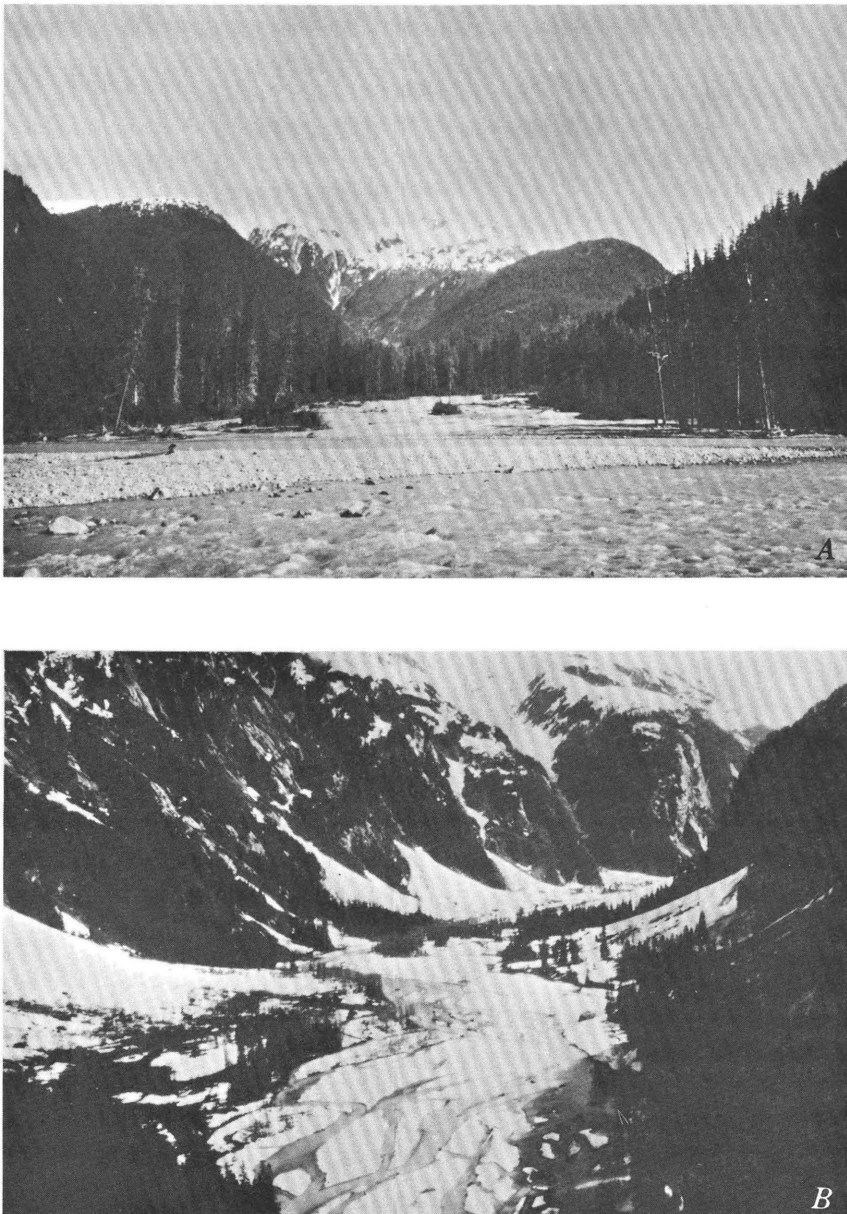



FIGURE 7.—*A*, Alluvial flats of the lower Chickamin River. The milky-gray, glacial-silt-laden river winds through a maze of brush- and tree-covered gravel bars. *B*, The flat-floored valley of the upper Chickamin contrasts sharply with the valley walls, which rise abruptly in kilometre-high, nearly vertical cliffs. Fan-shaped talus cones at the base of the cliffs merge with the river alluvium below.

These either are inferred from the outcrop patterns or relations among map units or are deduced from smaller structures.

2. Relatively local structural features, such as joints, small faults, folds, and most lineaments. These structures ordinarily are visible in a single outcrop but may persist for one or more mountain ranges.

### REGIONAL STRUCTURES

We recognized three regional structures in and adjacent to Granite Fiords. Two of them, a platelike terrane of paragneiss in the central part of the study area and a conspicuous lineament along Behm Canal, are shown on the geologic map (pl. 1) and described in more detail below. The third is a postulated zone of large-scale overthrust faulting involving the Hazelton(?) Group and Texas Creek Granodiorite in the northeastern part of the study area. We were unable to delineate this structure fully because of lack of time and unusually heavy snow cover, and therefore we have not depicted it on the geologic map. From the limited data available, however, the zone appears to consist of several subparallel, nearly horizontal thrust faults. In some places, it coincides with the lower contact of the Hazelton(?) Group; in others, it seems to be well above the base. The proposed thrust offsets the Hazelton(?) and Texas Creek units and is intruded by the Hyder Quartz Monzonite, which cuts across the fault zone without any offset. We therefore infer that the thrusting took place sometime between 200 and 50 m.y. ago.

The largest regional structure known in Granite Fiords is a 900-$km^2$ crudely tabular plate of paragneiss up to about 900 m thick that dips gently to moderately northeastward. The plate essentially coincides with the paragneiss map unit in the central part of the study area, and we accordingly call it the "central paragneiss terrane." Throughout its extent, the plate roofs the foliated granodiorite map unit, grading downward into the granodiorite through gneissic plutonic rock in which the foliation is parallel to that in the overlying paragneiss. The paragneiss also contains numerous isoclinal minor folds whose axial planes are parallel to the northeastward regional dip of the plate. The relatively flat structure of the central paragneiss terrane is in marked contrast to the nearly vertical foliation and minor fold axial planes in the paragneiss along Behm Canal.

The structural significance of the plate is uncertain. Platelike terranes of paragneiss have not been described elsewhere in the Coast Mountains of southeastern Alaska. Similar features in British Columbia, however, have been interpreted as parts of great, nappelike folds (Hutchison, 1970) and as domal roofs of subjacent plutons (Reesor, 1970).

In the northern part of the study area, the undivided metamorphic rocks and the rocks questionably assigned to the Hazelton Group also have a gentle to moderate regional dip to the northeast, suggesting that they either are part of the same feature as the central paragneiss terrane or of a subsidiary, parallel structure. In either case, it is noteworthy that although the projected regional dip of the paragneiss indicates that it structurally underlies the Hazelton(?), the paragneiss has not been found beneath it.

The largest lineament in the study area is Behm Canal, a remarkably straight fiord 3 km wide, 80 km long, and up to 620 m deep. For 41 km, it is the western boundary of Granite Fiords. Behm Canal is one of the many conspicuous linear features that characterize southeastern Alaska. It is mainly the result of intensive glacial scouring, presumably along a zone of structural or lithologic weakness. At the latitude of Walker Cove, the canal is marked by an abrupt bend parallel to a 20° regional change in strike of the bordering rocks.

Our investigation shows four reasons for glacial ice to have preferentially followed what is now Behm Canal.

1. The bordering and probably underlying rocks are composed mainly of relatively easily eroded amphibolite
2. The foliation in these rocks strikes parallel to the canal and dips vertically.
3. There is a prominent onland vertical fault zone on strike with Behm Canal at its northern end. We assume that the zone is a continuation of one or more parallel faults in Behm Canal.
4. There are Quaternary volcanic rocks at New Eddystone Rock and the New Eddystone Islands, just south of the mouth of Rudyerd Bay. Their occurrence in mid-Behm Canal suggests that the lineament at least locally marks a deep crustal fracture that provided a conduit for the extrusive rocks.

## LOCAL STRUCTURES

*Lineaments.*—Only a few of the hundreds of linear topographic features visible in aerial photographs of Granite Fiords are shown on the geologic map. The most conspicuous one, Behm Canal, is described above. Most of the others, interpreted from aerial photographs but not checked in the field, probably mark jointing and schistosity; a few probably reflect faults and shear zones. According to Smith (1973), most northeast-trending lineaments in Granite Fiords and adjacent areas are vertical joints occupied by Tertiary lamprophyre dikes.

*Joints.*—Joints, which are planar cracks in the rocks along which there has been no detectable lateral slippage, are abundant in all the rocks in the study area. The commonest variety are steeply dipping tectonic joints, produced in conjunction with deformation of the plutonic and metamorphic rocks. Some of these joints are filled with quartz and feldspar, others with epidote and quartz that locally carry small amounts of molybdenum and other metals; many that trend northeast are occupied by Tertiary lamprophyre dikes (Smith, 1973). Exfoliation joints, which are closely spaced, concentric thin shells of rock resembling an onion, and sheeting, which is characterized by nearly horizontal joints, are especially common in the plutonic rocks. Such joints probably result from expansion of the rocks under diminished confining pressures during uplift and unroofing of the plutons. Columnar joints, formed during cooling and contraction of extrusive volcanic rocks, are developed in many of the Quarternary lava flows. These joints commonly occur in three sets that intersect at an angle of 60° and produce the polygonal, closely packed vertical columns that characterize the steep cliffs at the edges of the flows.

*Folds.*—Hundreds of folds, ranging in amplitude and wavelength from a centimetre or so to tens of metres, occur in the metamorphosed rocks of the study area. They are especially common in the paragneiss and adjacent gneissose plutonic rocks. Many are parallel-limbed isoclinal folds, some of which in turn have been refolded, resulting in bizarre-looking, geometrically complex, composite folds (fig. 8). The folds in the paragneiss along Behm Canal generally have nearly vertical axial planes and plunge gently to moderately northwest and southeast. In contrast, many of the folds in the central paragneiss terrane and other metamorphosed bedded and intrusive rocks to the

FIGURE 8.—Composite or doubly folded fold in paragneiss, about 5 km north-northwest of Walker Lake.

northeast have axial planes that dip gently to moderately to the northeast, parallel to the regional schistosity of these units. Plunges of the folds vary from nearly horizontal in semirecumbent folds to nearly vertical in some of the refolded folds.

*Faults*.—Of all the geologic structures in Granite Fiords wilderness study area, faults proved to be the most difficult for us to identify and map, owing to the scarcity of persistent marker beds, the unusually heavy snow cover at the time of our investigation, and the lack of sufficient time to make the detailed studies necessary to reveal significant faults. Consequently, although we observed faults and shear zones in nearly every unit in the study area, we found none large or persistent enough to show on the geologic map. Most of the observed faults dip steeply; offset on them, wherever we could measure it, commonly is less than a metre. The sole exception to these small faults is the postulated overthrust fault zone in the northeastern part of the study area. Although it is as yet insufficiently mapped to show on the geologic map, we believe this zone is of regional significance. Despite their absence from our geologic map, we believe that there probably are several major faults in Granite Fiords, mainly because such faults have been recognized in comparable terranes in neighboring parts of Alaska and British Columbia (Twenhofel and Sainsbury, 1958; Eisbacher and Tempelman-Kluit, 1972).

## INTERPRETATION OF AEROMAGNETIC DATA

By Andrew Griscom

An aeromagnetic survey of the Granite Fiords wilderness study area was flown and compiled by Aero Service Corporation in 1972 along flight lines trending approximately N. 33° E. and spaced 1.6 km apart. The flight altitude was 1,830 m barometric and was locally increased by a few hundred metres so the surveying plane could safely clear the highest summits. Because of the irregular shape of the study area, the resulting magnetic map extends 2 to 12 km beyond the boundaries of the study area. Compilation scale was 1:63,360, and publication scale (pl. 1) is 1:125,000, with contour intervals of 10 and 50 gammas. The 1:63,360-scale aeromagnetic maps of the study area are published in a companion report (U.S. Geological Survey, 1976).

The local topographic relief between the summits and the bedrock floor of adjacent valleys is generally 1,000 to 1,500 m throughout the entire area. Many summits exceed 1,600 m, and a few exceed 2,000 m, the nominal flight altitude of the surveying aircraft. In an area of such high relief, if summits are very close to the surveying aircraft and are composed of magnetic rocks, then substantial local magnetic anomalies will be generated by the topography. This conclusion is amply demonstrated for the study area by the excellent correlation between the magnetic map and the topographic map in regions underlain mainly by plutonic rocks of the Coast Range batholithic complex. Here, magnetic highs and lows are in general closely associated with topographic highs and lows.

As a check on this conclusion, a series of selected topographic profiles were analyzed by means of a computer program that calculated the magnetic effect of the topography at the observation level of the survey aircraft. The results of the calculations indicate good agreement between observed and calculated magnetic anomalies throughout most of the area of Cretaceous or Tertiary plutonic rocks if one assumes that the apparent magnetic susceptibility of the rocks is in the range 0.0020–0.0025 emu/$cm^3$.

Magnetic susceptibility measurements on four samples of quartz monzonite, granodiorite, and quartz diorite from areas with magnetic anomalies caused by topography were consistent and gave an average susceptibility of 0.0015 emu/$cm^3$, in reasonable agreement with the calculated result, considering the limited sampling. Measurements on five samples of granodiorite, quartz diorite, and paragneiss from areas of low magnetic expression near the paragneiss (see discussion below) were scattered and had a much smaller average susceptibility of 0.0003 emu/$cm^3$.

Geologic interpretation of the magnetic map is substantially hindered by the large magnetic anomalies that the topography generates. These topographic anomalies range from 300 to 500 gammas in amplitude and probably obscure many features of smaller amplitude. Interpretation is thus restricted to those magnetic features of unusual amplitude, of greater width than the topographic anomalies, or of inverse correlation with topography. The following discussion proceeds in general from the southwest border of the study area at Behm Canal to the northeast boundary at the Canadian border.

Trending approximately along and parallel to the east shore of Behm Canal is a pronounced magnetic gradient that slopes up to a discontinuous linear magnetic high located 4–6 km east of the shoreline. This gradient and high do not correlate particularly well with topography and have the appropriate width and form to represent the magnetic expression of the southwest edge of a large mass of magnetic rocks. The gradient and high can be used to locate a boundary between magnetic rocks to the northeast and nonmagnetic rocks to the southwest. Calculations (magnetic profile and model, pl. 1) indicate that this boundary is located approximately at the steepest part of the magnetic gradient and thus trends parallel to, but 2–3 km east of, the curvilinear contact between the paragneiss and the plutonic rocks. South of lat 55°40′ N. this boundary gradually moves farther to the east of the Behm Canal shoreline, as does the paragneiss contact, until the magnetic effect of the young gabbro stock at the south end of the map obscures the location of the magnetic boundary. The calculated dip (pl. 1) on the magnetic boundary is 60° to the southwest, with an accuracy of ±10°. The calculated vertical depth extent of the boundary is at least 3 km. Regional magnetic data (Haines and others, 1971) indicate that this magnetic boundary is part of a much larger linear magnetic boundary trending approximately northwest and exceeding 600 km in length.

The contacts between the quartz diorite and foliated granodiorite are cut several times by this inferred boundary between magnetic and nonmagnetic rock. In addition, there is no indication on the magnetic map of any difference in magnetic properties between these two plutonic units on the northeast side of the boundary. The two plutonic units thus must have crystallized at approximately the same time in order to account for both their uniform magnetic properties where distant from the paragneiss and the uniformity of the boundary between magnetic and nonmagnetic rocks.

The magnetic map and magnetic property measurements indicate that plutonic rocks near the paragneiss are relatively weakly magnetic. The presence of such a zone of weakly magnetic rocks between the weakly magnetic paragneiss and strongly magnetic plutons supports the interpretation that the lithologic contacts between these units are transitional zones of mixed metamorphic and plutonic rocks. A further interpretation is that the plutonic rocks reacted locally with the paragneiss at the time of their emplacement in such a way that most of their magnetite was destroyed near the paragneiss.

At the south end of the map area near the top of the Behm Canal magnetic grandient is a circular magnetic anomaly, which is the largest anomaly on the magnetic map, having an amplitude of about 1,000 gammas. This anomaly is associated with a small gabbro stock. The width and form of the anomaly suggest that the concealed part of the top of the stock is about 4 km wide and that the marginal contacts dip outward. The amplitude of this anomaly is appropriate for such rocks, and there is no reason to suppose that the anomaly may have economic significance. It is tentatively regarded as a coincidence that this anomaly is located along the trend of the magnetic high that marks the eastern limit of the Behm Canal gradient.

The Quaternary volcanic rocks at Punchbowl Lake do not appear to have any magnetic expression. Young basalts are usually among the most highly magnetic of all rocks, so the absence of magnetic expression is probably because the basalts are thin and at low elevation, relatively distant from the magnetometer.

In the southwest half of the study area, a large area of paragneiss, the central paragneiss terrane, is generally associated with a relatively smooth and distinctive magnetic pattern. The terrane, where underlain by paragneiss, does not have associated magnetic anomalies, so most of the rocks of the paragneiss unit must be relatively nonmagnetic.

In a general way, the magnetic data show that the northern two-thirds of the central paragneiss terrane can be divided into three belts, trending approximately N. 30° W. and separated from each other by two narrow irregular belts of Cretaceous or Tertiary plutonic rocks. The westernmost of the three belts of paragneiss is associated with a magnetic low, and in general the hills of plutonic rocks within 1–2 km of this belt of paragneiss do not cause magnetic anomalies. It appears that plutonic rocks near the central paragneiss terrane are at most weakly magnetic, just as the previously discussed plutonic rocks near the paragneiss unit along the shore of Behm Canal. Near King Creek the westernmost of the two narrow irregular outcrop belts of plutonic rocks within the paragneiss terrane is associated with a pronounced linear magnetic high that extends from the northwest to the southeast edges of the study area. If one assumes that the plutonic rocks are relatively uniform in their magnetic properties where not associated with paragneiss, then this magnetic high is probably caused by a lessening of the depth to magnetic plutonic rocks on the east side of the westernmost belt of paragneiss (near Choca Creek). This assumption is illustrated in the calculation of the magnetic model on plate 1, a relatively simple two-dimensional model of a cross section of the paragneiss terrane. This model, which assumes a uniform apparent susceptibility of 0.0022 emu/cm$^3$ for the magnetic plutonic rocks, duplicates the observed magnetic data over the paragneiss area rather well, considering the simplicity of the model. The magnetic low along the eastern side of the paragneiss terrane is probably caused by a local thickening of the paragneiss to a total thickness of 1,500–2,000 m (pl. 1). The results of the calculation support and amplify the geologic interpretation that the central paragneiss terrane forms a crudely tabular plate that overlies the plutonic rocks of the batholith.

Northeast of the paragneiss area is a large region underlain by plutonic rocks of Cretaceous and Tertiary age. There, all the anomalies on the magnetic map are best explained as caused by the topography. Other magnetic features that may be present are obscured by these large topographic anomalies. As near Behm Canal, all the various plutonic rocks must be extremely uniform in their magnetic properties since there are no magnetic anomalies near their mutual contacts. In turn this uniformity suggests contemporaneous crystallization of some of the various plutons, an idea supported by the gradational nature of the plutonic contacts.

Near the Canadian border at the northeast edge of the study area are three areas of older rocks enclosed by Tertiary plutonic rocks. The largest such area is composed of layered rocks belonging to the Hazelton(?) Group and of the Texas Creek Granodiorite, which intrudes the Hazelton(?) Group. This large area of older rocks is associated with a very smooth magnetic field that has little correlation with topography. These rocks are much less magnetic than the Tertiary plutonic rocks. A small circular magnetic high (50,535 gammas) over the west end of the Texas Creek Granodiorite suggests that part of the unit may be weakly magnetic or perhaps that it is underlain at shallow depth by a tongue of the Hyder Quartz Monzonite. In addition, small linear magnetic highs (50, 611 and 50,615 gammas) over the Hazelton(?) Group 1.5 km to the north and 6.5 km to the northeast indicate the presence of a weakly magnetic unit—perhaps a tongue of Hyder—in this part of the group.

The magnetic map indicates that the relatively nonmagnetic, older layered and plutonic rocks extend to the east and north of the study area in the places where the magnetic field is relatively smooth. The most obvious such area is located to the east of the mapped exposures of Texas Creek Granodiorite. Here, the southern contact of the older rocks must lie to the south of the chain of smooth magnetic lows (50,227, 50,273, and 50,242 gammas) approximately at the position of the 50,350-gamma contour. The isolated sharp magnetic high (50,513 gammas) in the center of this smooth area is associated with a valley (Hidden Glacier) and is presumably caused either by a small unexposed plug of Tertiary plutonic rocks or by an unusual magnetic rock associated with the nonmagnetic older rocks. This feature might be worthy of examination for possible associated economic deposits, although it is well outside the study area.

## MINERAL RESOURCES

The mineral resources known in Granite Fiords wilderness study area consist of metalliferous lodes containing small amounts of gold, silver, molybdenum, copper, lead, and zinc. Traces of these and other metals were also detected in stream-sediment and rock samples. We found no mineral fuels, radioactive fuels, or nonmetallic minerals. The Punchbowl area, with the cinder cone and young extrusive rocks, may have geothermal potential. At present there are no active mines in the study area.

Our knowledge of the mineral resources in Granite Fiords is based mainly on four kinds of information: (1) published descriptions of prospected lodes within the study area; (2) published descriptions of productive lodes in geologically similar terranes adjacent to Granite Fiords; (3) the results of this study, which included mapping and grab sampling all observed altered zones and related mineral occurrences and systematic geochemical sampling of stream sediments and rocks; and (4) intensive quantitative sampling by the Bureau of Mines of prospects, mineral occurrences, and altered zones. The Bureau also resampled many of the rock geochemical sample localities that showed anomalous amounts of one or more metals.

## PROSPECTED LODES AND NEARBY PRODUCTIVE AREAS

Granite Fiords and neighboring areas of the southeastern Alaska Coast Mountains have been prospected for gold, silver, and other metals since the early 1900's. At least 20 lodes are known to have been staked within or just beyond the proposed boundary of the wilderness area (pl. 2), but except for a reported 1-ton test shipment from the Heckla in 1925 (Buddington, 1929) and 300–400 ounces of electrum from the Marietta (local residents), there is no record of any mineral production. Most of the prospected lodes are in the Banded Mountain–Texas Lake area in northeastern Granite Fiords, near the head of an old trail from Hyder, and one is on the Leduc River at the international boundary. Another three are near tidewater—one at the mouth of the Chickamin River and two at Walker Cove.

The main features of the prospects are summarized in table 1. Additional information on these prospects, collected by the Bureau of Mines during the present investigation, is given in the section on "Mineral Prospects and Occurrences."

Although Bureau of Mines engineers tried to examine every prospect in detail, several properties were covered by deep snow and could not be visited. Several others could not be found because dense vegetation probably has grown over the early workings. For some prospects published descriptions or descriptions on claim records were either erroneous or too vague to follow.

Elsewhere in the Coast Mountains near Granite Fiords, early prospectors staked numerous lodes in the Hazelton(?) Group and Texas Creek Granodiorite between the northeastern boundary of the study area and Hyder (Buddington, 1929). Small test shipments of ore containing gold, silver, copper, lead, and zinc were made before 1929 from several of these lodes, but only the Riverside mine, near Hyder, produced significant amounts of ore (Byers and Sainsbury, 1956). About 26,000 metric tons of ore, containing tungsten in addition to the above metals, were shipped from this mine between 1925 and 1951, the last year of recorded production.

Several major mines nearby in British Columbia have produced large amounts of ore. These include the Granduc copper-silver mine, a few kilometres north of the study area (Dudas and Grove, 1970; Holland, 1972, p. A55), and the inactive but once famous Silbak-Premier gold-silver-lead-zinc mine, about 16 km east of the northeastern boundary (Grove, 1971, p. 153–161).

TABLE 1.—*Prospects, Granite Fiords wilderness study area, Alaska*

[*, asterisk indicates recent activity; no asterisk indicates none]

| Name of property | U.S.G.S. designation | U.S.B.M. designation | Type and dimensions | Country rocks | Structure (strike/dip) | Minerals and valuable elements reported |
|---|---|---|---|---|---|---|
| Marietta | 1a | P–1 | ---------- | ---------- | ---------- | Gold, electrum: Pb, Zn, Ag, Au. |
| Silver King | 1b | P–1 | Quartz fissure vein 15–75 cm thick; contains up to 20-cm-thick lens of solid sulfide. | Graywacke and argillite of Hazelton(?) Group; quartz diorite dike of Texas Creek Granodiorite. | Quartz vein: N. 35° W./35° NE. | Sphalerite, galena, pyrite, chalcopyrite, arsenopyrite, (barite): Zn, Pb. Au, Ag, Cu. |
| Stampede | 2 | P–2 | Quartz fissure veins; sulfide stringers; mineralized aplite dike. On "Copper claim," sulfide-bearing quartz stringer lode 3–5 m wide traced for about 50 m. | Graywacke and black slate of Hazelton(?) Group. | Stringer lode: N. 30° W./45° W.; "bedding": N70–80E/"N." | Galena, sphalerite, pyrite, chalcopyrite: Zn, Pb, Cu. |
| Double Anchor | 3 | P–3 | Quartz breccia zones: subhorizontal zone 37–195 cm thick is exposed along strike for 220 m; zone dipping 60° W. is 60–86 cm thick and exposed along strike for 50 m. | Graywacke and argillite of Hazelton(?) Group. | Shear zone: N. 70° E/0–60° W. | Pyrite, galena, sphalerite, chalcopyrite: Cu, Pb, Zn Au, Ag, Mo. |
| Chickamin | 4 | P–4 | Quartz fissure veins (stringer lode); quartz vein 1 m thick. | Graywacke of Hazelton(?) Group. | Stringer lode: N. 25° W/50° NE.; quartz vein: N. 30° W./?. | Galena, chalcopyrite, sphalerite, pyrite, pyrrhotite, tetrahedrite: Pb, Zn, Cu. |
| Lake | 5 | P–5 | Quartz fissure vein about 30 cm thick. | Quartz diorite of Texas Creek Granodiorite. | Quartz vein: N. 35° W./60° E. | Galena, pyrite, chalcopyrite: Pb, Cu. |
| Lakeside* | 6 | P–6 | Quartz veins 30 cm thick. | Texas Creek Granodiorite. | Quartz vein; N. 25° W./65° E. | Pyrite, galena: Cu, Pb. Zn, Ag. |
| Blasher* | 7 | P–7 | Quartz vein 21–61 cm thick with 42-m strike exposure. | Quartzite and hornfels of Hazelton(?) Group and Texas Creek Granodiorite. | Quartz vein: N. 50° W./60°–70° NE. | Chalcopyrite, galena, sphalerite, pyrrhotite, pyrite, molybdenite: Cu, Pb, Zn, Ag, Mo, Au. |
| Cathedral | 8 | P–8 | Quartz vein 1–2 m thick and other smaller veins. | Graywacke of Hazelton(?) Group. | Quartz vein: N. 0°–5° E./50° E. | Sphalerite, galena, chalcopyrite: Au, Ag, Pb, Zn, Cu. |

**TABLE 1.**—*Prospects, Granite Fiords wilderness study area, Alaska*—Continued

| Name of property | Reported values | Reported development work | Source of information | Examined during present investigation? | Year first staked | Remarks |
|---|---|---|---|---|---|---|
| Marietta | | 32-m drift | Prospectors' reports; present investigation. | Partly | 1925 | Rumored production of 300 to 400 oz of gold in 1937. Mostly covered by snow during present investigation. Area restaked as Solo (1937), Electrum (1950), and Alaska State Mines (1958). Partly covered by Pecos claims staked in 1970. Old Silver King prospect reportedly in this vicinity. |
| Silver King | Sample of galena from "upper exposure": 1.28 oz Au and 5.96 oz Ag per ton; 55.2 percent Pb; 2.2 percent Cu. | Lower exposure of vein stripped for 15 m; upper exposure stripped for 2.5 m. | Buddington (1929, p. 99–100). | Searched for but not found. | 1925 | Reportedly in the vicinity of Marietta but at lower elevation and possibly farther south. |
| Stampede | | Two open cuts on "Copper claim." | Buddington (1929, p. 99) (called Dugas); present investigation. | Yes | 1925 | Small, widely spaced quartz veins and sulfide stringers are parallel to "bedding" of country rocks. Fractures in aplite dike are thinly coated with sulfides. Veins sampled during present investigation (and alinement of old cuts) are N. 45° E "E."; "bedding" in country rocks is "E." steep S. Also known as Dugas and Blasher Extension. Covered by Alaska State Mines Extension claims staked in 1958. |
| Double Anchor | | Short adits and pits. | Buddington (1929, p. 99). | do | 1923 | Quartz breccia zones in shear zones parallel to and cross-cutting horizontal bedding. Covered by Alaska State Mines Extension claims staked in 1958. |
| Chickamin | | "Practically none" | Buddington (1929, p. 100). | Searched for but not found. | 1925 | Veins exposed for very short lengths. |
| Lake | | | Buddington (1929, p. 101); present investigation. | Yes | 1923 | Vein in quartz diorite just below contact with the overlying Hazelton(?) Group. |
| Lakeside* | | Several pits | Present investigation | do | 1923 | Massive quartz boulders close to outcrop of smaller vein. Lakeside is probably a relocation of the Morning claims. Area covered by Lone Star Group in 1970. |
| Blasher* | | Short drift and pits | Buddington (1929, p. 100); present investigation. | Yes | 1923 | Covered by 32 claim Lone Star Group in 1970. |
| Cathedral | | Approximately 3-m-long stripped area. | Present investigation | do | 1930 | Small veins are at locality shown on plate 2; 2-m vein is about 240 m north-northeast of this locality. Lodes are intensely iron stained. |

TABLE 1.—*Prospects, Granite Fiords wilderness study area, Alaska*—Continued

| Name of property | U.S.G.S. designation | U.S.B.M. designation | Type and dimensions | Country rocks | Structure (strike/dip) | Minerals and valuable elements reported |
|---|---|---|---|---|---|---|
| Hummel Canyon | 9 | P–9 | Pyritic, silicified zone 18–30 cm thick. | Banded hornfels of Hazelton(?) group. | "Banding": N. 10° E./85° E. | Pyrite: Cu, Pb, Zn, Mo, Ag. |
| Swennings Greenpoint. | 10 | P–10 | Sulfide-bearing quartz veins. | Hornfels of Hazelton(?) Group near contact with Hyder Quartz Monzonite. | Veins: N. 30° W./65°–70° NE. | Galena, molybdenite: Pb, Mo, Zn, Cu, Ag. |
| Greenpoint Group*. | 11 | P–11 | Sulfide-bearing quartz-calcite veinlets 1 cm to 15 cm thick. | Hornfels of Hazelton(?) group. | Vein/fracture systems: N. 10° E.–N. 10° W./70° E.–75° W.; S. 45°–60° E./65°–85° NE.; N. 60° E/65–85° NW. | Pyrite, galena, molybdenite, chalcopyrite: Pb, Mo, Ag. |
| Heckla* | 12 | P–12 | Quartz fissure vein exposed for 25 m. | Graywacke of Hazelton(?) Group. | Quartz veins: N. 0°–30° E./43°–80° E. | Galena, pyrrhotite, sphalerite, chalcopyrite, molybdenite: Ag, Au, Pb, Zn, Cu, Mo. |
| Jumbo* | 13a | P–13 | Quartz fissure veins 15–60 cm thick. | Graywacke of Hazelton(?) Group. | Quartz veins: N. 10° E./steep; "bedding": N. 60°–70° W./steep. | Pyrite, galena, molybdenite: Ag, Pb, Mo. |
| Marmot—lower basin* | 13b | P–13 | Sulfide-bearing quartz veins and massive sulfide stringers. Veins are up to 45 cm thick; stringers are up to 15 cm thick. | Banded, variegated hornfels, phyllite, and fine-grained schist of Hazelton(?) Group; andesite of Texas Creek(?) Granodiorite; and aplite dikes of Hyder(?) Quartz Monozonite. | "Banding": N. 45° W./70° SW.–90°. | Chalcopyrite, galena, pyrite, molybdenite: Au(?), Cu, Mo, Pb, Zn, Ag. |
| Marmot—upper basin* | 14 | P–14 | | | | |
| Edelweiss* | 15 | P–15 | Quartz fissure vein. | Hazelton(?) Group. | ------------------------ | Galena, pyrite: Au, Ag, Pb. |
| Galena* | 16 | P–16 | Quartz stringers occupying several fracture systems; best mineralization is in 60°-East-dipping set 3 to 15 cm thick. | Hornfels of Hazelton(?) Group. | Quartz stringers N. 15° E./50°–60° E. | Pyrite, galena, sphalerite, molybdenite, chalcopyrite: Pb, Zn, Ag, Mo, Cu. |
| Goat, Cub* | 17a | P–17 | Locally sulfide-bearing quartz-calcite veins up to 15 cm thick. | Banded hornfels (metagraywacke) and argillite. | Veins: N. 15°–75° W./50° NW.–90°. | Pyrrhotite, chalcopyrite: Au(?), Cu. |
| Glacier* | 17b | P–17 | Quartz fissure veins 5–30 cm thick and several metres apart. | Graywacke: andesitic tuff and breccia. | Quartz veins: N. 50° E./45° SE., N. 20° W./45° NE.; "bedding": E/60° S. | Pyrite, pyrrhotite, chalcopyrite, galena: Au, Ag, Cu, Pb. |

TABLE 1.—*Prospects, Granite Fiords wilderness study area, Alaska*—Continued

| Name of property | Reported values | Reported development work | Source of information | Examined during present investigation? | Year first staked | Remarks |
|---|---|---|---|---|---|---|
| Hummel Canyon | ---------- | 3.4-m adit | Present investigation | Yes | ? | |
| Swennings Greenpoint. | ---------- | ---------- | do | do | 1930 | Veins in Hazelton(?) hornfels 15 m from Hyder Quartz Monzonite. |
| Greenpoint Group*. | ---------- | Small pit and open cut. | do | do | 1970 | Covers old Heckla prospect. |
| Heckla* | 0.08 oz Au and 54.3 oz Ag per ton; 21.6 percent Pb, 32.1 percent Zn; 4.1 percent Cu (picked sample). | Stripping; reported drilling and sampling. | Buddington (1929, p. 101–102); present investigation. | do | 1925 | One ton test shipment of ore was brought out to West Fork (Texas Creek) trail for shipment to smelter in 1925. Ore was broken from surface of outcrop. Covered by Greenpoint group of claims located in 1970. |
| Jumbo* | ---------- | ---------- | do | Original workings searched for but not found. General area examined. | 1925 | Graywacke cut by dikes of altered gabbro. Covered by snow during present investigation. Old Jumbo prospect is on present Marmot group of claims. |
| Marmot—lower basin*<br>Marmot—upper basin* | ---------- | Small amount of stripping. | Present investigation | Yes | 1969 | Some veins and stringers are parallel to the banding in the hornfels. Mineralized zone is intensely iron stained. Marmot group of 51 claims covers old Edelweiss and Jumbo prospects. |
| Edelweiss* | 1.6 oz Au and 10.2 oz Ag/ton (picked sample). | ---------- | Buddington (1929, p. 101); present investigation. | do | 1925 | Found galena-bearing quartz vein 0.3 m thick, N. 30° E./90°, on probable original Edelweiss claim. Old Edelweiss prospect is on present Marmot group of claims. |
| Galena* | ---------- | ---------- | Present investigation | do | 1969 | Thin galena-bearing quartz veins presently covered by Marmot claim group. |
| Goat, Cub* | ---------- | ---------- | do | do | 1969–70 | Mostly covered by snow during present investigation. |
| Glacier* | 0.04 oz Au and 6 oz Ag per ton; 3 percent Cu. | 8-m-long stripped area; 2.4 m tunnel. | Buddington (1929, p. 120–121). | Searched for but not found. | 1923 | Lamprophyre dike 1 m thick. Found reported cabin site but no stripping or tunnel. Upper end of old Glacier prospect may be on present Goat group of claims. |

TABLE 1.—*Prospects, Granite Fiords wilderness study area, Alaska*—Continued

| Name of property | U.S.G.S. designation | U.S.B.M. designation | Type and dimensions | Country rocks | Structure (strike/dip) | Minerals and valuable elements reported |
|---|---|---|---|---|---|---|
| Alamo* | 18 | P–18 | Sulfide-bearing zone 25 m wide; minor quartz veins. | Pelitic gneiss and schist near contact with foliated granodiorite. | Zone trends north-northwest and dips steeply northeast, parallel to foliation in country rocks. | Chalcopyrite, pyrite: Cu, Zn, Au, Ag. |
| Marble Copper*? | 19 | P–19 | Marble-skarn zone. | Marble and pelitic gneiss and schist of paragneiss; near contact with foliated granodiorite. | Zone trends north and dips steeply west, parallel to foliation in country rocks. | Chalcopyrite: Cu, Ag, Au. |
| Gnat | 20 | P–20 | Glassy quartz fissure vein 2.5 m thick. | Granodiorite | Quartz vein: N. 30° W./ 60° NE. | Pyrite, molybdenite, chalcopyrite, galena: Mo, Cu, Pb. |
| Joker | 21 | P–21 | Quartz-calcite fissure veinlets. | Fine-grained schist of Hazelton(?) Group cut by aplitic quartz monzonite dikes. | "Bedding": N. 45° E./ 48° NE.; dike: N. 30° W/ 25° SW. | Pyrite, molybdenite(?): Mo. |

TABLE 1.—*Prospects, Granite Fiords wilderness study area, Alaska*—Continued

| Name of property | Reported values | Reported development work | Source of information | Examined during present investigation? | Year first staked | Remarks |
|---|---|---|---|---|---|---|
| Alamo* | | Drilling; open-cuts | Present investigation | Yes | 1969 | Zone is intensely iron stained. |
| Marble Copper*? | | Shallow cut | do | do | ---- | No evidence that claims were staked. |
| Gnat | | | Buddington, (1929, p. 120); present investigation. | do | 1900(?) | |
| Joker | | | Present investigation | do | 1954 | Intense iron oxide alteration within 15 cm of dikes. Sulfides very sparse; mainly associated with veinlets. Located as molybdenum prospect. |

## ALTERED ZONES AND RELATED MINERAL OCCURRENCES

About 70 altered zones (termed "mineralized areas" on fig. 16 and pages 123–134, marked by bleaching or by conspicuous ochre- and red-weathering rocks (gossan), were mapped in and near Granite Fiords wilderness study area during the present investigation (pl. 2). Only about half a dozen of the zones shown on plate 2 are at or near the prospected lodes listed in table 1; the rest are newly mapped. The bright coloration of these zones is due mainly to weathering, under conditions of high rainfall, of pyrite and other iron-bearing sulfides to form various hydrous iron oxides (limonite). The process also produces quantities of weakly acidic groundwater, which promotes still deeper leaching and ultimate conversion of the host rocks to weakly coherent aggregates of clay minerals, earthy limonite, and quartz.

The zones range in size from isolated patches a few square metres in area to bands hundreds of metres wide and several kilometres long. They occur in four main settings: (1) in the central paragneiss terrane near contacts with foliated and gneissic plutonic rocks; (2) in paragneiss inclusions and roof pendants within the plutons; (3) in paragneiss screens between adjacent plutons; and (4) in the Hazelton(?) Group and Texas Creek Granodiorite.

The altered zones in all three paragneiss settings typically contain small amounts of pyrite and, rarely, traces of pyrrhotite, chalcopyrite, galena, and molybdenite. In many of the zones, the sulfides have been entirely leached, leaving only limonite-coated boxlike cavities to mark former sites of the metallic minerals. Quartz stringers are present, but thick, persistent veins are uncommon. Most of the zones consist of intensely iron-stained bands, several centimetres to a few metres wide, that alternate with comparably sized bands of unaltered rock. In many places the altered bands contain abundant pale-brown to colorless mica. These "bleached mica" bands can be traced along strike into layers of unaltered biotite-rich pelitic gneiss, suggesting that the original composition of the pelitic gneiss favored sulfide formation and subsequent alteration in preference to the intercalated biotite-poor members of the paragneiss unit. With few exceptions, the strike and dip of the altered zones are parallel to the foliation of the enclosing unaltered gneiss and schist.

Most of the altered zones in the Hazelton(?) Group and closely associated Texas Creek Granodiorite have probably been examined at least once by prospectors, and several were staked as long ago as 1923 (table 1; pl. 2). As in the paragneiss, some of these zones are barren or carry only traces of sulfide minerals. Most, however, contain visible pyrite, and some contain stringers and veins up to several centimetres thick of one or more sulfide minerals, including pyrite, pyrrhotite, chalcopyrite, galena, sphalerite, molybdenite, tetrahedrite, and arsenopyrite. Some zones are characterized by sulfide-bearing quartz stringers, others by relatively large, persistent quartz veins. In places, sulfides also occur in sparsely disseminated minute grains in the country rocks between the veins.

The main geologic features of the altered zones and related mineral occurrences in the Hazelton(?) and Texas Creek units are as follows:

1. The country rocks are deformed but not strongly metamorphosed; many show relict sedimentary and igneous textures.
2. Many zones are at or near the contact between the Hazelton(?) and Texas Creek, or near the margins of aplite and quartz monzonite dikes that intrude both units.
3. Some altered zones are along faults characterized by milling (cataclasis) of Hazelton(?) and Texas Creek rocks.

Chemical analyses of samples from the altered zones throughout the study area show metal contents ranging from indeterminate traces to locally significant amounts of gold, silver, molybdenum, copper, lead, and zinc. The distribution and abundance of these metals, which may occur singly or in combination, are described more fully under "Geochemical Studies," "Mineral Commodities," and "Mineral Prospects and Occurrences."

## GEOCHEMICAL STUDIES

A geochemical survey of the study area was conducted in order to identify areas with a relative enrichment of certain elements of economic interest, specifically areas that might contain previously unknown or concealed mineral deposits. More than 1,500 samples, including 625 stream-sediment samples and 877 rock samples, were collected, analyzed, and evaluated in terms of their element content and geologic environment. The sample locations are shown in plate 2; complete geochemical data are described in two companion reports (Koch and others, 1976a, b). In addition, a computer tape (N.T.I.S. catalog No. P–232–049) of the analytical data can be obtained from National Technical Information Service, Department of Commerce, Springfield, VA. 22161.

We collected stream-sediment samples from the active stream channel wherever possible; where this was not possible, we sampled the stream sediment adjacent to the active channel. Silt-sized and finer sediments free of visible organic material were chosen wherever available. The samples were dried, sieved, and the minus-80-mesh fractions reserved for analysis.

Two types of rock samples were collected for geochemical analysis, one to determine the background levels of 31 common elements in the principal rock types, the other to test the metal content of suspected metalliferous rocks and minerals. We collected background geochemical rock samples at more than 500 geology stations throughout the study area. Their selection was basically unbiased, and the sample density is relatively uniform. This extensive sample group served to establish threshold (lowest positively anomalous) values for several elements of economic interest (see below).

Rock samples collected for possible metal content (1) contained visible sulfide minerals or alteration products characteristic of sulfide mineralization; (2) typified altered zones such as those described on page 43; (3) came from any other bleached or iron-stained zones along contacts, joints, fractures and shear zones; and (4) were from quartz, quartz-epidote, and pegmatite veins. Many individual rock specimens satisfied more than one of these conditions. All rock samples were pulverized before analysis.

The stream-sediment and rock samples were analyzed by standard semiquantitative spectrographic and atomic absorption methods similar to those described by Ward, Lakin, Canney, and others (1963). The semiquantitative six-step spectrographic analyses report values for 30 elements in parts per million (ppm) or in percentage to the nearest number in the series 1, 1.5, 2, 3, 5, 7, 10, etc. The precision of the reported value is approximately plus 100 percent or minus 50 percent. Atomic absorption analyses were made for gold, copper, lead, and zinc; analyses for mercury by instrumental methods were also made. For the reader's convenience, table 2 converts parts per million to percent and to troy ounces per ton, and vice versa. The spectrographic and chemical analyses were made in a U.S. Geological Survey field laboratory at Anchorage, Alaska, and at the Survey's main laboratories in Denver, Colo.

## EVALUATION OF SAMPLE DATA

We evaluated the geochemical distribution in Granite Fiords of gold, silver, molybdenum, copper, lead, and zinc, both for their intrinsic economic value and as possible indicators of undiscovered mineral deposits. We selected these metals because they are known to occur in lode deposits in Granite Fiords and in adjacent areas and because they are the only ore metals present in anomalous amounts in a significant number of our samples. Because tungsten ore was mined at the Riverside mine, about 10 km east of the northeastern boundary of the study area, all samples were analyzed for this metal. However, it was detected in only four samples, all in amounts at or below the lower limit of spectrographic determinability, and therefore is not considered further in this report.

For stream-sediment samples, we considered the highest 5 percent of all analytical values for each element to be potentially anomalous and chose the "step" value closest to this percentile as the threshold value. In this report, the threshold value is the lowest positive anomalous value for each element.

**TABLE 2.**—*Conversion of parts per million to percent and to troy ounces per ton and vice versa*

[Conversion factors: 1 lb avoirdupois = 14,583 oz troy; 1 ppm = 0.0001 percent = 0.0291667 oz troy per short ton = 1 gram per metric ton; 1 ounce per ton (Au or Ag) = 34.286 ppm = 0.0034286 percent]

| Parts per million to percent to ounces per ton | | | Ounces per ton to percent to parts per million | | |
|---|---|---|---|---|---|
| Ppm | Percent | Ounces per ton | Ounces per ton | Percent | Ppm |
| 0.01 | 0.000001 | 0.0003 | 0.01 | 0.00003 | 0.3 |
| .02 | .000002 | .0006 | .02 | .00007 | .7 |
| .05 | .000005 | .0015 | .05 | .00017 | 1.7 |
| .10 | .00001 | .003 | .10 | .00034 | 3.4 |
| .20 | .00002 | .006 | .20 | .00069 | 6.9 |
| .30 | .00003 | .009 | .30 | .00103 | 10.3 |
| .40 | .00004 | .012 | .40 | .00137 | 13.7 |
| .50 | .00005 | .015 | .50 | .00171 | 17.1 |
| .60 | .00006 | .017 | .60 | .00206 | 20.6 |
| .70 | .00007 | .020 | .70 | .00240 | 24.0 |
| .80 | .00008 | .023 | .80 | .00274 | 27.4 |
| .90 | .00009 | .026 | .90 | .00309 | 30.9 |
| 1.0 | .0001 | .029 | 1.0 | .00343 | 34.3 |
| 10.0 | .001 | .292 | 10.0 | .03429 | 342.9 |
| 20.0 | .002 | .583 | 20.0 | .06857 | 685.7 |
| 50.0 | .005 | 1.458 | 50.0 | .17143 | 1,714.0 |
| 100.0 | .01 | 2.917 | 100.0 | .34286 | 3,429.0 |
| 500.0 | .05 | 14.583 | 500.0 | 1.71 | 17,143.0 |
| 1,000.0 | .10 | 29.167 | 1,000.0 | 3.43 | 34,286.0 |
| 10,000.0 | 1.00 | 291.667 | 10,000.0 | 34.29 | 342,857.0 |

Determining the threshold values for elements in rock samples required consideration of the two basically different classes of samples described above—the background samples of the various rock units and those samples selected for their alteration, sulfide content, or special lithology. We thus were able to base our rock geochemical threshold values on two main criteria—the frequency distribution of the analytical values for each element and the behavior of the particular element in this terrane.

*Gold.*—The lower limit of determination for gold by the atomic absorption method is 0.05 ppm. Less than 2 percent of all the rock and stream-sediment samples contained this amount. We consider all such samples anomalous.

*Silver.*—Silver concentrations of less than 0.5 ppm are not determinable by semiquantitative spectrographic analysis. Silver in amounts of 0.5 ppm or more was reported in less than 2 percent of all stream-sediment samples, and these are considered anomalous. Rock samples with 1.5 ppm or more silver, also approximately 2 percent of the total, are regarded as anomalous.

*Molybdenum.*—Molybdenum values of 7 ppm or more occur in approximately 7 percent of the stream-sediment samples. The threshold value in rock samples is designated as 20 ppm molybdenum, reported in about 2 percent of the analyses.

*Copper.*—Copper values of 150 ppm or more occur in approximately 5 percent of all stream-sediment samples analyzed by semiquantitative spectroscopy. Copper values from stream sediments analyzed by the atomic absorption method are systematically lower than corresponding values by the semiquantitative spectrographic method, and we established a threshold one step lower (100 ppm) for these analyses to compensate partly for this analytical difference. However, only 1 percent of the copper values determined by atomic absorption equal or exceed even this lower threshold. Rock samples with reported values, by either analytical method, of 300 ppm or more copper, approximately 2 percent of the total, are considered anomalous.

*Lead.*—Lead values from stream sediments analyzed by atomic absorption are also systematically lower than corresponding values obtained by semiquantitative spectroscopy. Spectrographic values of 70 ppm or more lead occur in approximately 3 percent of the stream-sediment samples, whereas only 1 percent of the atomic-absorption-analyzed samples contain 50 ppm or more. The threshold value chosen for lead in rock samples is 100 ppm by either method; this value was reported in about 1 percent of the analyses.

*Zinc.*—Because the lower limit of determination for zinc by the spectrographic method is relatively high (200 ppm), any determinable zinc reported by this method in stream-sediment and rock samples is considered anomalous. As with copper and lead, we set the threshold value for zinc in stream-sediments analyzed by atomic absorption one step lower at 150 ppm. Anomalous zinc values were reported in less than 1 percent of the stream-sediment samples analyzed by either method. To match the spectrographic limit, we selected a threshold value of 200 ppm for zinc in rock samples analyzed by atomic absorption. This value was reported in about 2 percent of all rock analyses.

## GEOCHEMICAL PATTERNS

The geological significance of the geochemical data is illustrated in figure 9, which shows the relation of all anomalous rock and stream-sediment samples to selected map units. The elements present in anomalous amounts at each sample locality are represented by their chemical symbols. The analytical value of an anomalous element at any sample locality can be obtained by referring to the corresponding locality on the individual metal maps (figs. 10–15). In addition, table 3 contains additional analytical and geological data for all anomalous rock samples.

The distribution of anomalous metal values in figure 9 shows certain gross patterns. Stream-sediment and rock samples that contain anomalous amounts of one or more metals are particularly abundant in or near the paragneiss terrane in the western half of the study area. It is especially noteworthy that samples containing two or more anomalous elements are almost all located either within, or less than a mile from, the paragneiss unit. The northeastern part of the study area contains fewer anomalous values than would be predicted from the abundance of prospected lodes in the Hazelton(?)–Texas Creek terrane. This deficiency, however, is mainly due to heavy snow and ice cover that severely limited sampling in that area and not to lower values.

Anomalous metal values are relatively sparse in granitic terrane, and except near contacts with the paragneiss unit, where the plutons commonly contain abundant paragneiss roof pendants and inclusions, the few anomalies within this terrane are almost exclusively of single elements.

## MINERAL COMMODITIES

The valuable metals known in the study area are gold, silver, molybdenum, copper, lead, and zinc. Other metals also occur but none appear to be of potential commercial value. The principal commodities, which occur both singly and in combinations of two or more metals, are found in several settings: (1) in the prospects; (2) in largely unprospected altered zones; (3) in rocks containing sulfide minerals and, in a few places, in rocks without any megascopically visible sulfides; and (4) in stream sediments.

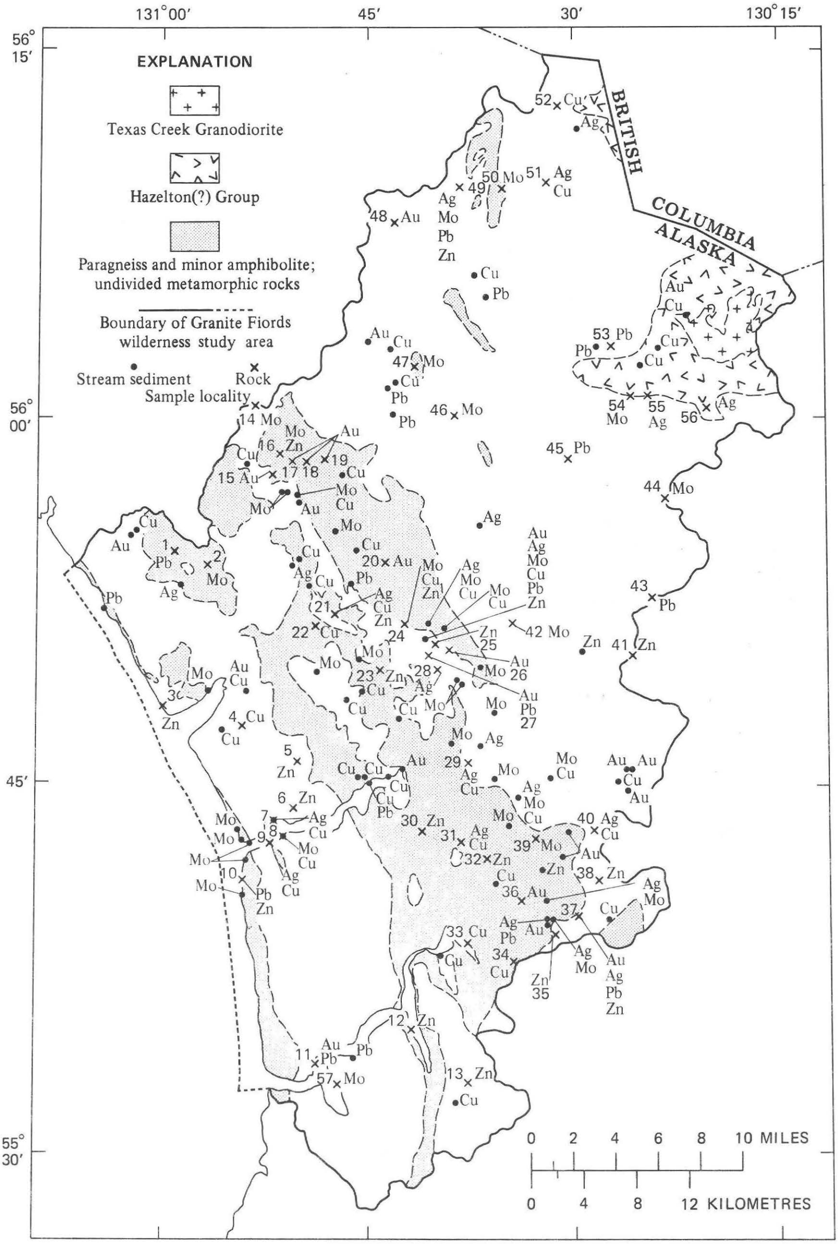



FIGURE 9.—Relation of anomalous rock and stream-sediment samples to selected geologic units. Unpatterned areas are largely underlain by granitic rocks. Au, gold; Ag, silver; Mo, molybdenum; Cu, copper; Pb, lead; Zn, zinc. Numbers refer to analyses of rock samples in table 3.

All metal occurrences in settings 2, 3, and 4 (table 3) were detected by geochemical sampling methods during the present investigation. Metal occurrences in the prospects (table 1) are known partly from earlier studies (Buddington, 1929) and partly from examinations, chiefly by the Bureau of Mines, during the present investigation.

All mineral occurrences in the area are in bedrock; no commercially valuable placer deposits are known.

## GOLD

Gold occurs mainly in the western and northeastern parts of the study area (fig. 10). It is reported in 11 of the prospected lodes (pl. 2; table 1), 9 of which are in Hazelton(?) and Texas Creek terrane in northeastern Granite Fiords. The remaining two are at Walker Cove—one in pelitic gneiss and schist (No. 18, table 1 and fig. 10) and the other in a marble (skarn) zone in the paragneiss unit (No. 19); both are near the contact of foliated granodiorite. Three of the occurrences (13b, 14, and 17a) in the northeastern area are considered to be doubtful because prospectors' reports of gold in them could not be fully verified.

The gold in the northeastern lodes occurs both as megascopically invisible flakes of native metal and in solid solution in sulfide minerals, chiefly pyrite, galena, and tetrahedrite (Buddington, 1929, p. 48). It is everywhere associated with sulfide minerals and occurs in quartz fissure veins and stringer lodes, massive sulfide veins, and disseminated deposits (Buddington, 1929, p. 42–44).

The traces of gold in the Walker Cove lodes probably occur mainly in solid solution with chalcopyrite and pyrite.

Gold values reported from the lodes in the Hazelton(?)–Texas Creek terrane range from about 0.04 to 1.6 oz per ton (table 1). However, for most of the lodes, the results of assays made by early and recent prospectors are not known. Most of these lodes were systematically sampled by the U.S. Bureau of Mines during the present investigation. Gold assays of these samples are reported mainly in tables 6–9, 12, and 14 and in figures 17, 21, 27, 28, and 30.

Our geochemical investigations revealed 12 rock samples that contain anomalous amounts of gold (fig. 10). Eleven are from paragneiss in western Granite Fiords or from paragneiss inclusions and screens in granitic plutons (table 3). Only one sample of granitic rock (Hyder Quartz Monzonite) relatively free of inclusions contains a determinable amount of gold.

About half of the gold-bearing samples are intensely iron-stained or hydrothermally altered paragneiss containing at least traces of visible sulfide minerals; the other half are comparatively fresh rocks without discernible sulfides.

Gold values range from 0.05 to 1.30 ppm, but only a third of the samples contain more than the threshold amount. It is perhaps noteworthy that the highest value was found in a background sample

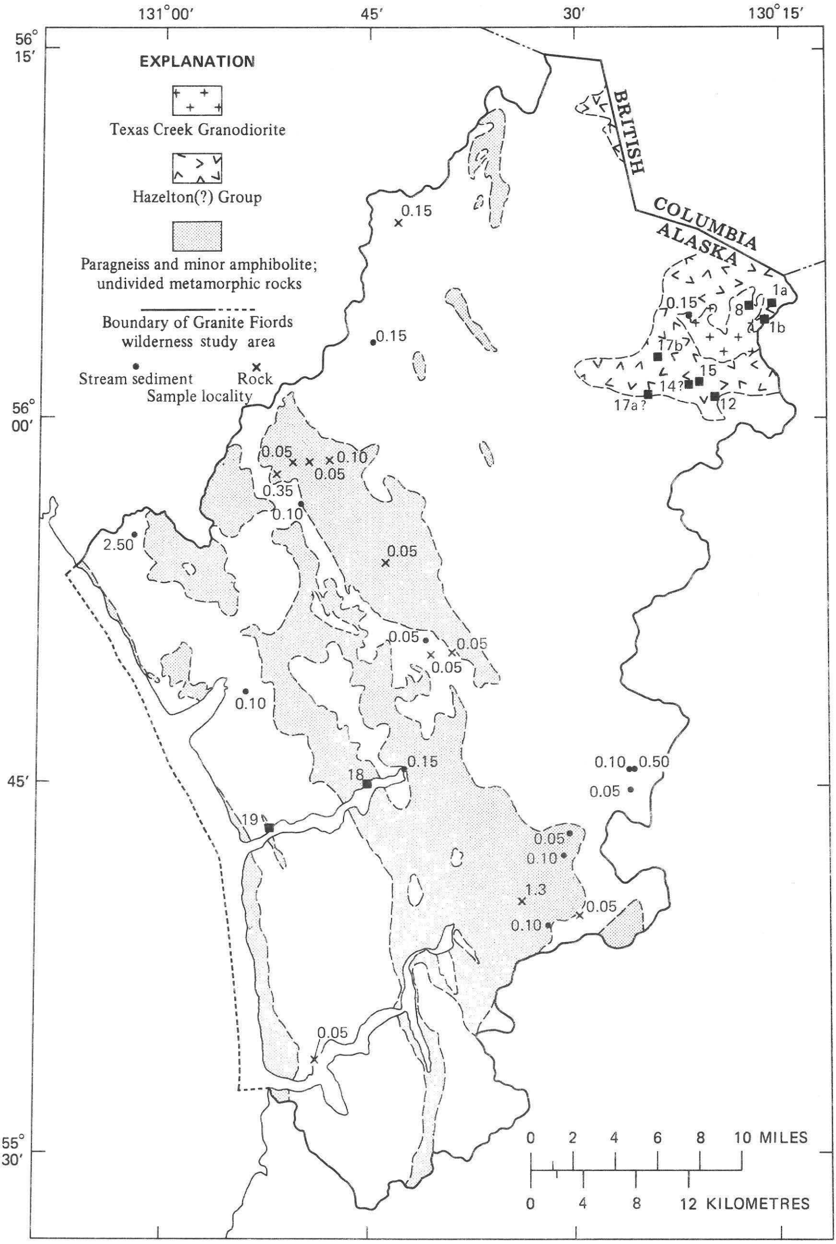



FIGURE 10.—Gold in Granite Fiords. Locations of samples containing determinable amounts (in ppm) of gold. All analyses by atomic absorption. Numbered squares indicate reported occurrences of gold in prospects (pls. 1, 2; table 1).

of paragneiss without visible sulfide minerals (36, table 3).

Only three rock samples contain anomalous concentrations of other metals in addition to gold (fig. 9). One, collected in the southeastern part of the study area, also carries silver, lead, and zinc and is from a sulfide-bearing, intensely iron-stained and hydrothermally altered paragneiss screen about 10 m wide in granodiorite country rocks (37, table 3). The other two samples, which contain anomalous lead along with the gold, include one of a sulfide-bearing, iron-stained paragneiss inclusion in quartz monzonite at Rudyerd Bay (11, table 3) and one of relatively unaltered paragneiss without discernible sulfides in central Granite Fiords (26, table 3).

The distribution of stream-sediment samples with anomalous gold values roughly parallels that of the gold-bearing rock samples. Of the 13 stream-sediment samples shown in figure 10, 11 are from streams draining paragneiss or granitic rocks containing abundant paragneiss screens and inclusions. One of these samples contains the largest amount of gold (2.5 ppm) reported in any sample in Granite Fiords. Of the two remaining samples, one is from a stream draining Hyder Quartz Monzonite in north-central Granite Fiords, and the other is from a stream that crosses the contact between the Hazelton(?) Group and the Texas Creek Granodiorite in the northeastern part of the study area.

The latter sample is especially noteworthy because it also contains anomalous copper and is one of only three stream-sediment samples in the study area that contains anomalous amounts of one or more other metals in addition to gold (fig. 9). The second, which also carries anomalous copper, is from a sluggish stream draining foliated granodiorite near the mouth of the Chickamin River. The third, which contains anomalous quantities of all six metals, is from a stream draining intensely iron-stained paragneiss in central Granite Fiords.

## SILVER

Silver occurs in 15 of the prospects (pl. 2; fig. 11; table 1). Thirteen are in Hazelton(?) Group and Texas Creek Granodiorite that locally are intruded by aplite and pegmatite dikes and by irregular tongues of the Hyder Quartz Monzonite. The remaining two are at Walker Cove in gneiss, schist, and marble country rocks near the contact of foliated granodiorite. According to Buddington (1929, p. 48–51), the silver in the Hazelton(?) and Texas Creek lodes occurs almost exclusively in sulfide minerals, including galena, tetrahedrite, sphalerite, and, in minor amounts, pyrite. Traces of native silver have been reported in a few of the lodes near Hyder, but not in the study area.

Lodes in the Hazelton(?)–Texas Creek terrane that contain silver include quartz fissure veins with small streaks of sulfide minerals, veinlets and lenses of solid sulfides without significant quartz, and disseminated deposits. Buddington (p. 43–44) noted that the fissure

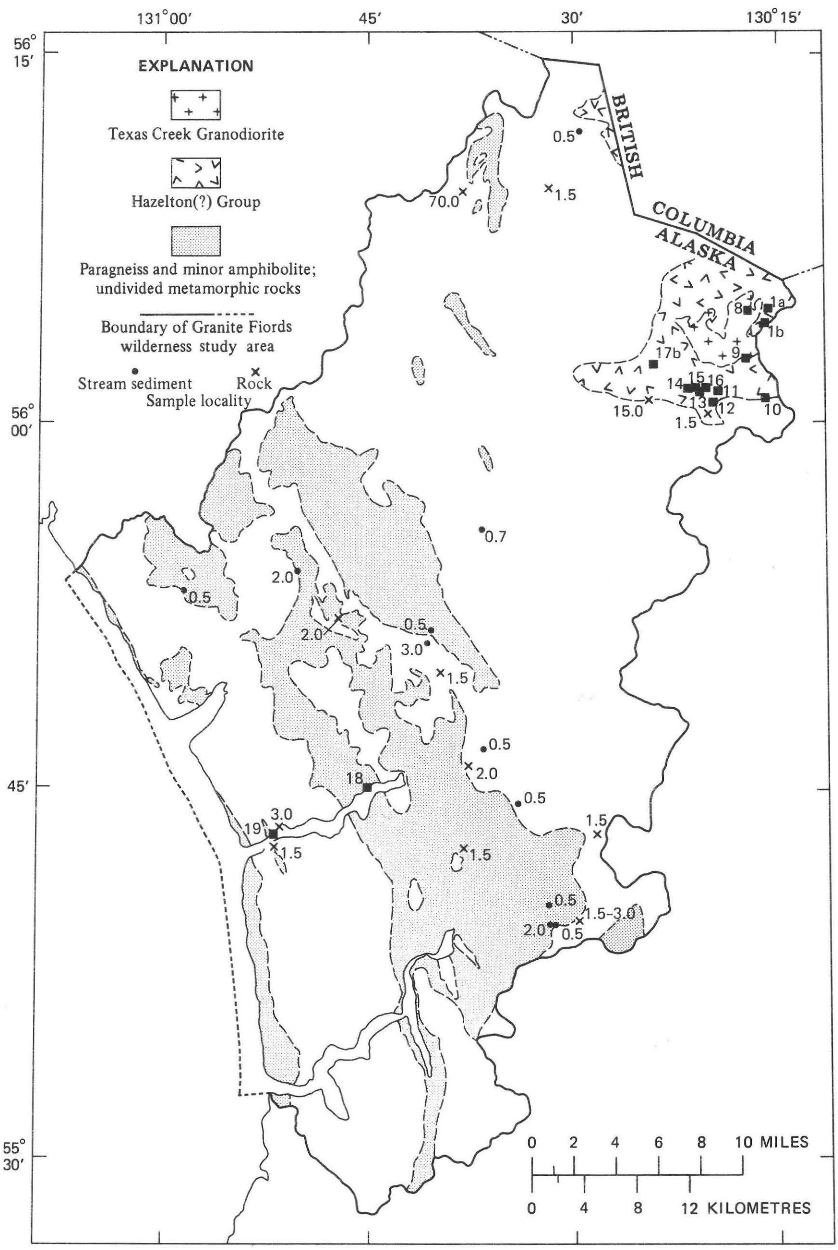



FIGURE 11.—Silver in Granite Fiords. Locations of rock samples containing 1.5 ppm or more of silver and of stream-sediment samples containing 0.5 ppm or more of silver. All analyses by semiquantitative spectroscopy. Numbered squares indicate reported occurrences of silver in prospects (pls. 1, 2; table 1).

veins tend to cut across the structure (mainly foliation) of the country rocks, whereas the other types of deposits are approximately parallel to the structure. He also pointed out that the fissure veins tend to occur in relatively brittle rocks such as Texas Creek granodiorite and Hazelton(?) massive graywacke, whereas the other deposits, considered by him to be chiefly of replacement origin, commonly occur in relatively soft, incompetent rocks such as Hazelton greenstone (meta-andesite) and argillite.

As much as 50 ppm of silver occurs in sulfide-bearing samples of paragneiss collected by the Bureau of Mines at the Alamo copper prospect in Walker Cove (table 11). Silver was also detected in a Bureau of Mines sample of chalcopyrite-bearing marble (skarn) at a small copper prospect near the mouth of Walker Cove (fig. 33).

Early prospectors reported silver values ranging from about 6 to 54 oz per ton in the prospects in northeastern Granite Fiords. However, assay data are available for only a few prospects, and at least some of the assays were made on selected samples. Results of systematic sampling of these prospects by the Bureau of Mines during the present investigation are described on pages 76–116.

Twenty-three geochemical samples, 12 rock and 11 stream sediment, contain enough silver to be considered anomalous (fig. 11). All the anomalous rock samples were collected from paragneiss and undivided metamorphic country rocks, from inclusions and screens of these rocks in the plutons, and from gneissic plutonic rocks adjacent to these metamorphic terranes (table 3).

Most samples from the western half of the study area are intensely iron-stained and hydrothermally altered paragneiss containing at least traces of pyrite (9, 21, 29, 31, and 37, table 3). Two samples returning anomalous silver values are altered paragneiss without visible sulfides (28 and 40), and one of unaltered paragneiss was collected for background (7). Two samples contain two or more anomalous commodities in addition to silver. One, collected from an altered paragneiss zone about 10 m wide in the southeastern part of the study area (37), carries gold, lead, and zinc. The other, from an iron-stained zone of migmatite and gneissic granodiorite several hundred m long and about 30 m wide in central Granite Fiords, contains copper and zinc.

The four silver-bearing rock samples in northeastern Granite Fiords differ markedly in host rock and geologic setting from those in the western area. Two of the samples (49 and 51, table 3) are from epidote-rich veinlets that cut gneiss and schist inclusions in quartz monzonite and granodiorite. We detected no visible sulfides in either sample, although the enclosing country rocks carry sparsely disseminated pyrite. Sample 49 contains the most silver (70 ppm) detected by geochemical methods in the study area and also anomalous amounts of molybdenum, lead, zinc. The two other anomalous samples (55 and 56) are from intensely iron stained pyritic Hazelton(?) hornfels locally intruded by quartz monzonite and aplite dikes. Sample 55 contains the second highest silver value (15 ppm) in the study area.

Nine of the 11 stream-sediment silver anomalies detected in the study area, including all those containing one or more other anomalous metals, are from streams draining paragneiss terrane in western Granite Fiords (fig. 9). Of the two remaining samples, one is from a stream draining Hyder Quartz Monzonite and foliated granodiorite in central Granite Fiords; the other is from a stream draining Hazelton(?) strata intruded by an unnamed quartz monzonite pluton in the northernmost part of the study area.

The two most noteworthy of the anomalous multimetal stream-sediment samples were collected about 1.6 km apart along a stream draining a zone of intensely altered paragneiss in central Granite Fiords. In addition to silver, one sample contains molybdenum and copper, and the other gold, molybdenum, copper, lead, and zinc. Both are in good geochemical agreement with rock samples collected from the altered zone, which contain anomalous gold, silver, and lead (27 and 28, table 3).

Another cluster of stream-sediment samples containing anomalous concentrations of metals in addition to silver is in southeastern Granite Fiords, where three samples collected from streams immediately below iron-stained outcrops of paragneiss and foliated granodiorite also carry molybdenum and lead. These results accord with geochemical analyses of rock samples from the altered outcrops, which show anomalous gold, silver, lead, and zinc (35 and 37, fig. 9 and table 3).

## MOLYBDENUM

Molybdenum occurs in trace amounts throughout the study area, but, like the other principal commodities, is concentrated in western and northeastern Granite Fiords (fig. 12). It was detected in threshold or greater amounts in 39 rock and stream-sediment samples and has been reported in 10 of the prospected lodes (figs. 1 and 12; table 1).

Published accounts of molybdenum in the prospects are very meager, presumably because early prospectors concentrated on the precious metals. Recent prospectors, on the other hand, have focused more on base metals, including molybdenum, but their findings have not been made public.

Nine of the ten lode occurrences of molybdenum are in the Hazelton(?) Group in northeastern Granite Fiords; the tenth is in foliated granodiorite just above the mouth of the Chickamin River in western Granite Fiords. All known occurrences of the metal are as molybdenite, $MoS_2$.

TABLE 3.—*Analyses of anomalous rock geochemical*

[Samples analyzed by semiquantitative spectrographic analyses are reported to the nearest number in the series 1, parentheses indicate lower limit of spectrographic determination for that element. All samples were analyzed for containing amounts equal to or greater than the lower spectrographic detection limits for Bi (10 ppm) and W (50 significant values and no determinations are shown. As (200 ppm), Cd (20 ppm), Sb (100 ppm), and Sn (10 ppm) vapor detector analyses for Hg are labeled Inst. Symbols used are: N, looked for but not found; G, the amount of below the sensitivity limit. Six-step semiquantitative spectrographic analyses were made by K. J. Curry, J. mercury-vapor (Inst.) analyses were made by D. G. Murrey, A. L. Meier, and R. L. Miller. Footnotes are at end of

| | | Semiquantitative spectrographic analyses | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (percent) | | (ppm) | | | | | | | | | | | |
| Map No. (Fig. 9) | Field No. | Fe (0.07) | Ti (0.003) | Mn (10) | Ag (0.5) | Ba (20) | Be (1) | Co (5) | Cr (10) | Cu (5) | Mo (5) | Ni (5) | Pb (10) | Sc (5) | Sr (100) |
| 1 | 2E319 | 3 | 0.50 | 1,500 | N | 1,500 | L | 5 | 150 | 30 | N | 10 | 150 | 30 | L |
| 2 | 2E316 | 5 | .30 | 1,500 | N | 2,000 | 3 | N | 70 | 150 | 20 | 30 | 20 | 15 | L |
| 3 | 2C098A | 5 | .50 | 700 | L | 2,000 | 1 | 15 | 150 | 150 | L | 50 | 15 | 20 | 500 |
| 4 | 2E106A | 2 | .07 | 150 | .7 | 2,000 | L | L | L | 300 | 15 | 5 | 15 | 5 | 700 |
| 5 | 2S085 | 7 | .30 | 1,000 | N | 700 | 1 | 20 | 30 | 20 | L | 7 | 30 | 20 | 700 |
| 6 | 2C089 | 7 | .30 | 1,500 | N | 2,000 | 1 | 15 | 50 | 30 | N | 15 | 20 | 15 | 700 |
| 7 | 2E011A | 3 | .15 | 700 | 3 | 1,500 | 1 | 5 | 70 | 100 | N | 50 | 30 | 7 | 700 |
| 8 | 2E214 | 5 | .70 | 700 | N | 1,500 | 1 | 15 | 100 | 30 | 20 | 15 | 20 | 15 | 500 |
| 9 | 2B013 | 3 | .30 | 500 | 1.5 | 1,500 | 1 | 10 | 100 | 500 | 5 | 70 | 20 | 15 | 200 |
| 10 | 2S015 | 2 | .30 | 1,000 | N | 700 | 1 | L | 10 | 150 | N | 5 | 100 | 10 | 300 |
| 11[2] | 2B269 | 7 | .30 | 700 | N | 700 | 1 | L | 30 | 150 | 5 | L | 150 | 20 | 500 |
| 12 | 2S104 | 3 | .20 | 300 | N | 3,000 | 1 | 10 | 70 | 70 | 5 | 30 | 15 | 7 | 300 |
| 13 | 2C031 | 10 | 1 | 1,500 | N | 2,000 | 1 | 20 | 15 | 70 | L | 7 | L | 20 | 1,500 |
| 14 | 2B484 | 1 | .15 | 300 | N | 200 | 1 | N | 30 | 50 | 30 | 15 | N | N | 300 |
| 15 | 2E378 | 3 | .30 | 500 | N | 500 | 1.5 | 7 | 70 | 30 | N | 15 | 20 | 10 | 300 |
| 16 | 2B438C | 5 | .70 | 1,000 | 1 | 1,500 | 1 | 20 | 150 | 150 | 50 | 100 | 15 | 30 | 700 |
| 16 | 2B438G | 3 | .30 | 1,500 | N | 700 | 1.5 | 10 | 150 | 150 | 30 | 150 | 10 | 15 | 700 |
| 17 | 2B439B | 2 | .50 | 700 | N | 1,500 | L | L | 20 | 100 | N | 15 | N | 7 | 200 |
| 18 | 2E377 | 2 | .20 | 300 | N | 700 | L | 5 | 50 | 30 | N | 15 | 30 | 7 | 150 |
| 19 | 2E376 | 2 | .30 | 300 | N | 1,000 | L | L | 30 | 30 | N | 15 | 30 | 7 | 300 |
| 20 | 2E391 | 1 | .15 | 200 | N | 1,500 | L | N | N | 7 | N | N | 30 | N | 300 |
| 21 | 2B378 | 10 | .50 | 300 | 2 | 700 | L | 10 | 100 | 700 | 5 | 50 | 20 | 30 | L |
| 21 | 2B378A | 7 | .20 | 1,000 | 1.5 | 1,500 | L | N | L | 500 | L | L | 50 | 10 | N |
| 22 | 2B375B | 15 | .50 | 700 | 1 | 700 | L | 30 | 70 | 1,500 | 7 | 30 | 20 | 30 | 200 |
| 23[3] | 2B414 | 3 | .30 | 700 | .7 | 1,500 | 1.5 | 10 | 70 | 200 | 7 | 20 | 70 | 15 | 150 |
| 24 | 2S040 | 5 | .30 | 500 | 1 | 2,000 | 1 | 7 | 10 | 700 | 30 | 15 | 70 | 7 | 300 |
| 25 | 2B555 | 3 | .30 | 2,000 | N | 150 | 2 | N | 30 | 7 | 7 | 10 | 30 | 15 | 700 |
| 26 | 2E403 | 5 | .50 | 1,500 | N | 700 | 1 | 15 | 150 | 20 | N | 50 | 30 | 30 | 300 |
| 27 | 2B381 | 5 | .70 | 2,000 | N | 300 | 1.5 | 7 | L | 150 | 10 | 5 | 20 | 20 | 1,500 |
| 27 | 2B381B | 1.5 | .20 | 700 | L | 500 | 1.5 | L | N | 30 | N | L | 700 | 5 | 700 |

See footnotes at end of table.

In northeastern Granite Fiords, molybdenite has been reported by prospectors in Hazelton(?) slate, graywacke, and fine-grained schist *samples from Granite Fiords wilderness study area, Alaska*

0.7, 0.5, 0.3, 0.2, 0.15, 0.1 which represent approximate midpoints of group data on a geometric scale. Numbers in
As, B, Bi, Ca, Cd, La, Mg, Nb, Sb, Sn, and W. Those containing 100 ppm or more La are shown in footnotes. Those
ppm) are also shown in footnotes. Analyses for B (10 ppm), Ca (.05%), Mg (.02%), and Nb (10 ppm) revealed no
were not detected in any samples. Atomic absorption analyses for Au, Cu, Pb, and Zn are labeled AA: mercury-
the element present is greater than the sensitivity limit; L, an undetermined amount of the element is present
Reynolds, and C. Smith; atomic absorption analyses were made by R. L. Miller, A. L. Meier, and A. J. Toevs; and
table]

| | Semiquantitative spectrographic analyses--Continued (ppm) | | | | Chemical analyses AA (ppm) | | | | Inst. (ppm) | Sample description[1] (All are grab samples unless otherwise specified) |
|---|---|---|---|---|---|---|---|---|---|---|
| Map No. (Fig. 9) | V (10) | Y (10) | Zn (200) | Zr (10) | Au (0.05) | Cu (5) | Pb (5) | Zn (5) | Hg (0.02) | |
| 1 | 150 | 30 | N | 200 | N | 20 | 10 | 45 | N | Bckgrnd spl of paragn; no visib sulf |
| 2 | 300 | 20 | L | 200 | N | 35 | 10 | 140 | .06 | Do. |
| 3 | 300 | 30 | 200 | 100 | N | 45 | 5 | 100 | N | Fe-st paragn locally contg a few % of dissem PY |
| 4 | 30 | L | N | 30 | N | 600 | 5 | 15 | L | Bckgrnd spl of fol GD; no visib sulf |
| 5 | 150 | 15 | N | 70 | N | 20 | 10 | 350 | .09 | Bckgrnd spl of fol QD; no visib sulf |
| 6 | 200 | 30 | 200 | 70 | N | L | L | 10 | .02 | Bckgrnd spl of QM; no visib sulf |
| 7 | 100 | 10 | N | 70 | N | 110 | 30 | 80 | L | Bckgrnd spl of paragn; no visib sulf |
| 8 | 150 | 15 | N | 70 | N | 20 | L | 30 | N | Bckgrnd spl of QD; no visib sulf |
| 9 | 150 | 30 | N | 70 | N | 280 | 20 | 25 | .02 | Fe-st paragn contg dissem PY |
| 10 | 100 | 10 | 300 | 150 | N | 140 | 30 | 160 | .12 | Chip spl across 7 m of fe-st paragn. No visib sulf |
| 11 | 150 | 20 | N | 300 | .05 | 65 | 10 | 65 | .16 | Comp spl. Shr zn 2-2½ m wd in fe-st paragn incln in QM. Paragn conts dissem PY |
| 12 | 200 | 15 | 300 | 150 | N | 70 | 10 | 140 | .03 | Bckgrnd spl of paragn contg dissem PY |
| 13 | 300 | 30 | 200 | 70 | N | 25 | 10 | 70 | .26 | Bckgrnd spl of GD GN; no visib sulf |
| 14 | 150 | 20 | N | 30 | N | 15 | L | 5 | N | Fe-st siliceous band in paragn intruded by QM and GD. No visib sulf |
| 15 | 100 | 15 | N | 300 | .35 | 15 | 5 | 35 | N | Bckgrnd spl of paragn; no visib sulf |
| 16 | 500 | 100 | N | 300 | N | 65 | 5 | 20 | N | Fe-st paragn + minor PEG vns. Paragn conts very sprsly dissem sulf, including traces of MO. Fe-st zone may be several hund ft wd |
| 16 | 1,000 | 50 | 300 | 70 | N | 40 | 10 | 200 | N | Hydro altd QM and PEG cut by sparse QZ-CA vnlts a fract of a cm wd. Traces of sulf minerals, including MO, associated with vnlts |
| 17 | 50 | 15 | N | 500 | .05 | L | L | 30 | .04 | Paragn, w/o visib sulfides, from zone of fe-st paragn, AP, and hydro altd QM contg sprsly dissem PY |
| 18 | 70 | 15 | N | 200 | .05 | 15 | L | 30 | N | Bckgrnd spl of paragn; no visib sulf |
| 19 | 70 | 10 | N | 300 | .10 | 5 | 10 | 50 | N | Do. |
| 20 | 20 | L | N | 500 | .05 | L | L | 20 | N | Do. |
| 21 | 300 | 30 | N | 300 | N | 110 | 10 | 100 | N | Fe-st GD GN contg finely dissem PY |
| 21 | 15 | 20 | 1,000 | 700 | N | 120 | 5 | 450 | N | Intensely fe-st migmatite (paragn + gnc GD) contg finely dissem PY. Altd zone is a few hund m long and about 30 m wd |
| 22 | 200 | L | N | 70 | N | 370 | 15 | 110 | N | Intensely fe-st paragn and gnc QD contg dissem PY. Altd zone is about .4 km wd |
| 23 | 200 | 50 | L | 150 | N | 170 | 15 | 200 | .02 | Fe-st QZ vnlt in paragn. No visib sulf |
| 24 | 150 | 20 | 300 | 70 | N | 500 | 20 | 250 | .04 | Random chips of fe-st paragn contg dissem PY |
| 25 | 150 | 20 | 300 | 50 | N | 25 | 10 | 110 | N | Silicified(?) paragn; no visib sulf |
| 26 | 150 | 20 | N | 100 | .05 | L | L | 40 | N | Bckgrnd spl of paragn; no visib sulf |
| 27 | 200 | 70 | N | 700 | .05 | 110 | 10 | 40 | .04 | Hydro altd, intensely fe-st gnc QD contg dissem PY and MA |
| 27 | 70 | 10 | N | 50 | N | 25 | 450 | 140 | .14 | Do. |

TABLE 3.—*Analyses of anomalous rock geochemical*

| Map No. (Fig. 9) | Field No. | Semiquantitative spectrographic analyses (percent) Fe (0.07) | Ti (0.003) | (ppm) Mn (10) | Ag (0.5) | Ba (20) | Be (1) | Co (5) | Cr (10) | Cu (5) | Mo (5) | Ni (5) | Pb (10) | Sc (5) | Sr (100) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | 2C131 | 7 | .70 | 1,000 | 1.5 | 2,000 | L | 15 | 150 | 100 | L | 20 | 30 | 20 | 500 |
| 29 | 2B393A | 10 | .70 | 1,500 | 2 | 1,500 | 1 | 50 | 100 | 300 | N | 100 | 20 | 20 | 500 |
| 30 | 2E207A | 10 | .70 | 700 | N | 1,500 | N | 30 | 150 | 30 | L | 30 | 30 | 15 | 300 |
| 31[4] | 2C082 | 3 | .20 | 150 | 1.5 | 700 | L | 30 | 70 | 300 | 15 | 200 | 20 | 7 | 100 |
| 32 | 2C078 | 10 | 1 | 1,500 | N | 700 | N | 20 | N | 100 | N | L | 20 | 30 | 150 |
| 33 | 2C025 | 7 | .15 | 150 | N | 200 | N | 70 | 20 | 500 | L | 7 | N | N | L |
| 34 | 2B327 | 10 | .70 | 700 | N | 1,500 | 1 | 20 | 150 | 500 | L | 50 | 10 | 15 | 150 |
| 35 | 2B297 | 3 | .50 | 1,500 | N | 1,000 | L | 7 | L | 20 | N | L | 50 | 7 | 1,000 |
| 36 | 2C035 | 3 | .30 | 1,000 | N | 2,000 | L | 5 | 100 | 50 | N | 10 | 70 | 15 | 300 |
| 37 | 2B298A | 5 | .70 | 5,000 | 3 | 700 | L | 10 | 10 | 70 | N | 10 | 50 | 20 | 300 |
| 37 | 2B298B | 5 | .70 | 1,500 | 1.5 | 700 | 1 | 5 | 15 | 150 | N | 7 | 30 | 15 | 500 |
| 37 | 2B298C | 5 | .70 | 1,500 | 2 | 300 | 1 | 7 | 30 | 50 | 7 | 7 | 30 | 15 | 700 |
| 37 | 2B298D | 3 | .30 | 1,000 | 3 | 1,500 | L | L | N | 30 | N | L | 100 | 5 | 150 |
| 38 | 2E194B | 3 | .20 | 700 | N | 1,000 | 1 | N | 150 | 50 | 15 | 10 | N | 10 | 300 |
| 39 | 2C081B | 3 | .30 | 700 | L | 200 | 1 | 10 | 150 | 200 | 150 | 70 | L | 15 | 150 |
| 40 | 2C079A | 7 | .50 | 700 | 1.5 | 2,000 | 1 | 15 | 30 | 500 | 15 | 50 | 30 | 5 | 500 |
| 41 | 2B397 | 7 | .50 | 1,500 | N | 700 | 1.5 | 7 | N | 70 | N | L | 20 | 20 | 700 |
| 42 | 2B407 | 3 | .30 | 1,000 | .5 | 300 | 1.5 | 5 | 100 | 200 | 300 | 5 | 10 | 10 | 500 |
| 43 | 2B400 | 3 | .30 | 700 | N | 1,500 | 1 | 7 | 10 | 20 | N | L | 150 | 7 | 700 |
| 44 | 2B557A | .20 | .007 | 50 | N | 50 | N | N | N | 7 | 70 | 5 | N | N | L |
| 45 | 2B427 | 1.5 | .15 | 500 | N | 1,500 | 1.5 | N | N | 70 | N | L | 30 | L | 700 |
| 46[5] | 2E491 | 3 | .30 | 500 | N | 2,000 | 1 | N | 15 | L | 20 | N | 15 | L | 500 |
| 47 | 2B538 | 5 | .50 | 1,500 | N | 1,000 | L | 7 | 30 | 30 | 30 | 20 | 15 | 20 | 300 |
| 48 | 2B508 | 3 | .20 | 300 | N | 1,500 | 1 | N | N | 15 | N | L | 20 | 5 | 700 |
| 49[6] | 2B601B | 15 | .50 | 5,000 | 70 | 30 | 1 | 10 | 15 | 15 | 70 | 15 | 1,500 | 20 | 1,500 |
| 50[7] | 2B605D | 3 | .15 | 700 | 1 | 700 | 1.5 | L | 10 | 100 | 20 | L | 20 | 10 | 150 |
| 51 | 2B442C | 15 | G(1) | 2,000 | 1.5 | 150 | L | 30 | 15 | 700 | L | 30 | N | 50 | 150 |
| 52 | 2B612A | 10 | 1 | 1,500 | N | 500 | 1 | 30 | 30 | 300 | 10 | 50 | 20 | 30 | 300 |
| 53[8] | 2S076 | 2 | .10 | 1,000 | N | 3,000 | 1.5 | L | L | 30 | N | L | 150 | 5 | 1,500 |
| 54 | 2B581B | 1.5 | .20 | 500 | N | 150 | L | N | 50 | 20 | 20 | 30 | L | 7 | 100 |
| 55[9] | 2B583C | 15 | 1 | 2,000 | 15 | 150 | 1.5 | L | N | 200 | 5 | N | 70 | 20 | L |
| 56 | 2B589A | 2 | .15 | 700 | 1.5 | 700 | 1.5 | N | 10 | 50 | N | L | 30 | 7 | 300 |
| 57 | 2S112 | 5 | .30 | 1,500 | .7 | 700 | L | 20 | 300 | 200 | 150 | 50 | 20 | 30 | 300 |

*samples from Granite Fiords wilderness study area, Alaska*—Continued

| Map No. (Fig. 9) | Semiquantitative spectrographic analyses--Continued (ppm) V (10) | Y (10) | Zn (200) | Zr (10) | Chemical analyses AA (ppm) Au (0.05) | Cu (5) | Pb (5) | Zn (5) | Inst. (ppm) Hg (0.02) | Sample description[1] (All are grab samples unless otherwise specified) |
|---|---|---|---|---|---|---|---|---|---|---|
| 28 | 300 | L | L | 70 | N | 45 | 15 | 160 | N | Intensely fe-st paragn; no visib sulf |
| 29 | 300 | 50 | N | 70 | N | 100 | 10 | 20 | N | Intensely fe-st paragn screen in gnc GD. Paragn locally conts up to a few % dissem PY |
| 30 | 150 | N | 300 | 150 | N | 65 | 15 | 55 | .18 | Bckgrnd spl of paragn; no visib sulf |
| 31 | 300 | 70 | L | 300 | N | 50 | L | 100 | .02 | Fe-st paragn, about 20% of which conts a few % of dissem PY |
| 32 | 300 | 20 | 200 | 200 | N | 5 | 5 | 120 | .02 | Bckgrnd spl of paragn; no visib sulf |
| 33 | 300 | 10 | N | 300 | N | 350 | 10 | 30 | .20 | Paragn contg dissem PY |
| 34 | 150 | 20 | N | 500 | N | 170 | 15 | 30 | .08 | Comp spl of fe-st bands in paragn. Bands cont sprsly dissem minute grains of PY(?) |
| 35 | 150 | 15 | 200 | 100 | N | 20 | 10 | 180 | .03 | Fe-st QD contg dissem PY |
| 36 | 100 | 30 | N | 100 | 1.30 | 25 | 10 | 90 | .16 | Bckgrnd spl of paragn; no visib sulf |
| 37 | 300 | 50 | 200 | 100 | L | 30 | 10 | 110 | .16 | Fe-st paragn screen 8-10 m wd in GD. Dissem PY and CP(?) |
| 37 | 300 | 30 | L | 70 | .05 | 40 | 10 | 130 | .04 | Fe-st paragn |
| 37 | 200 | 70 | N | 20 | .05 | 30 | 10 | 20 | .02 | Fe-st HF (= paragn) contg dissem PY |
| 37 | 150 | 10 | N | 100 | L | 10 | 10 | 40 | .22 | Fe-st hydro altd paragn contg dissem PY |
| 38 | 700 | 30 | 200 | 150 | N | 60 | 5 | 45 | N | Bckgrnd spl of paragn; no visib sulf |
| 39 | 700 | 70 | N | 200 | N | 50 | L | 35 | .10 | Intensely fe-st paragn contg a few % of dissem PY |
| 40 | 70 | 30 | N | 70 | N | 230 | 5 | 25 | N | Fe-st paragn inclusion in schlieren GD. No visib sulf |
| 41 | 200 | 20 | 300 | 70 | N | 40 | 5 | 120 | N | GN incln in QM. Bckgrnd spl; no visib sulf |
| 42 | 200 | 15 | N | 70 | N | 250 | 5 | 25 | N | Comp spl of fe-st gnc QM and paragn inclns contg dissem PY. Altd zone exposed along strike for about 300 m |
| 43 | 100 | 10 | N | 70 | N | L | 450 | 60 | .06 | Comp spl of EP-bearing vnlts 2 cm or so wd in GD. No visib sulf |
| 44 | 10 | N | N | N | N | L | L | L | .04 | Small QZ vn in QM; no visib sulf |
| 45 | 30 | N | N | 150 | N | 5 | 200 | 60 | .04 | Bckgrnd spl of gnc QM; no visib sulf |
| 46 | 100 | 10 | N | 700 | N | 15 | 5 | 55 | .02 | Bckgrnd spl of GD contg paragn inclns. No visib sulf |
| 47 | 150 | 15 | N | 70 | N | 55 | 5 | 80 | N | Fe-st paragn; no visib sulf |
| 48 | 70 | N | N | 50 | .15 | L | L | 40 | N | Bckgrnd spl of fol QM; no visib sulf |
| 49 | 300 | 15 | L | 70 | N | 15 | 1,000 | 450 | .02 | EP-QZ vnlt about 2 cm wd in GN incln in QM. No visib sulf in vn; GN conts sprsly dissem PY |
| 50 | 150 | 10 | N | 50 | N | 80 | L | 10 | .02 | Small fe-st QZ vn in HO-rich GN contg traces of PY(?) and MA |
| 51 | 700 | 30 | N | 150 | N | 420 | 5 | 45 | .04 | Comp spl of 1 cm wd EP-QZ-CA vnlts; no visib sulf. Vnlts cut HF (= SC), AP, and PEG cntry rx contg sprsly dissem PY |
| 52 | 150 | 20 | N | 300 | N | 150 | 10 | 20 | .02 | Locally fe-st AM contg minor dissem PY |
| 53 | 100 | 15 | N | 200 | N | 15 | 15 | 5 | .02 | Bckgrnd spl of msv GD; no visb sulf |
| 54 | 70 | N | N | 50 | N | 20 | 5 | 10 | L | Small QZ vn in fe-st PH; no visb sulf |
| 55 | 150 | 70 | N | 150 | N | 140 | 35 | 100 | L | Intensely fe-st pyritic HF (= PH); float spl |
| 56 | 70 | 10 | N | 70 | N | 50 | 10 | 10 | L | 15 cm QM dike in fe-st HF (= PH); no visb sulf |
| 57 | 200 | 300 | N | 70 | N | 160 | L | 10 | .30 | Comp spl. Random chips across outcrop of locally fe-st AM, paragn, migmatite, and PEG. Sprsly dissem PY |

TABLE 3.—*Analyses of anomalous rock geochemical samples from Granite Fiords wilderness study area, Alaska*—Continued

[1]Abbreviations used in table:

| | | | |
|---|---|---|---|
| altd | = altered | incln(s) | = inclusion(s) |
| AM | = amphibolite | MA | = magnetite |
| bckgrnd | = background | MO | = molybdenite |
| CA | = calcite | msv | = massive |
| comp | = composite | paragn | = paragneiss |
| cntry rx | = country rocks | PEG | = pegmatite |
| cont, contg, conts | = contain, containing, contains | PH | = phyllite |
| CP | = chalcopyrite | PY | = pyrite |
| dissem | = disseminated | QD | = quartz diorite |
| EP | = epidote | QM | = quartz monzonite |
| fe-st | = iron-oxide stained | QZ | = quartz |
| fol | = foliated | SC | = schist |
| GD | = granodiorite | shr zn | = shear zone |
| GN | = gneiss | spl | = sample |
| gnc | = gneissic | sprsly | = sparsely |
| HF | = hornfels | sulf | = sulfide(s) |
| HO | = hornblende | visib | = visible |
| hund | = hundred | vn, vnlt, vns | = vein, veinlet, veins |
| hydro | = hydrothermally | wd | = wide |

[2]100 ppm La.

[3]150 ppm La.

[4]300 ppm La.

[5]300 ppm La.

[6]70 ppm Bi.

[7]15 ppm Bi.

[8]100 ppm La.

[9]15 ppm Bi; W detected, but below limits of sensitivity.

that locally are intruded by Texas Creek Granodiorite, Hyder Quartz Monzonite, and aplite dikes. It commonly is associated with one or more other sulfides, including pyrite, galena, and chalcopyrite. The molybdenite generally is less conspicuous than the other sulfides and ranges from minute silvery platelets about 1 mm in diameter to dark-bluish-gray dusty streaks whose individual particles are not visible to the naked eye. According to Buddington (1929, p. 50), the lodes near the headwaters of the West Fork of Texas Creek contain small amounts of molybdenite in quartz veinlets in Texas Creek quartz diorite and coating fractures in Hyder Quartz Monzonite adjacent to the contact with Hazelton(?) graywacke and slate. During the present investigation, very fine grained molybdenite was noted at the Marmot prospect (13b and 14, table 1), in selvages a cm or so wide at the margins of quartz veins that also carry pyrite and chalcopyrite. The veins are parallel to the composition banding in Hazelton(?) phyllite and hornfels.

The only lode occurrence of molybdenite known in western Granite Fiords is at the Gnat prospect (20), where small amounts of the sulfide are in a 2.5-m wide glassy quartz vein in granodiorite. The vein is approximately parallel to the foliation of the enclosing granodiorite.

The molybdenum content of the lodes has not been reported by the prospectors. The results of detailed sampling during the present investigation by the Bureau of Mines are described on pages 92–112 and 121–123.

Semiquantitative spectrographic analyses of almost 900 rock specimens collected in Granite Fiords show anomalous amounts of molybdenum in 14 samples (fig. 12), three of which also contain threshold or greater amounts of one or more other metals (fig. 9; table 3).

Two of the anomalous multimetal samples were collected from zones of intensely iron stained and hydrothermally altered paragneiss in northwestern and central Granite Fiords (16 and 24, table 3). Samples from these zones containing sparsely disseminated pyrite and traces of molybdenite respectively contain 50 and 30 ppm molybdenum, as well as anomalous amounts of copper and zinc. Our mapping shows that the zones, which trend northwest (parallel to the foliation in the country rocks), are up to a few hundred metres wide and crop out discontinuously along strike for 2 km or more. Two rock samples (14 and 39) containing only molybdenum in anomalous amounts were also collected from northwest-trending zones of altered paragneiss, approximately on strike with the zones that yielded the anomalous multimetal samples.

The third multimetal sample containing anomalous molybdenum was collected in northern Granite Fiords and is unusual in that it was taken entirely from an epidote-quartz veinlet about 2 cm wide in a comparatively unaltered gneiss inclusion in quartz monzonite (49). We detected no sulfides in the veinlet, although the enclosing gneiss contains sparsely disseminated pyrite. In addition to 70 ppm molybdenum, this sample contains anomalous silver, lead, and zinc.

The rock geochemical sample containing the largest amount (300 ppm) of molybdenum collected in the study area is iron-stained quartz monzonite with paragneiss inclusions, both containing minor amounts of pyrite (42). This altered zone is in eastern Granite Fiords and is exposed along a westward strike for more than 300 m. Two anomalous single-metal samples containing 150 ppm molybdenum are sparsely pyritic iron-stained plutonic and metamorphic rocks in Punchbowl Cove (57), and altered paragneiss in the southeastern part of the study area (39).

Twenty-six of the 625 stream-sediment samples collected in the study area contain anomalous amounts of molybdenum, 18 with molybdenum as the sole anomalous metal and 8 containing one or more additional anomalous metals (fig. 9). All these samples were collected in the western part of the study area; none are from the northeastern part of Granite Fiords, although several lode and other rock samples from there contain molybdenum.

The stream-sediment molybdenum anomalies show two main distribution patterns (fig. 12). One pattern forms a northwest-trending belt within or adjacent to the terrane of paragneiss and subordinate

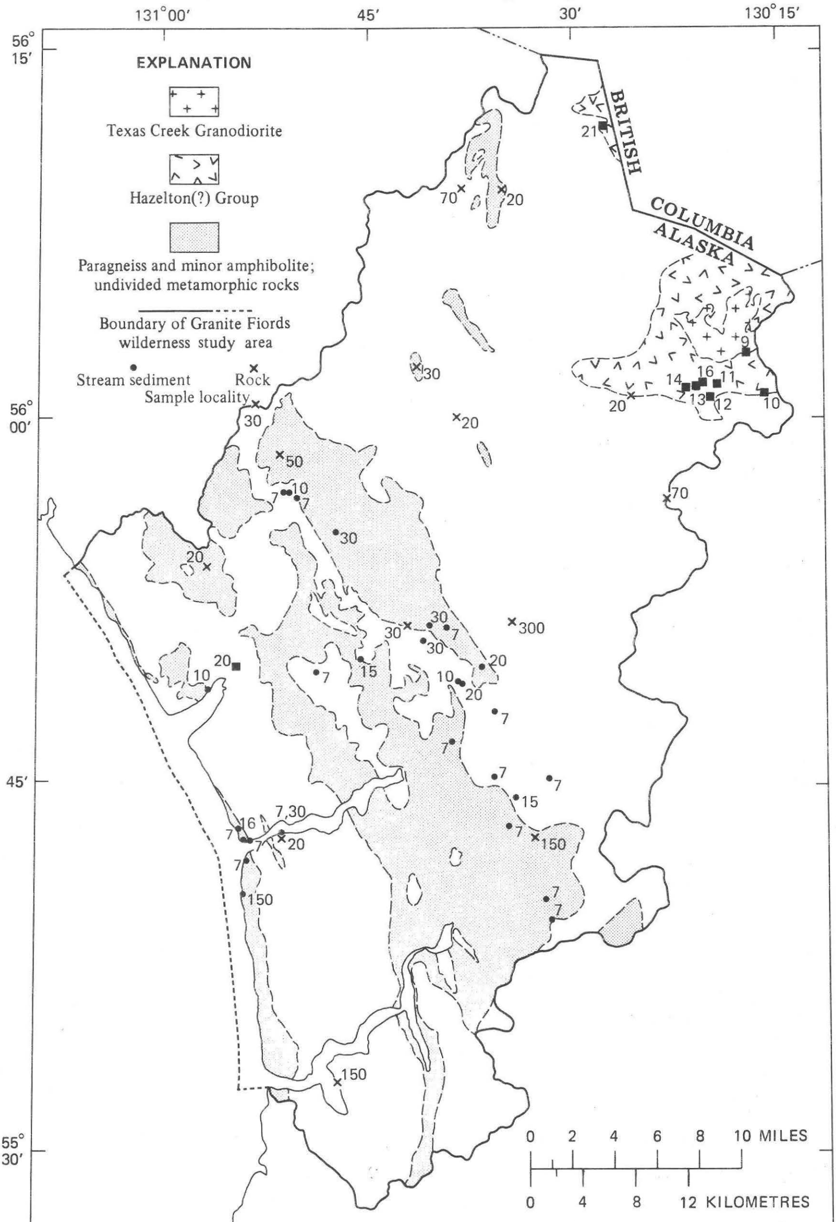



FIGURE 12.—Molybdenum in Granite Fiords. Locations of rock samples containing 20 ppm or more of molybdenum, and of stream-sediment samples containing 7 ppm or more of molybdenum. All analyses by semiquantitative spectroscopy. Numbered squares indicate reported occurrences of molybdenum in prospects (pls. 1, 2; table 1).

plutonic rocks that runs the length of central Granite Fiords. The other forms a cluster in paragneiss, amphibolite, and minor quartz diorite country rocks near the mouth of Walker Cove.

All the multimetal stream-sediment samples containing anomalous molybdenum are in the central belt, and all were collected from streams draining altered zones from which we collected rock samples containing anomalous molybdenum and other metals.

### COPPER

Copper occurrences are markedly concentrated in metamorphic rocks in the western and northeastern parts of the study area (fig. 13). Copper is reported in 16 of the prospected lodes (fig. 13; table 1): 13 in the Hazelton(?)–Texas Creek terrane in northeastern Granite Fiords, 1 in pelitic gneiss and schist and 1 in marble (skarn) at Walker Cove, and 1 in a quartz vein in granodiorite near the mouth of the Chickamin River.

Chalcopyrite ($CuFeS_2$), the principal copper mineral in all reported lode occurrences of copper, is generally subordinate to galena, pyrite, and sphalerite. Small amounts of tetrahedrite ($Cu_8Sb_2S_7$) have been reported in one of the lodes; early prospectors in the area considered it to be an important ore mineral because of its high gold and silver values (Buddington, 1929, p. 48, 50–51). Surface exposures of copper-bearing veins generally show some alteration to malachite.

Minor amounts of chalcopyrite commonly are in the disseminated deposits and in the small veinlets and lenses of massive sulfides that approximately parallel the compositional banding in the Hazelton(?) Group. Such occurrences are mainly in the thinly intercalated graywacke, argillite, and slate (Buddington, 1929, p. 44). Some chalcopyrite also accompanies galena and pyrite in quartz fissure veins. These veins are most prevalent in the relatively brittle Hazelton(?) rocks, such as the massive graywacke, and in the Texas Creek Granodiorite, where they generally cut the foliation and gneissic structure.

Copper values of 2 to 4 percent were reported by early prospectors in three assays from the prospected lodes within the study area (table 1). These values have little significance today because two of the three were for selected samples and the origin of the third is unknown. Results of systematic sampling by the U.S. Bureau of Mines during the present investigation are reported on pages 76–123.

Our regional geochemical studies show anomalous copper values in 12 rock samples and 34 stream-sediment samples (fig. 13). Ten of the anomalous rock samples (table 3) were collected in western Granite Fiords and two in northern Granite Fiords. Nine of those in the western area are from the paragneiss unit or from paragneiss screens or inclusions in nearby gneissic plutonic rocks; one is from foliated granodiorite collected for background. All nine of the paragneiss samples are notably iron stained, and all but one contain visible

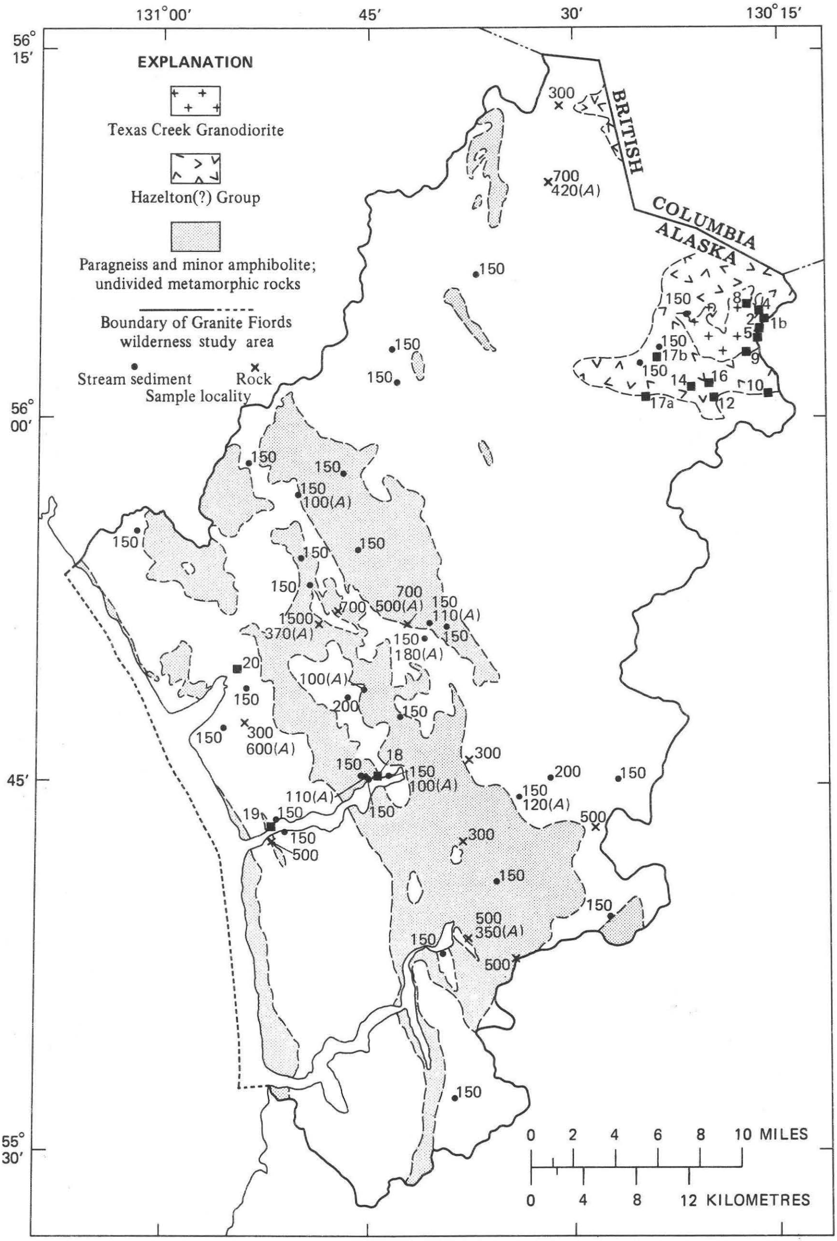



FIGURE 13.—Copper in Granite Fiords. Locations of rock samples containing 300 ppm or more of copper, spectrographically analyzed stream-sediment samples containing 150 ppm or more of copper, and atomic absorption-analyzed (*A*) stream-sediment samples containing 100 ppm or more copper. Numbered squares indicate reported occurrences of copper in prospects (pls. 1, 2; table 1).

pyrite. Chalcopyrite, in trace amounts, was tentatively identified in only one sample (37, table 3). One (51) of the copper-bearing rock samples from northern Granite Fiords is from a narrow epidote-rich veinlet, without visible sulfide minerals, cutting hornfels (schist), aplite, and pegmatite country rocks. The other (52) is from an iron-stained amphibolite inclusion (in quartz monzonite) containing minor disseminated pyrite.

Seven rock samples contain anomalous amounts of one or more other metals in addition to copper (fig. 9, table 3). In five of these (9, 29, 31, 40, and 51, table 3), silver is the sole additional anomalous metal. The two remaining multimetal samples (21 and 24), both from strongly altered zones in the paragneiss terrane of central Granite Fiords, respectively contain silver and zinc and molybdenum and zinc. The rock sample (22) with the highest copper value (1,500 ppm) is from an intensely altered zone in the same area.

Thirty-four stream-sediment samples carry anomalous amounts of copper (fig. 13), but 32 of these contain only the threshold value of 150 ppm. The remaining two samples are only one step higher at 200 ppm. Most of these samples were collected from streams draining paragneiss or nearby gneissic granitic rocks containing abundant paragneiss inclusions and roof pendants. Three anomalous samples were obtained from small streams draining Hazelton(?)–Texas Creek terrane in northeastern Granite Fiords, and only three or four from streams in predominantly granitic terrane.

Twenty-four stream-sediment samples with threshold-or-greater values for copper contain no other metals in anomalous amounts; seven others contain one other anomalous metal in addition to the copper. Two notable multimetal stream-sediment samples containing anomalous copper were collected from streams draining strongly iron stained and altered zones in paragneiss in central Granite Fiords. One of these contains anomalous amounts of molybdenum and silver in addition to copper, and the other is anomalous in all six metals. Anomalous rock samples containing copper and other metals (21, 22, and 24, fig. 9 and table 3) were collected in the same general area.

## LEAD

Lead, like the other metals, commonly is associated with the metamorphic rocks (fig. 14). It has been reported in 17 of the prospects, all but one of which are in the Hazelton(?)–Texas Creek terrane of northeastern Granite Fiords. The exception consists of minor amounts of lead in a molybdenum prospect in granodiorite near the mouth of the Chickamin River (20, table 1 and fig. 14). One prospect near Chickamin Glacier (1a) was mostly snow covered during the present investigation, and prospectors' reports could not be fully verified.

Galena (PbS), the principal lead mineral in the Hazelton(?) and Texas Creek lodes (table 1), generally is the most abundant and con-

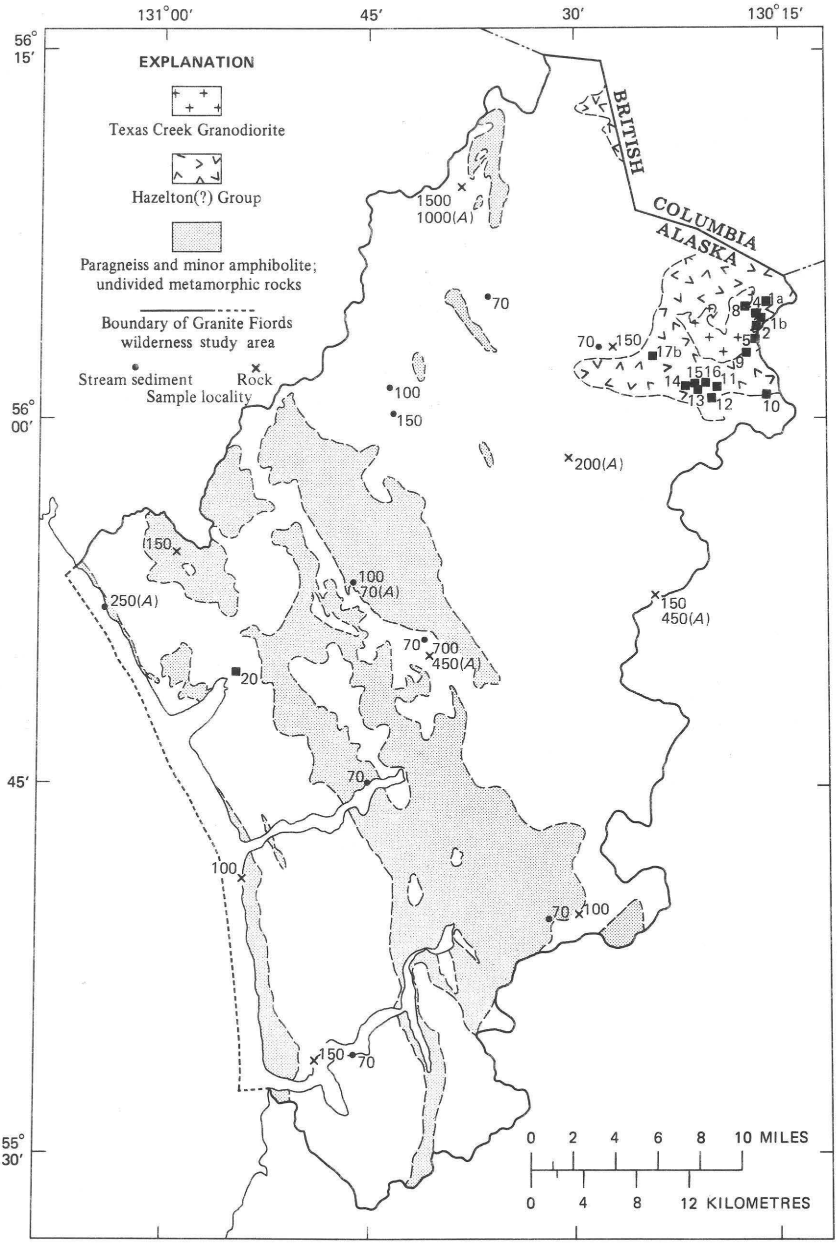



FIGURE 14.—Lead in Granite Fiords. Locations of rock samples containing 100 ppm or more of lead, spectrographically analyzed stream-sediment samples containing 70 ppm or more of lead, and atomic absorption-analyzed (*A*) stream-sediment samples containing 50 ppm or more of lead. Numbered squares indicate reported occurrences of lead in prospects (pls. 1, 2; table 1).

spicuous ore mineral. Partial alteration of galena to anglesite ($PbSO_4$) is common, particularly in surface exposures. Galena is everywhere associated with other sulfides, most commonly pyrite, sphalerite, and chalcopyrite. Analyses of galena samples from the Hyder district and from the lodes within Granite Fiords generally show low to moderate silver content and some gold (Buddington, 1929, p. 48).

Most galena in Hazelton(?)–Texas Creek country rocks is in quartz fissure veins containing small streaks of sulfide minerals. These veins generally crosscut the gneissic structure and foliation in the Texas Creek Granodiorite and the competent (brittle) rocks of the Hazelton(?) Group. Galena also occurs in disseminated deposits and in veinlets and lenses of nearly solid sulfides parallel to the compositional layering of the less competent Hazelton(?), particularly the graywacke, argillite, and slate (Buddington, p. 44).

The only lead values reported by early prospectors from the lodes within the study area are from picked samples of nearly pure sulfides (1b and 12, table 1). Results of systematic sampling by the U.S. Bureau of Mines during the present investigation are reported on pages 76–116 and 121–123.

The distribution of samples containing anomalous amounts of lead (fig. 14) suggests a somewhat less marked correlation of lead with the metamorphic rocks than is indicated for the other metals.

Nine rock samples and ten stream-sediment samples contain anomalous amounts of lead. Four of the anomalous rock samples (table 3) are paragneiss; two of these (11 and 37) contain disseminated pyrite, and a third (10) is iron stained but contains no visible sulfides. Two samples (45 and 53) are relatively fresh granitic rock selected for background, and a third granitic sample (27) is strongly iron stained and contains disseminated pyrite. The two remaining rock samples are from narrow, epidote-rich veins: one (49) in a gneiss inclusion in quartz monzonite and one (43) in granodiorite. Neither bear visible sulfide minerals.

Two rock samples (37 and 49, table 3 and fig. 9) contain anomalous amounts of three other metals in addition to lead. Silver, zinc, and molybdenum were reported from the epidote-rich veinlet (49) in northern Granite Fiords, and silver, zinc, and gold from an altered paragneiss screen (37) in granodiorite near the southeastern boundary of the study area. Two other samples carry anomalous amounts of gold along with lead (11 and 27).

Eight of the ten stream-sediment samples with anomalous amounts of lead contain no other anomalous metals and are from widely scattered localities throughout the study area (fig. 14). The most noteworthy multimetal stream-sediment sample contains anomalous amounts of lead and all five other principal metals. It was collected from a small stream draining heavily iron stained paragneiss in the central part of the study area. The only other multimetal sample carries silver in addition to the lead and was collected from a stream draining altered paragneiss and granodiorite near the southern border.

### ZINC

Zinc occurs in 12 of the prospected lodes within the study area (pl. 2). Eleven of these are in the Hazelton(?) Group and Texas Creek Granodiorite in northeastern Granite Fiords; the last is in the paragneiss at Walker Cove (fig. 15). One reported lode occurrence of zinc near Chickamin Glacier (1a, table 1 and fig. 15) was mostly covered by snow during the present investigation and could not be verified.

Sphalerite (ZnS) is the only zinc mineral reported in the Hazelton(?)–Texas Creek prospects, where it is one of the principal sulfide minerals (Buddington, 1929, p. 50). It commonly is associated with galena, pyrite, and chalcopyrite and occurs in several types of deposits, including quartz veins and stringers, massive sulfide veins, and disseminations (Buddington, p. 42–44). Although sphalerite was not identified at the Alamo prospect at Walker Cove (18, table 1 and fig. 15), zinc is reported in most of the samples collected there by the Bureau of Mines (table 21).

Zinc values generally are not included in the few assay reports available from the early prospecting period in the lodes within the study area. Zinc assays of samples collected by the Bureau of Mines during the present investigation are largely reported in tables 6–10 and 14, figures 17, 21, 22, and 30, and on pages 112–114.

Anomalous amounts of zinc were detected in 18 of the 877 rock samples collected during the present investigation (fig. 15; table 3). All but two of the anomalous samples are in or adjacent to paragneiss terrane, or in paragneiss inclusions in granitic terrane. Threshold values of 200 ppm were reported in only two samples of relatively fresh granitic rock. Just over half of the anomalous samples contain visible sulfide minerals, usually pyrite in iron-stained or altered paragneiss. Of the remainder, two are iron stained but do not contain visible sulfides, and the rest are relatively fresh samples collected for background. Sphalerite or other zinc minerals were not identified in any of the samples.

Six rock samples contain other anomalous metals in addition to zinc (fig. 9; table 3). Lead, silver, and molybdenum accompany zinc in a sample (49, table 3) from an epidote-rich veinlet in a gneiss inclusion in quartz monzonite near the northern boundary of the study area, and lead, silver, and gold accompany zinc in an altered para-

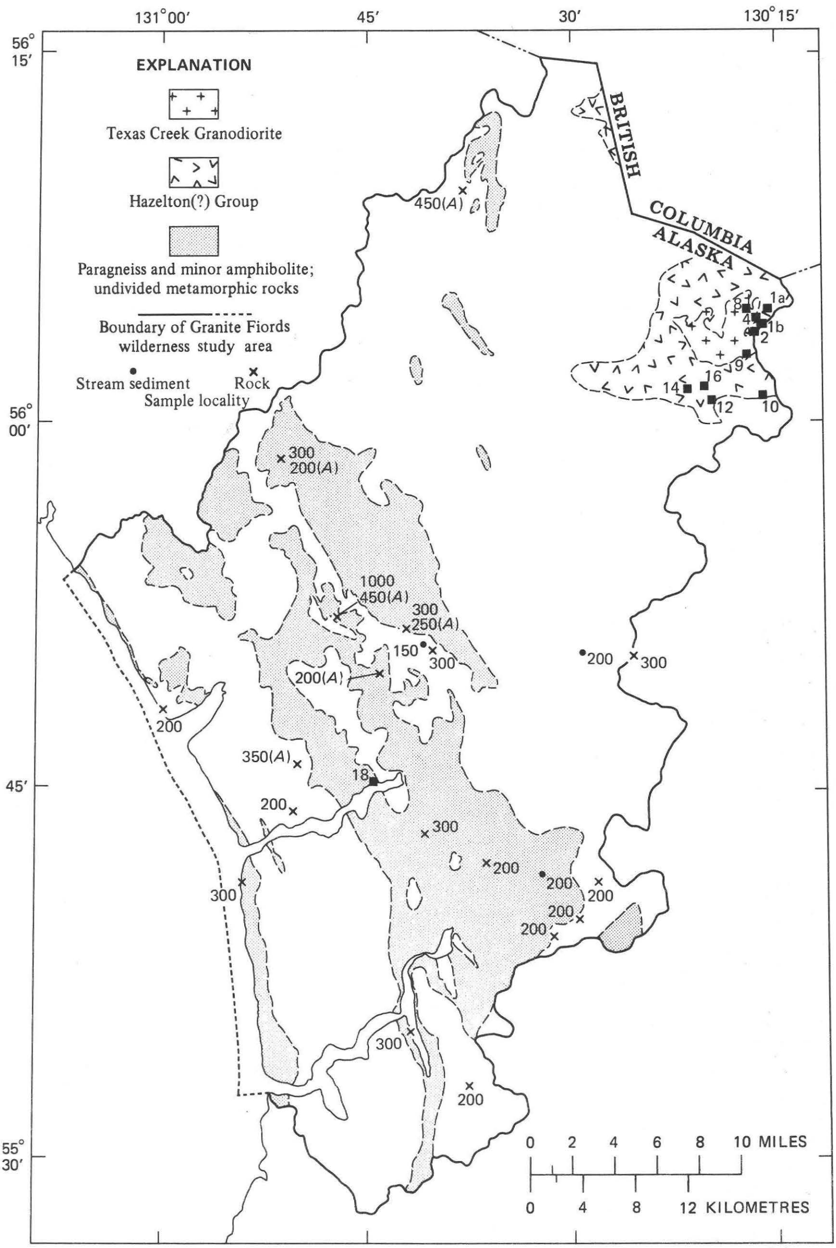



FIGURE 15.—Zinc in Granite Fiords. Locations of rock samples containing 200 ppm or more of zinc, spectrographically analyzed stream-sediment samples containing 200 ppm or more of zinc, and atomic absorption-analyzed (*A*) stream-sediment samples containing 150 ppm or more zinc. Numbered squares indicate reported occurrences of zinc in prospects (pls. 1, 2; table 1).

gneiss sample (37) from southeastern Granite Fiords. In the central part of the study area, two altered, pyrite-bearing samples (21 and 24) of paragneiss respectively carry anomalous copper, silver, and zinc and anomalous copper, molybdenum, and zinc.

Only two steam-sediment samples analyzed by spectrographic methods contain determinable (200 ppm or greater) zinc values, and only one other sample meets the lower (150 ppm) threshold set for analyses by atomic absorption (fig. 15). One of these samples, from a stream in strongly altered paragneiss in the central part of the study area, contains anomalous amounts of all five other elements studied. The two remaining samples, one from granitic terrane and the other from paragneiss terrane, produced single-metal anomalies.

## MINERAL PROSPECTS AND OCCURRENCES

### HISTORY

Mineral exploration of the Granite Fiords study area began about 1898 and has continued sporadically to the present. More than 375 base- and precious-metal lode claims were staked and considerable exploration was done in the relatively accessible northeast corner on the edge of the Hyder mining district and near salt water on the western edge of the study area. In the northeast part of the area, the only active claims in the fall of 1973 were the Marmot, Goat, and Cub groups of 51, 2, and 28 claims, respectively (P–13, P–14, P–17, fig. 16). The only other active claims are the Alamo group of eight claims near Walker Cove (P–18).

Production from the study area consists of 300 to 400 oz of gold and electrum from a vein on the Marietta prospect (P–1), reported by local residents, and a reported 1-ton smelter test shipment from the Heckla prospect (Buddington, 1929, p. 102) (P–12).

The absence of claim locations throughout most of the study area may reflect inaccessibility rather than an absence of mineral deposits. Prospecting has been limited by the remote and rugged terrain and inclement weather. Throughout most of the area access is practical only by helicopter during relatively brief periods in the summer.

### HYDER DISTRICT

Gold-silver lode deposits were discovered in British Columbia near the head of Portland Canal in 1898, and the town of Stewart, British Columbia, soon was established 24 km east of the study area. The early gold seekers reached the head of the Chickamin River and the mineralized area adjacent to the Texas Creek Granodiorite by various routes including Salmon River and the West Fork of Texas Creek, but in general, they were searching for placers and paid little attention to lodes.

Prospecting on the American side of the international boundary was intensified after 1918 when rich gold-silver ores were discovered

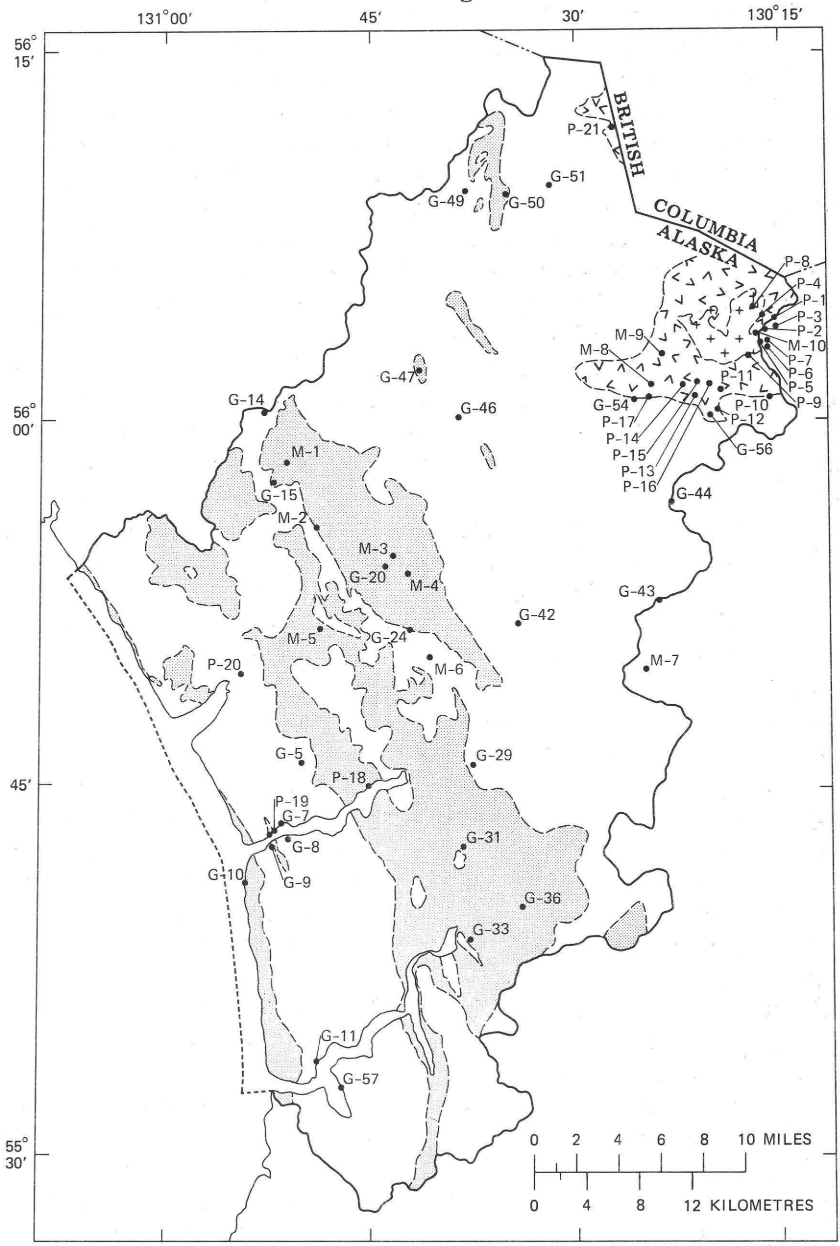



FIGURE 16.—Location of mineral prospects (P– ), mineralized areas (M– ), and rock geochemical anomalies (G– ) examined by the Bureau of Mines. The letter "P," "M," or "G" followed by a number refers to the description in the text. Map units same as in figures 9–15.

at Premier, British Columbia, less than 3 km from the Alaskan border. The Riverside mine and the town of Hyder were established on the American side of the boundary during the early 1920's. The Hyder district, between 1925 and 1951, produced about 3,000 oz of gold, 100,000 oz of silver, 100,000 lb of copper, 250,000 lb of lead, 20,000 lb of zinc, and 3,500 units of tungstic oxide (Berg and Cobb, 1967, p. 147). Practically all was from the Riverside mine, about 11 km east of the study area. Just across the international boundary, the Stewart district was one of the major gold-silver districts in British Columbia (Grove, 1971, p. 19). Most production was from the Premier and Silbak-Premier mines about 16 km east of the study area. Between 1918 and 1965 they produced more than 1.5 million oz of gold and more than 40 million oz of silver.

In 1923 metalliferous veins were discovered along the West Fork of Texas Creek. Most of the prospects now known in or near the study area were staked between 1923 and 1930. Prospects were on both sides of the Chickamin River–West Fork divide, which forms the boundary of the Granite Fiords study area. The Marietta (Silver King), Alaska State Mines, Stampede, Double Anchor, Chickamin, Lake, Lakeside, Blasher, Cathedral, Hummel Canyon, Swennings Greenpoint, and Heckla claim groups (P–1 to P–12, fig. 16) were on the east side of the north-south valleys containing the Chickamin and Through Glaciers. The Jumbo, Edelweiss, and Glacier groups (P–13, P–15, P–17, fig. 16) were on Banded Mountain to the west.

A 1-ton test shipment of ore from the Heckla prospect was broken from the outcrop and sledged over Through Glacier to the West Fork trail in September 1925. A small lot of ore that may be part of this shipment remains at the end of the West Fork road. Local residents generally agree that during the late 1930's and early 1940's, Larry Thornton produced between 300 and 400 oz of native gold and electrum from claims located in 1925 and described in this report as the Marietta prospect. The source reportedly was a narrow quartz and breccia vein.

Since 1970, the Pecos, Lone Star, and Greenpoint groups have been active, but at the time of our investigation were being abandoned after an exploration program that included geologic mapping, sampling, ground geophysical work, and some diamond drilling. The six claims of the Pecos group are in the same general area as the Marietta (Silver King) and Alaska State Mines groups. The 32 claims of the Lone Star group cover parts of the old Lake and Lakeside groups and Blasher locations. Greenpoint claims 1 through 12 extend from the junction of the Greenpoint and Through Glaciers across the Heckla veins to the south-southwest. In the fall of 1973, the only active lode claims in the part of the Hyder district that extends into the study area were the Marmot, Cub, and Goat groups on Banded Mountain.

#### WALKER COVE AREA

The Alamo group of claims is in altered, iron-stained paragneiss in a gorge on the north side of Walker Cove 11 km from Behm Canal. The metals claimed are copper, zinc, and silver. The deposit was located as the Glacier prospect in 1954 and restaked in 1969 as the Alamo group of six lode claims. The property is held by local mineral exploration groups. Two additional claims were staked in 1973. Exploration has included diamond drilling and trenching. The rugged terrain necessitates the use of a helicopter for access to some of the drilling and sampling sites.

Except for the relatively accessible location, the Alamo prospect appears similar to numerous other iron-stained zones in the paragneiss found during this investigation. Until recently these zones have received almost no attention from prospectors.

#### CHICKAMIN RIVER–LEDUC RIVER AREA

The Gnat prospect, a molybdenum occurrence, was staked in 1900(?) near the mouth of the Chickamin River. Apparently a thick quartz vein with associated sulfides attracted the attention of gold prospectors, although no gold was detected in Bureau of Mines samples.

The Joker group of claims was staked for molybdenum in 1952 on the north side of the Leduc River adjacent to the international boundary and within sight of the Granduc mine (Benson, 1971). No ore bodies or mineralization similar to the Granduc were found at the Joker prospect.

## METHODS OF EXAMINATION

### MINERAL DEPOSIT SEARCH

The Bureau of Mines examined relevant literature on mineral deposits and mining activity in and near the Granite Fiords study area and searched for mining claim locations in the records of the Ketchikan and Hyder recording districts. These studies were followed by detailed examination and sampling of lode claims and prospects, mineral occurrences previously known or discovered during the present investigation, and localities where Geological Survey geologists reported geochemically anomalous rock samples. Access to examination sites was by boat at Walker Cove and Rudyerd Bay and by helicopter and foot at all other areas.

The snow was unusually deep during the 1972 and 1973 field seasons. Many prospects remained partly covered during both field seasons, and at least two remained completely covered. Avalanches from the previous winter that persisted in many of the gorges and canyons provided access to some otherwise inaccessible locations but covered other reported deposits. The snow cover generally was deeper in 1973. Several prospects examined in 1972 were partly or completely covered, and several sites where the Geological Survey collected anomalous rock geochemical samples in 1972 could not be reexamined in 1973.

More than 375 claims have been located in the study area, but many are relocations of old claims or restaking of ground previously located and abandoned. Most of the older claim records are confusing or inadequate. Many older claims could not be found, and almost none could be plotted accurately. Ice fields or glaciers commonly were used as location or elevation references. Chickamin Glacier has retreated almost 3 km since the 1920's, and ice has receded generally. Ties to landmarks bearing local names that have not been perpetuated add to the confusion. Avalanches, snow creep, and alder growths have oblitered claim corners and signs of mining activity in many areas. A few relatively recent identifiable claim posts and a somewhat larger number of rock monuments were found, but most contained either relatively recent information or none at all. The prospects were found by supplementing reported positions with descriptions furnished by people with local knowledge, by making ground traverses in the reported areas, and by tracing float specimens from creek beds or outwash fans to the lode source.

The Bureau engineers examined 21 mineral prospects: 17 in the northeast corner of the study area, 2 near the north shore of Walker Cove, 1 near the mouth of the Chickamin River, and 1 on the west side of the Leduc River valley just south of the Alaska-Canada border. To avoid confusion resulting from restaking and multiple prospect or claim names, the prospects sampled are identified by a serial number preceded by the letter "P".

Several occurrences of altered, locally sulfide-bearing rocks were sampled that are not known to have been located as lode prospects. Most of these bleached and iron-stained zones are in paragneiss and were found by Geological Survey personnel during geologic mapping (p. 43–44). These occurrences, informally termed "mineralized areas" in this section of the report (fig. 16), are identified by a serial number preceded by the letter "M."

Fifty-seven rock samples collected by the Survey are listed as anomalous in one or more of the elements gold, silver, copper, molybdenum, lead, and zinc. Bureau engineers examined and sampled as many of these sample sites as snow cover, weather conditions, and available time permitted. These sites are identified by the letter "G" and a number that corresponds to the Geological Survey map number in figure 9 and table 3.

## SAMPLING AND MAPPING

The Bureau of Mines field sampling and mapping program was designed to provide a maximum of data considering the constraints imposed by limited time, abnormal snow cover, and difficult access. Two types of samples were taken: (1) selected specimens for petrographic identification of rock type, mineralogy, and origin and (2) quantitative (chip and channel) samples to determine grade. About 400 rock specimens and 425 quantitative samples were collected.

The specimens selected for petrographic identification were analyzed at the petrographic laboratory of the Bureau of Mines in Juneau, Alaska. The results are not tabulated but form the basis for the deposit descriptions.

Quantitative samples from veins and mineralized zones were obtained either by cutting channels with a moil or by continuous chip cuts. Broad mineralized zones were sampled by compositing uniform chips taken by moil or sample pick at regular intervals, usually at 0.3- or 0.6-m (1 or 2 ft) intervals, across a representative section. Samples were shipped to the Anchorage field laboratory of the U.S. Geological Survey to be crushed and split. A split was submitted for 30-element semiquantitative spectrographic analyses. Another split was analyzed by atomic absorption for copper, lead, zinc, and gold. Additional splits of about half of the samples were submitted to the Reno laboratory of the Bureau of Mines, where gold and silver content was determined by fire assay and molybdenum, copper, lead, and zinc values were checked by atomic absorption analyses.

Analytical values have been tabulated in parts per million to conform with the tabulations by the U.S. Geological Survey, but significant values are converted for this text to percent or ounces per ton. (See table 2 for converting parts per million to percent or to ounces per ton.) When available, spectrographic and atomic absorption analytical results both are tabulated. Because of the larger sample volume analyzed and inherent characteristics of the analytical system, the atomic absorption results are considered more reliable.

No maps were available of any of the prospects. Prospects and sample sites were mapped using a Brunton compass combined with taping and pacing. Elevations were obtained from aircraft and pocket aneroid altimeters.

## MINERAL PROSPECTS

The prospects are grouped by areas in the descriptions that follow. The number in parentheses after the prospect name identifies that prospect in figure 16 and on table 1. Prospects numbered P–1 through

P–17 are in the northeastern part of the study area; P–18 and P–19 are in the Walker Cove area; P–20 is on the Chickamin River about 6 km upstream from the mouth; P–21 is on the Leduc River adjacent to the Canadian border.

### MOUNT JEFFERSON COOLIDGE AREA

#### ALASKA STATE MINES GROUP (P–1)

This claim group, the contiguous Alaska State Mines Extension and four Silver King claims, comprises 19 lode and two placer claims staked in 1958 to 1960 between 1,200 and 1,500 m (4,000 and 5,000 ft) elevation on the open ridge north of Texas Lake. These claims under common ownership held the Marietta (P–1), Dugas (Stampede) (P–2), and Double Anchor (P–3) prospects, separately staked in the mid-1920's, and all now inactive.

#### MARIETTA PROSPECT (P–1)

The six-claim Marietta group was staked in September 1925 by Larry Thornton and George Lemmons near the lower edge of an icefield on west-facing bluffs overlooking Chickamin Glacier nearly 2.4 km north of Texas Lake. Local residents report a production of from 300 to 400 oz of gold from an electrum-bearing vein discovered under a glacier in April 1937 by Thornton. Ice tunnels were driven to bedrock and along vein structures in search of the source of gold- and electrum-bearing float found on the mountainside below. The workings are reported to have been under the ice not far from Thornton's cabin located at approximately 1,500 m (4,900 ft) elevation near the southwest edge of the icefield. Unpublished records of the Territorial Department of Mines (Wilcox, 1938) indicate that Thornton drove more than 1,800 m of ice tunnels during a period of several years before making the high-grade discovery. Tunneling was done by pick and shovel; the ice was removed by sled.

After the discovery, the Marietta claims were relocated in July 1937 as the Solo group, also comprising six claims, with Thornton the principal stockholder in the Solo Mining Company. According to Wilcox (1938), about $2,630 was recovered from high-grade ore in 1937. This ore reportedly came from a vein visible at the surface below the edge of the icefield but having low values where exposed. Thornton reportedly drove 42 m of drift on the vein during the winter of 1938–39 and planned to raise 20 m to the high-grade section previously discovered (Roehm, 1939, p. 12).

During the present investigation, tools, hand steel, and sled parts were found near the reported site of the bedrock workings at the edge of the ice, to the west of and 45 m below the cabin. At that site a location certificate in the cairn stated "This notice is posted at portal of adit." About 20 m of snow trenching failed to reveal the adit. The terrain was too steep for a dump to accumulate.

Samples of a sparsely mineralized vein (3K108) and pod (3K109) containing small amounts of copper, lead, zinc, and silver but virtually no gold were collected from two outcrops. The vein sample was taken about 10 m northwest of the tool cache near the reported bedrock portal. It is a composite of five cuts across a width of 9 to 12 cm along 6 m of exposure striking N. 70° W. and dipping 30° NE. The vein consists of several brecciated iron-stained calcite-quartz stringers containing a little pyrrhotite. The wallrock is dark fine-grained graywacke and argillite that strikes roughly east and has a 25° southerly dip. Sample 3K109 is a select grab sample from a 9 by 40-cm pod of calcite and epidote, with a trace of chalcopyrite. Several similar pods were seen in nearby outcrops. Very little mineralization was seen in the immediate area. Results of sample assays are given in table 4.

Thornton failed to do his assessment work in 1950, and on October 1 when his ground became open, there was a small but wildly competitive rush to restake the area. The six Electrum claims were staked that day. The Electrum group was restaked as the Alaska State Mines, comprising seven lode claims, in 1958. Two placer claims were staked over them in 1960. Silver Kings Nos. 1–4 were staked by the same locators somewhere in the area in 1958(?). In 1970 six Pecos claims were located, partly covering Thornton's ground and extending northeast to another target area. This area yielded argentiferous galena float. In 1973 the Pecos claims were abandoned after an exploration program that included geologic mapping, sampling, ground geophysical work, and very limited diamond drilling. Reportedly, weather conditions prevented drilling to the target zone.

The Silver King prospect (1b, table 1 and pl. 2), which was reportedly in the vicinity of the Marietta but at a lower altitude and possibly farther south, was not found; it was probably covered with snow during this investigation. The Silver King veins described by Buddington (1929, p. 99–100) were staked by Angus Kennedy in August of 1925. The Copper Queen (one claim) was staked in 1956 somewhere in the area. However, the locators' description, if correct, would put it in Canada.

#### Stampede Prospect (P–2).

Three small pits or trenches were found between 1,250 and 1,280 m (4,100 and 4,200 ft) on a west-facing, lightly rubble covered slope of a ridge overlooking the Chickamin Glacier. They are about 140 m west-northwest of the Marietta trail and 1.4 km north-northwest of Blasher cabin on Texas Lake. It is uncertain whether these pits are

TABLE 4.—*Assay data, Marietta prospect*

[L, an undetermined amount of the element is present below the sensitivity limit. N, looked for but not found]

| | | | Spec/AA, ppm | | | |
|---|---|---|---|---|---|---|
| Sample | Au | Ag | Cu | Pb | Zn | Description |
| 3K108 | N/L | 20/ | 1,000/750 | 1,500/800 | 200/170 | Composite of five cuts 9 - 12 cm wide crossing series of brecciated iron-stained calcite-quartz stringers with minor pyrrhotite. |
| 3K109 | N/N | 10/ | 5,000/3,300 | 10/10 | N/120 | Grab from 9- x 40-cm pod of calcite and epidote with trace of chalcopyrite. |

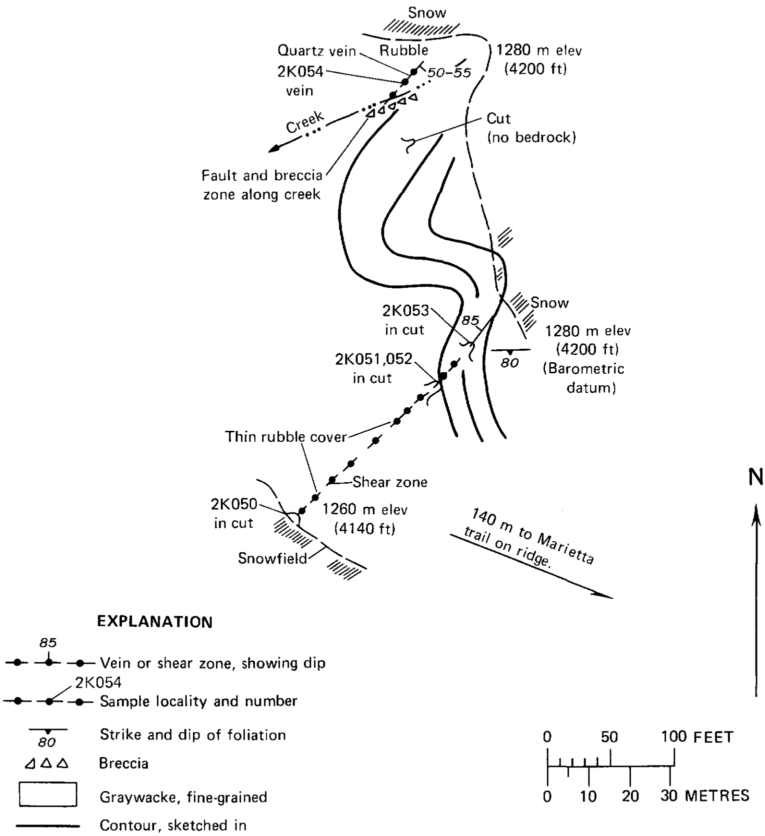
part of the Stampede, Dugas (Buddington, 1929, p. 99), or Blasher Extension. They were the only workings visible through the extensive snow cover at the time this area was visited. Records show that the Dugas, Blasher Extension, and Stampede groups of eight, four, and five claims were staked in 1923–25, 1937, and 1953, respectively, and could have covered one prospect. Alaska State Mines Extension claims staked in 1958 did cover this locality, which was identified in the field. All four claim groups are now inactive.

The three pits are aligned along a poorly defined shear zone 30 to 60 cm wide that strikes N. 45° E. and dips steeply northwest. Local rocks strike east and dip steeply south. Small amounts of galena, sphalerite, and traces of chalcopyrite occur with quartz and gossan in heavily red brown stained, fractured argillite and graywacke (fig. 17). The sulfide minerals appear to be confined to the shear zone; however, such veining as could be defined usually was not parallel to the strike. Only the northeast wall of the lowest pit was visible, and extensive snowfields beyond the pit area obscured any possible extension of the zone along strike.

A quartz vein about 60 cm wide exposed 60 m northwest of the shear zone has the same strike but an opposite dip. It is exposed for more than 6 m in a creek bank. To the northeast it is under snow; to the southwest it terminates against a narrow breccia zone in the creek. The quartz is slightly iron stained and contains a trace of malachite and chalcopyrite. Samples from three channel cuts 43, 49 and 67 cm wide were composited into a single assay sample that contains 300 ppm copper, 250 ppm lead, 200 ppm zinc, and 10 ppm (0.3 oz/ton) silver. Assay data (fig. 17) cover both the vein and the shear zone.

### Double Anchor Prospect (P–3)

The Double Anchor prospect is 1.2 km north of the outlet of Texas Lake and 0.4 km outside of the wilderness study area, at 1,250 m (4,100 ft) elevation. It is just above timberline near the top of a steep south-facing slope. A flat-dipping oxidized quartz breccia zone in graywacke and argillite is exposed on a low cliff and in several small trenches and short adits. Quartz and some pyrite occur with small amounts of sporadically distributed galena, sphalerite, and chalcopyrite. The zone is exposed for 90 m and ranges in width from 37 to 107 cm (see fig. 18 and accompanying assay data in table 5). Values in the zone are as high as 70,000 ppm (7.0 percent) lead, 200 ppm (5.8 oz/ton) silver, and 3.2 ppm (0.09 oz/ton) gold across a 37-cm width, but the arithmetic average grade is 15,500 ppm (1.5 percent) lead, 41 ppm (1.2 oz/ton) silver, 4,100 ppm (0.4 percent) zinc, and 0.5 ppm (0.015 oz/ton) gold across a 72-cm average width. One sample assayed 1,000 ppm copper. The three samples with the highest silver and lead values and above average gold content are adjacent cuts spaced about 9 m apart and represent a strike length of about 22 m. A weighted average is 43,000 ppm (4.3 percent) lead, 10,000 ppm (1.0 percent)




Assay data

| Sample | Width (cm) | Cu | Pb | Zn | Au | Ag | Mo | Description |
|---|---|---|---|---|---|---|---|---|
| | | Spectrographic/Atomic absorbtion, ppm | | | | | | |
| 2K050 | Grab | 70/65 | 3,000/ 3,000 | 300/200 | N/N | 7/ | 70/ | Quartz from dump |
| 2K051 | 46 | 30/140 | 700/500 | 700/550 | N/N | 5/ | L/ | Shear zone; quartz, pyrite and oxides |
| 2K052 | Grab | 300/500 | 700/750 | 1,000/ 1,400 | N/N | 10/ | L/ | Gossan and pyrite. Floor and dump |
| 2K053 | Grab | 1,000/ 1,500 | 15,000/ 14,000 | G(10,000)/ 95,000 | N/0.05 | 30/ | L/ | Rusty shear with sulfides, dump |
| 2K054 | 49, 67, 43 | 150/300 | 700/250 | 700/200 | N/N | 10/ | N/ | Composite quartz vein cuts |

L, an undetermined amount of the element is present below the sensitivity limit.
N, looked for but not found.
G, the amount of the element present is greater than the sensitivity limit.

FIGURE 17.—Sketch map and assay data, Stampede prospect.

zinc, 119 ppm (3.5 oz/ton) silver, and 0.76 ppm (0.022 oz/ton) gold across a 65-cm width.

A poorly defined quartz breccia zone, possibly an extension of the zone exposed in the trenches, occurs in a cliff at approximately the

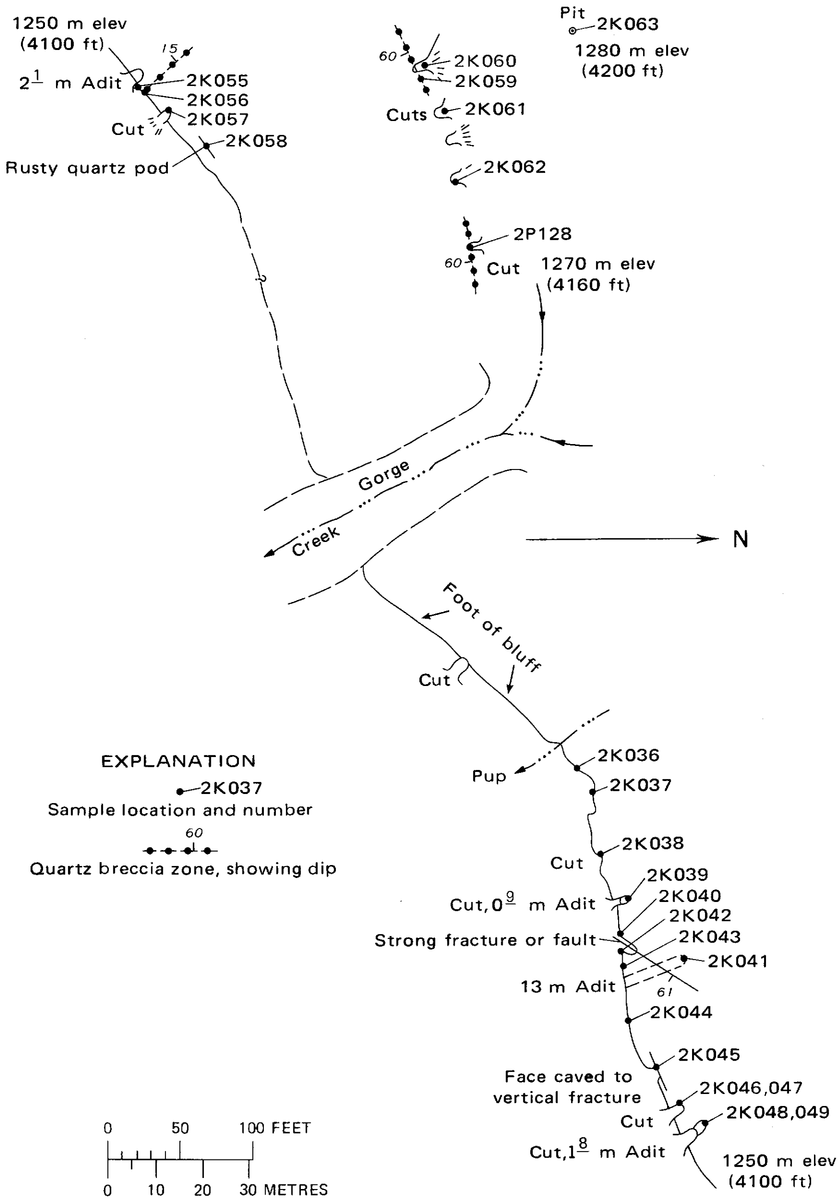



FIGURE 18.—Double Anchor prospect.

TABLE 5.—*Assay data, Double Anchor prospect*

[L, an undetermined amount of the element is present below the sensitivity limit. N, looked for but not found. G, the amount of the element present is greater than the sensitivity limit]

East of gorge

| Sample | Channel width, cm. | Spec/AA, ppm Cu | Pb | Zn | Au | Ag | Mo | Description |
|---|---|---|---|---|---|---|---|---|
| 2K036 | 49 | 30/90 | 3,000/4,000 | 2,000/2,500 | N/N | 20/ | 30/ | Oxidized shear; quartz and galena. |
| 2K037 | 43 | 15/15 | 3,000/8,500 | 700/1,000 | N/0.05 | 15/ | 15/ | Oxidized quartz with pyrite. |
| 2K038 | 79 | 20/80 | G(20,000)/60,000 | 2,000/6,000 | N/0.20 | 150/ | 5/ | Argillite, quartz, and minor sulfides. |
| 2K039 | 79 | 70/160 | 15,000/21,000 | 10,000/14,000 | N/0.20 | 50/ | L/ | Argillite and quartz, trace sulfides. |
| 2K040 | 37 | 50/130 | G(20,000)/70,000 | 7,000/11,000 | N/3.20 | 200/ | 7/ | Sheared quartz with galena. |
| 2K041 | 170 | 10/65 | 500/1,500 | 300/350 | N/N | 3/ | 7/ | Calcareous graywacke, minor pyrite. |
| 2K042 | 104 | 30/95 | 3,000/4,500 | 1,000/1,500 | N/0.10 | 10/ | 7/ | Oxidized shear zone. |
| 2K043 | 79 | 700/1,000 | 10,000/15,000 | 5,000/6,500 | N/N | 30/ | 50/ | do. |
| 2K044 | 46 | 30/80 | 2,000/2,000 | 1,500/2,000 | N/N | 10/ | 20/ | do. |
| 2K045 | 92 | 70/190 | 5,000/6,500 | 1,000/1,500 | N/2.20 | 15/ | 7/ | Shear zone; quartz and pyrite. |
| 2K046 | 79 | 30/100 | 2,000/3,500 | 1,500/3,000 | N/0.10 | 10/ | 15/ | Oxidized shear; 0.3 m. quartz. |
| 2K047 | 92 | 30/100 | 5,000/5,500 | 2,000/4,000 | N/0.30 | 20/ | 7/ | Oxidized shear, minor pyrite. |
| 2K048 | 55 | 30/110 | 700/700 | 1,000/700 | N/0.20 | 3/ | 5/ | Sheared argillite, some pyrite. |
| 2K049 | 107 | 30/85 | 150/60 | 200/210 | N/N | 1.5/ | 5/ | Oxidized shear zone, pyritic. |

West of gorge

| Sample | Channel width, cm. | Spec/AA, ppm Cu | Pb | Zn | Au | Ag | Mo | Description |
|---|---|---|---|---|---|---|---|---|
| 2K055 | 195 | 150/200 | 300/400 | 500/450 | N/N | 3/ | 10/ | Phyllite and breccia. |
| 2K056 | 12 | 700/600 | 1,000/1,300 | N/140 | N/N | 10/ | 5/ | Quartz breccia. |
| 2K057 | Grab | 50/50 | G(20,000)/60,000 | 300/500 | 20/24.00 | 150/ | 7/ | Quartz, rusty. |
| 2K058 | 192 | 30/130 | 1,500/1,500 | 200/400 | N/0.10 | 10/ | 7/ | Argillite, pyritic. |
| 2K059 | 86 | 30/85 | 150/65 | L/150 | N/N | 1/ | 15/ | Quartz breccia. |
| 2K060 | Grab | 30/30 | 70/20 | L/95 | N/N | 1.5/ | 7/ | Phyllite, rusty. |
| 2K061 | do. | 100/350 | 70/130 | 500/700 | N/N | 3/ | 7/ | Breccia, rusty. |
| 2K062 | do. | 150/170 | 500/450 | 500/550 | N/N | 1.5/ | 15/ | Phyllite, rusty. |
| 2K063 | do. | 150/190 | 70/50 | 500/600 | N/0.05 | 5/ | 20/ | do. |
| 2P128 | do. | 70/ | 1,500/ | 5,000/ | N/ | 3/ | L/ | Quartz and breccia. |

same elevation about 150 m to the west beyond a steep gorge. Mineralization is similar, but assay values were lower except for a grab sample of a small rusty quartz pod that indicated 60,000 ppm (6.0 percent) lead, 150 ppm (4.4 oz/ton) silver, and 24 ppm (0.70 oz/ton) gold. A short adit driven nearby showed no mineralization. On the gentle north-facing slope 60 m north of the adit and 20 to 30 m above, a row of shallow cuts has been dug. A 60- to 85-cm thick quartz and breccia zone is exposed in two of the cuts 38 m apart at opposite ends of the row. A grab sample at the east pit and a sample cut across the quartz and breccia in the west pit yielded very low metal values.

The Double Anchor prospect was briefly described by Buddington (1929, p. 98–99). Four claims were staked here in 1923 and were relocated as the four Snow Shoe claims in 1937. The Alaska State Mines Extension group of claims staked in 1958, and now inactive, covered the Double Anchor and the Stampede prospect as well.

### Chickamin Prospect (P–4)

A grab sample was collected from a 24-cm thick dike 2 km north of Disappearing Lake on a precipitous west-facing mountain slope overlooking the Chickamin Glacier at approximately 900 m (3,000 ft) elevation. The dike is granitic and contains traces of pyrrhotite and goethite. Assays were not made. This site is near the reported site of the Chickamin prospect described by Buddington (1929, p. 100), which was searched for but not found. The prospect may have been covered by the snow in one of the local gullies.

### Lake Prospect (P–5)

This prospect is about 0.5 km northeast of Disappearing Lake at an altitude of about 730 m (2,400 ft). A quartz vein 101 cm wide is exposed in an opencut just above the Marietta pack trail. It is in Texas Creek granodiorite just below the contact with Hazelton(?) metamorphic rocks, and it strikes across the contact N. 35° W. and dips 65° NE. It contains visible pyrite and galena for 23 cm above the footwall. The upper part of the vein is white quartz almost devoid of sulfide minerals and containing some micaceous schistose material. A trace of chalcopyrite was identified under the microscope. Sample 2P121 across the 101 cm width of the vein yielded 35 ppm copper, 35 ppm lead, and 25 ppm zinc. South of the pit cleaned out for sampling there is some evidence of other badly caved and overgrown pits on the south side of the trail. The exposure reported by Buddington (1929, p. 101) may have been in one of these pits. This prospect was first located in July 1923.

### Lakeside (P–6)

The two Lakeside claims (fig. 19) lie across the divide between

Disappearing Lake and Texas Lake on the east boundary of the study area. They are probably a relocation of the Morning claims (Buddington, 1929, p. 101). The vein described by Buddington was not found.

Massive quartz, believed to be vein outcrop, was sampled, but later digging to determine more accurately the width and attitude of the occurrence indicated that the quartz may be boulders embedded in overburden over grandiorite. The base of the "outcrop" was not reached because of an adjoining pond. Sample 2P119 cut across the massive quartz near the pond assayed 280 ppm copper, 4,000 ppm lead, 120 ppm zinc, and 15 ppm (0.4 oz/ton) silver.

A caved trench in thoroughly weathered granodiorite is about 106 m northwest of the massive quartz. Two nearby recent cuts in the granodiorite show badly broken quartz outcrop material about 30 cm wide, striking north. A sample of quartz from the trench (2P120) yielded negligible metal values.

### Blasher Prospect (P–7)

The Blasher prospect workings are 460 m N 30° W of the west end of Texas Lake at an elevation of about 810 m (2,600 ft.) (fig. 19). The workings can be reached by a trail that leaves the old West Fork road just west of Texas Lake. The prospect is believed to be on a group of four lode claims located by Frank Blasher in 1923. The ground has been restaked several times and is now mostly covered by the 32-claim Lone Star group located in 1970 and 1971.

Exploration workings are about 300 m outside the study area boundary on the east end of a mineralized structure reported to have been traced for a length of 460 m northwest and into the study area (Buddington, 1929, p. 102). Accessible workings (fig. 20) consist of the southeast opencut, a portal bench cut with a 14-ft adit, and an opencut above the adit that exposes the vein for a distance of 35.7 m upslope to the northwest. There is a caved trench across the projected strike of the Blasher vein 18 m northwest of the long opencut; the trench was partly covered by snow. Exposed dump material appeared to be overburden. No vein exposures or workings were found on the steep slope northwest along the projected trace of the vein. This area is mostly covered with soil, talus, and avalanche debris and overgrown by a dense cover of bushes, alder, and patches of timber. Four holes have been drilled in the southeast cut and portal bench areas, and three holes were drilled from a station on the hanging wall northeast of the upper end of the long cut. No depth, assay, or geological information is available from these holes.

The Blasher prospect is the best exposed example of the contact area vein deposits typical of the Mount Jefferson Coolidge area. The vein walls are fractured brown quartzite or hornfels on the west and light-gray fine-grained quartz monzonite on the east. The quartz monzonite exposed in the southeast opencut and the adit area is probably a small cupola of the underlying Texas Creek Granodiorite. Buddington (1929) reported that the outcrop of the vein is probably not more than 60 m above the contact with the Texas Creek Granodiorite.

The southeast opencut exposes the Blasher vein at the upper end of a gravel and boulder fan in the valley of a creek that drains toward Texas Lake. The quartz vein is 18 to 46 cm wide and dips 60°–70° NE. It contains chalcopyrite, galena, sphalerite, pyrrhotite, pyrite, and very small amounts of molybdenite. Sulfide minerals are erratically distributed and usually constitute only a few percent of the vein material. Similar quartz seams and veinlets occupy some of the fractures in locally sheeted and fractured wallrocks. Molybdenite occurs in the wallrocks as very thin facings on some fracture surfaces and rarely as discrete aggregates within the rock.

The vein is exposed in the floor and on the east wall of the portal bench. It is 61 cm wide in the face of the adit and has about the same sulfide content as in the southeast cut. Sulfides are less plentiful in the hornfels and quartzite footwall and the quartz monzonite hanging wall. In the long opencut, northwest of the portal, vein widths range from 21 to 61 cm. The vein appears to be displaced along cross frac-

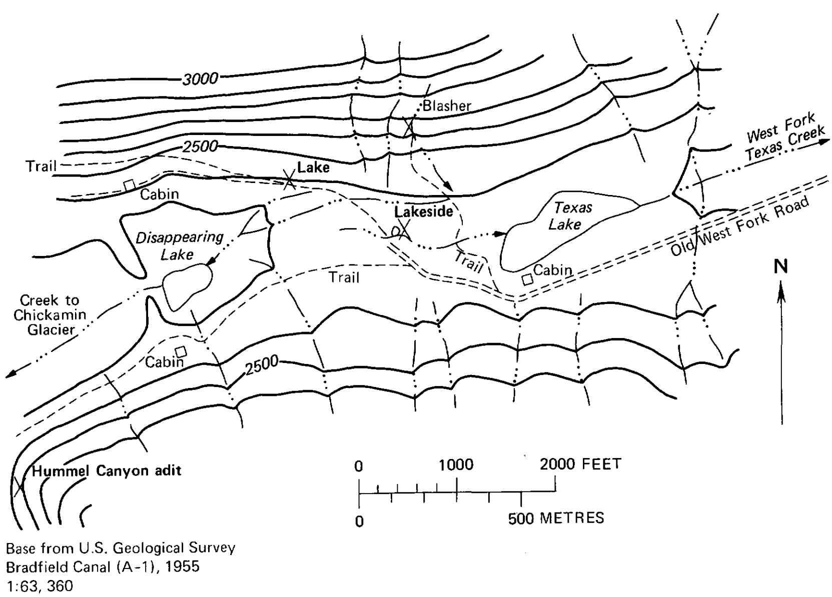



FIGURE 19.—Lake, Lakeside, and Hummel Canyon prospects.

tures at the upper end of the cut. There is very little sulfide in the hornfels wallrocks.

A weighted average of assay data (table 6) over the exposed length of 43 m gives 9,300 ppm (0.93 percent) copper, 11,530 ppm (1.15 percent) lead, 12,500 ppm (1.25 percent) zinc, 21 ppm (0.002 percent) molybdenum, and 151 ppm (4.4 oz/ton) silver. Gold values are 0.56 ppm (0.016 oz/ton) over a width of 37 cm. Bismuth and cadmium ranged from below the limit of spectroscopic detection up to 200 ppm and over 500 ppm, respectively. Small amounts of fluorescent powellite are present locally. Radioactivity was not detected.

Molybdenite-bearing quartz monzonite at the southeast cut yielded

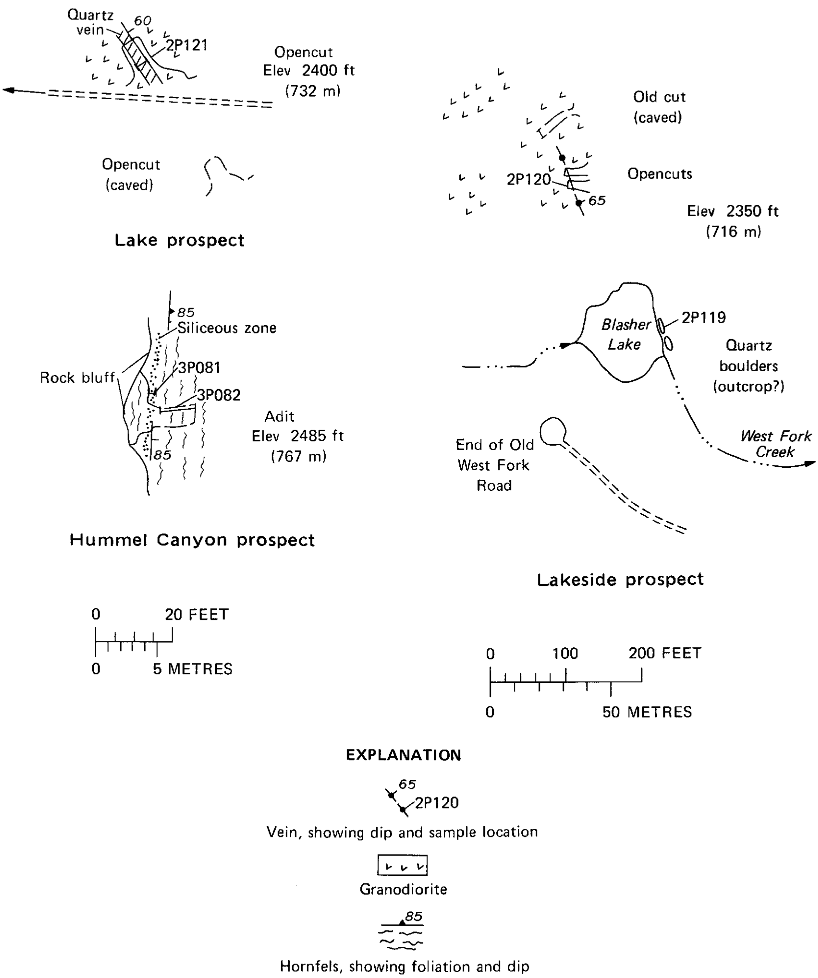



FIGURE 19.—Continued.

some showy small specimens, but a 320-cm-long cut sample across a recently blasted face assayed only 700 ppm molybdenum. Samples across footwall quartzite and hornfels yielded 15 to 70 ppm.

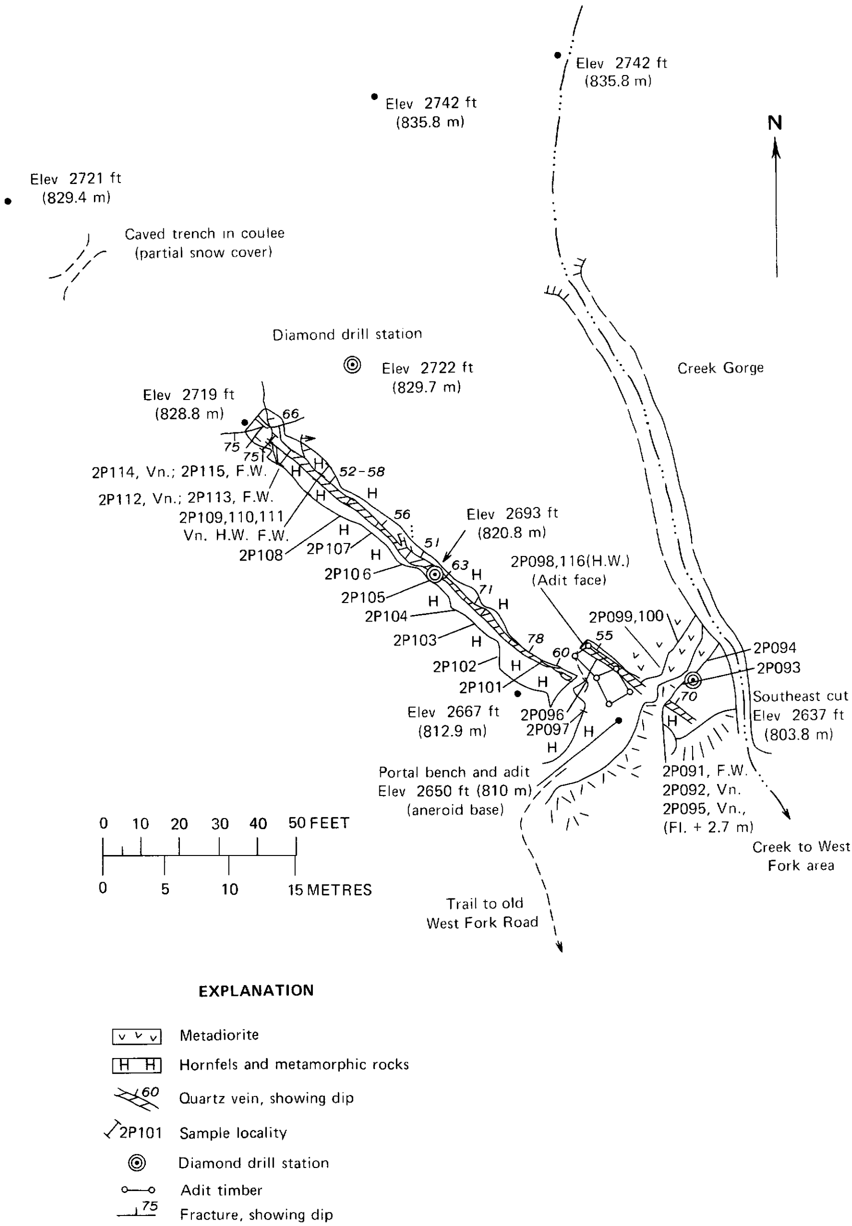



FIGURE 20.—Blasher prospect.

TABLE 6.—*Assay data, Blasher prospect*

[L, an undetermined amount of the element is present below the sensitivity limit. N, looked for but not found]

| Sample | Sample length, cm | Spec/AA, ppm | | | | Spec, ppm | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cu | Pb | Zn | Au | Ag | Mo | Bi | Cd | |
| **Southeast opencut** | | | | | | | | | | |
| 2P091 | 46 | 200/400 | 300/500 | 300/500 | N/N | 3 | 15 | N | N | Footwall rocks. |
| 2P092 | 18 | 10,000/12,000 | 3,000/7,500 | 1,000/1,300 | N/0.9 | 150 | 70 | 100 | N | Vein. |
| 2P093 | 320 | 30/230 | 70/110 | N/100 | N/0.05 | 1 | 700 | N | N | Hanging wall rocks. |
| 2P094 | 290 | 7/40 | 50/25 | N/90 | N/N | N | 7 | N | N | Do. |
| 2P095 | 46 | 15,000/16,000 | 3,000/11,000 | 7-000/10,000 | N/0.2 | 150 | 10 | 50 | 150 | Vein. |
| **Portal bench and adit** | | | | | | | | | | |
| 2P096 | 244 | 20/70 | 150/100 | N/90 | N/N | 1 | 70 | N | N | Footwall rocks. |
| 2P097 | 213 | 150/120 | 200/350 | N/N | N/N | 1.5 | 50 | N | N | Do. |
| 2P098 | 61 | 10,000/6,000 | 3,000/2,800 | 7,000/3,000 | N/0.1 | 70 | 20 | 15 | 150 | Vein. |
| 2P116 | 43 | 150/280 | 300/310 | N/70 | N/N | 3 | 100 | N | N | Hanging wall rocks. |
| 2P099 | 274 | 10/50 | 150/85 | N/30 | N/N | 1 | 30 | N | N | Do. |
| 2P100 | 366 | 10/40 | 50/50 | N/30 | N/N | N | 20 | N | N | Do. |
| **Opencut on Blasher vein** | | | | | | | | | | |
| 2P101 | 30 | 500/4,000 | 200/2,800 | N/130 | N/2.5 | 20 | 70 | 200 | N | Vein. |
| 2P102 | 61 | 15,000/14,000 | 15,000/10,000 | 1,000/4,000 | N/0.6 | 300 | 50 | 150 | N | Do. |
| 2P103 | 34 | >20,000/19,000 | 5,000/10,000 | 7,000/10,000 | N/0.7 | 200 | 20 | 70 | 200 | Do. |
| 2P104 | 27 | 3,000/4,000 | 15,000/23,000 | >10,000/50,000 | N/N | 100 | 20 | 70 | >500 | Do. |
| 2P105 | 21 | 10,000/8,000 | 10,000/10,000 | >10,000/50,000 | N/N | 150 | L | 10 | 500 | Do. |
| 2P106 | 49 | 5,000/8,500 | 10,000/18,000 | 7,000/10,000 | N/N | 50 | 7 | 10 | 150 | Do. |
| 2P107 | 34 | 3,000/4,500 | 2,000/5,800 | 1,500/4,500 | N/1.5 | 20 | N | L | 50 | Do. |
| 2P108 | 24 | 150/850 | 1,000/9,000 | N/500 | N/0.5 | 3 | N | N | N | Do. |
| 2P109 | 27 | 3,000/7,500 | 2,000/1,500 | 500/220 | N/0.7 | 50 | 20 | 20 | N | Do. |
| 2P110 | 70 | 70/140 | 100/50 | L/110 | N/L | 1.5 | 5 | N | N | Hanging wall rocks. |
| 2P111 | 82 | 200/230 | 300/130 | L/300 | N/N | 1.5 | 10 | N | N | Footwall rocks. |
| 2P112 | 37 | 3,000/2,700 | >20,000/40,000 | >10,000/55,000 | N/0.5 | 500 | L | 200 | >500 | Vein. |
| 2P113 | 52 | 30/170 | 150/450 | N/200 | N/N | 1.5 | L | N | N | Footwall rocks. |
| 2P114 | 55 | 20,000/14,000 | 15,000/10,000 | 15,000/6,000 | N/0.5 | 200 | 15 | 100 | 150 | Vein. |
| 2P115 | 162 | 1,500/1,500 | 1,000/5,000 | 200/250 | N/N | 20 | 5 | N | N | Footwall rocks. |

### Cathedral Prospect (P–8)

Two silver-lead-zinc-bearing quartz veins on the south end of the bold ridge between Chickamin and West Texas Glaciers are exposed at 970 and 1,050 m (3,170 and 3,450 ft) elevation just above west-facing cliffs. Four Cathedral claims staked by Sam Swenning in 1930 probably covered these veins, which lie about 3 km northwest of Texas Lake.

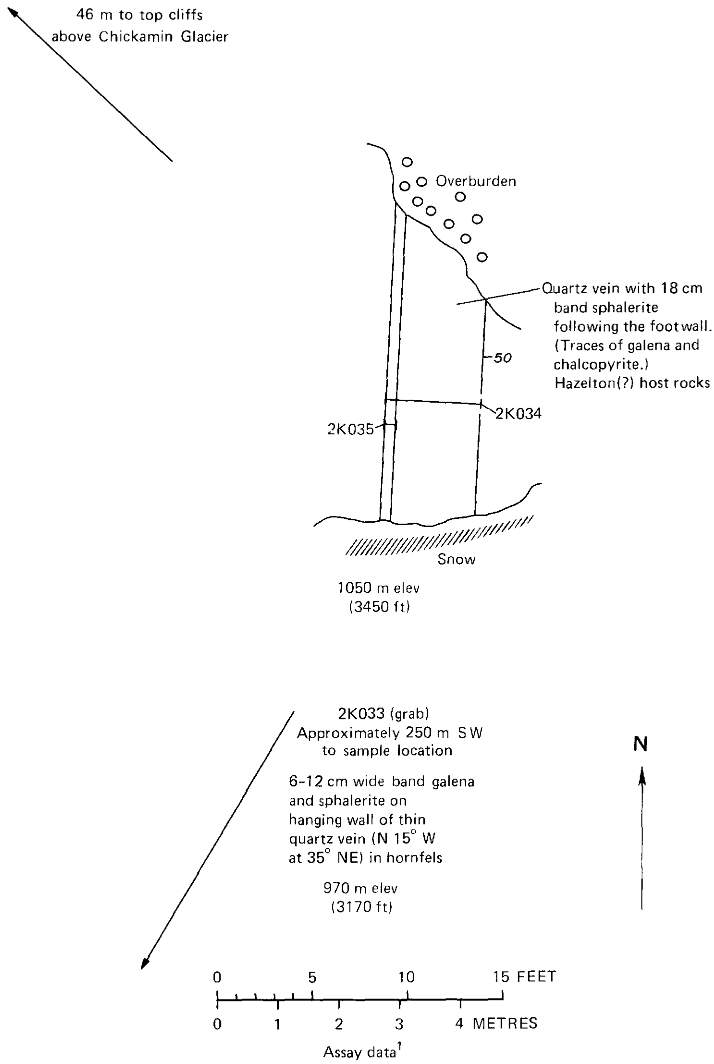
Both veins cut Hazelton(?) metamorphic rocks, which appear more hornfelsic at the lower site. The veins strike nearly north and dip moderately east. Massive sulfides are along one wall of each vein. Sphalerite and galena dominate the sulfides, although traces of pyrite, pyrrhotite, and chalcopyrite are present.

The upper quartz vein (fig. 21), much the thicker of the two, is about 1.5 m wide. The vein has been stripped of overburden, and 3 m of strike length were exposed at the edge of a snowfield. Massive sphalerite 18 cm thick containing traces of galena and chalcopyrite follows the footwall. From the hanging wall of the vein to the hanging wall of the sphalerite zone, the vein consists predominantly of quartz with minor blebs of sulfides. A moiled channel sample of the full vein width including the sulfide zone contained 70 ppm (2.0 oz/ton) silver, 1,700 ppm (0.17 percent) copper, 7,500 ppm (0.75 percent) lead, and 75,000 (7.5 percent) zinc. A moiled separate sample of the sulfide zone contained 150 ppm (4.4 oz/ton) silver, 2,700 ppm (0.27 percent) copper, 9,000 ppm (0.9 percent) lead, and 350,000 ppm (35 percent) zinc.

The quartz vein at the lower site approximately 250 m to the south-southwest is poorly exposed in a shallow pit on the edge of a cliff. Vein quartz 6 cm thick adjoins 6 cm of massive sulfides on the hanging wall. Galena dominates the sulfides, with lesser sphalerite and traces of chalcopyrite, pyrrhotite, and pyrite present. The vein is covered with soil and vegetation to the south and is only slightly mineralized where it is exposed 6 m to the north beyond morainal cover. A small dump near the pit contains similar sulfides up to 12 cm thick. A grab sample (2K033) reasonably representative of the sulfide band on the hanging wall of the vein contained 700 ppm (20.4 oz/ton) silver, 200 ppm (0.02 percent) copper, 190,000 ppm (19 percent) lead, and 90,000 ppm (9 percent) zinc.

Other veins have been reported but were not seen during this examination because many hollows in the ridge topography were filled with snow.

A rusty-weathering zone farther to the north was chip sampled. Occasional grains of pyrite were seen, and sample assays yielded 2 ppm silver, 20 ppm molybdenum, and negligible amounts of other metallic elements.




Assay data[1]

| Sample | Width (cm) | Ag | Cu | Pb | Zn | Au | Description |
|---|---|---|---|---|---|---|---|
| | | Spectrographic/Atomic absorbtion, ppm | | | | | |
| 2K033 | Select grab | 700/ | 100/ 200 | G(20,000)/ 190,000 | G(10,000)/ 90,000 | N/N | Quartz vein with galena and sphalerite |
| 2K034 | 152 | 70/ | 2,000/ 1,700 | 10,000/ 7,500 | G(10,000)/ 75,000 | N/0.05 | Quartz vein, massive sphalerite |
| 2K035 | 18 | 150/ | 3,000/ 2,700 | 20,000/ 9,000 | G(10,000)/ 350,000 | N/N | Footwall sphalerite of vein No. 34 |

[1]Cd G(500)/ in all samples.
N, looked for but not found.
G, the amount of the element present is greater than the sensitivity limit.

FIGURE 21.—Sketch map and assay data, Cathedral prospect.

## AREA EAST OF THROUGH GLACIER

### HUMMEL CANYON PROSPECT (P–9)

The Hummel Canyon prospect is 0.6 km S. 42° W. of Disappearing Lake, east of Chickamin Glacier and northeast of the mouth of the Hummel Glacier canyon (P–9, fig. 16). Original access was by trail along moraine benches perched on the lower slopes of the mountain above Chickamin Glacier. Most of the trail is now densely overgrown with alder and brush.

A conspicuous rusty-weathering zone in Hazelton(?) Group metamorphic rocks is exposed in bluffs and crosses the steep ridge northeast of the mouth of the canyon below Hummel Glacier. It crops out from the top of moraine and talus on the canyon floor to just below a timbered bench at 808 m (2,650 ft) elevation. An adit at 767 m (2,485 ft) has been driven eastward 3.4 m into the ridge to crosscut a pyritic silicified zone 18 to 30 cm wide and the slightly pyritic hornfels wallrock (fig. 19). The pyritic, silicified material and the thin-banded hornfels strike N. 10° E. and dip 85° E. Samples cut across the silicified zone and along the north wall of the adit contained negligible amounts of copper, lead, zinc, molybdenum, and silver. Gold was not detected.

### SWENNINGS GREENPOINT PROSPECT (P–10)

Lead-silver-molybdenum-bearing quartz veins occur in the side of an avalanche gully above Greenpoint Glacier 4 km south of Texas Lake. Their elevation is about 1,300 m (4,265 ft) on the valley wall northeast of the glacier and nearly 300 m above the ice. Seventeen Greenpoint claims, reportedly staked by Sam Swenning on this mountainside in 1930 and 1938, undoubtedly included the site of these veins.

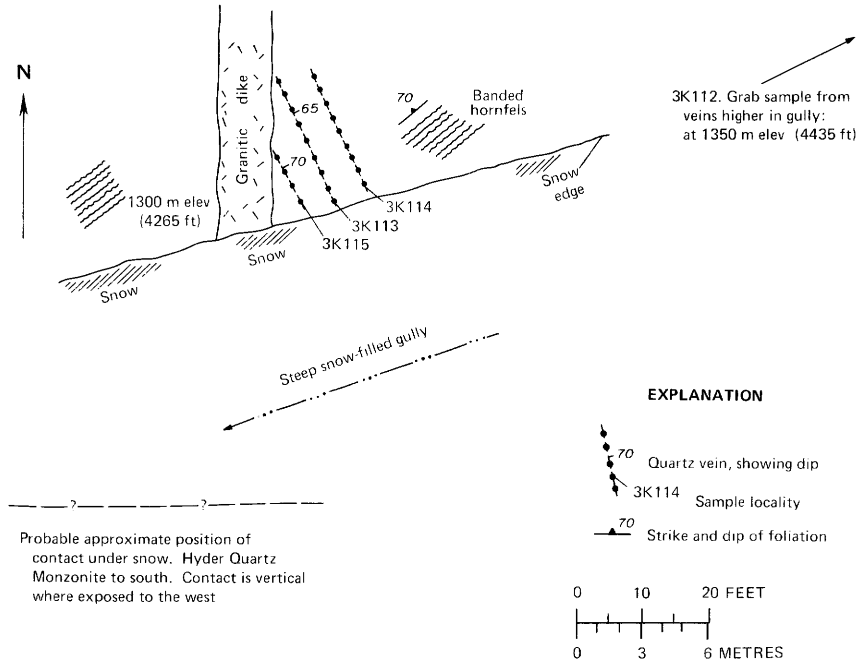
The quartz veins are enclosed in Hazelton(?) hornfels probably less than 15 m north of a contact with Hyder Quartz Monzonite (fig. 22). The contact is vertical where exposed to the west and strikes east into the gully near the veins, where it was covered with snow. Average strike and dip of the veins are N. 30° W. and 65°–75° NE. The vein quartz is somewhat iron stained and contains scattered knots of galena and less obvious molybdenite.

A channel sample was cut from each of three veins at this site. Sample 3K113, a 24-cm cut, had higher combined metal values than the other two samples (fig. 22) and clearly represents above average grade for this vein. Sample 3K112 is a grab sample from two thinner veins 52 m higher in the gully. Gold was not detected in the four samples.

Claim monuments and workings were not found. However, claims have long been inactive, and the steep mountainside is subject to avalanches. Much of the topography is similar to the contact gully area where workings may have been buried by snow and rock debris.

### Greenpoint Group Prospect (P–11)

The Greenpoint group molybdenum-lead prospect is situated on an untimbered point about 230 m south of the confluence of Greenpoint and Through Glaciers at 808 m (2,650 ft) elevation. It is 4.2 km southeast of Disappearing Lake and the head of the old trail from Hyder.




Assay data

| Sample | Width (cm) | Ag | Cu | Pb | Zn | Mo | Bi | Description |
|---|---|---|---|---|---|---|---|---|
| | | Spectrographic/Atomic absorbtion, ppm | | | | | | |
| 3K112 | Grab | 20/ | 200/350 | 3,000/ 3,700 | 1,000/ 750 | 2,000/ | 50/ | Quartz veins(2) (several sulfides) |
| 3K113 | 24 | 100/ | 15/20 | 20,000/ 45,000 | N/10 | 1,000/ | G(1,000)/ | Quartz vein (galena knots) |
| 3K114 | 3 | 50/ | 100/85 | 5,000/ 5,000 | N/60 | 2,000/ | 200/ | Quartz vein (much goethite) |
| 3K115 | 21 | 10/ | 50/70 | 700/ 1,700 | N/10 | 1,000/ | 50/ | Quartz vein (with galena) |

N, looked for but not found.
G, the amount of the element present is greater than the sensitivity limit.

Figure 22.—Sketch map and assay data, Swennings Greenpoint Prospect.

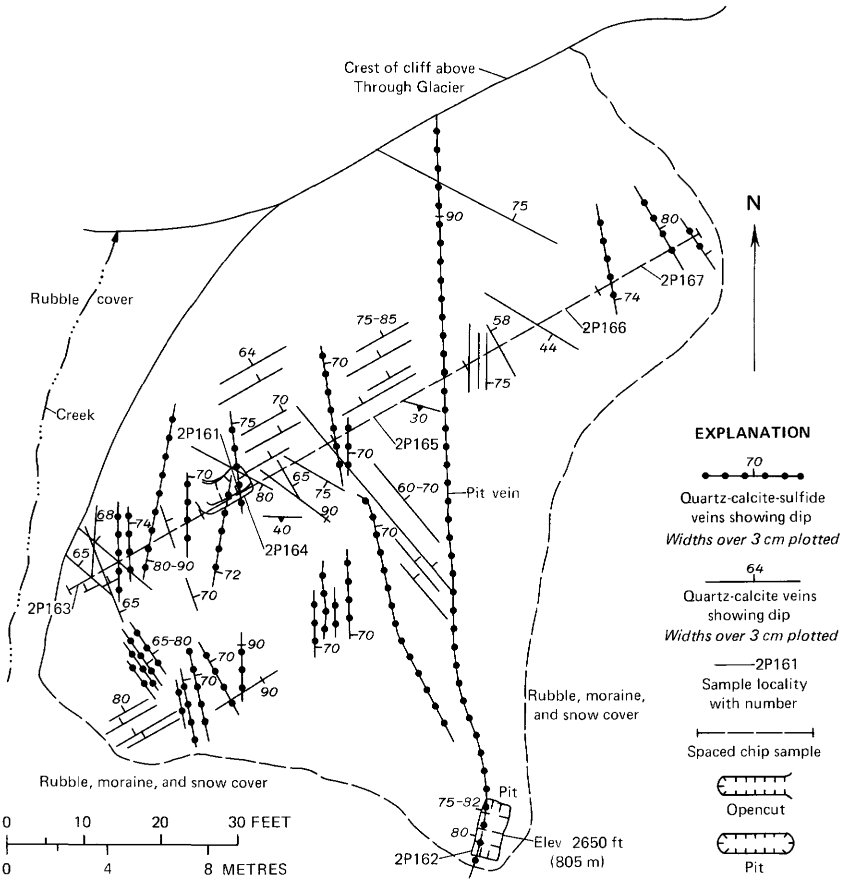
The Greenpoint group of 12 lode claims was located in 1970. The old Heckla prospect, 1.4 km south of the Greenpoint prospect, is also included on this group. The workings are near the northeast corner of Greenpoint No. 11 claim. Development consists of a pit 0.6 m wide, 2.1 m long, and about 0.6 m deep and an opencut 0.9 m wide and 2.1 m long with a 0.6-m face.

The deposit is exposed on a bare bench bounded on the north by cliffs dropping to Through Glacier and on the west by glacial moraine and rubble. The deposit consists of closely spaced seams and small veins occupying several different fracture systems in Hazelton(?) hornfels (fig. 23).

A fracture system striking N. 10° E. to N. 10° W. and dipping from 70° to 75° W. hosts most of the sulfide-bearing veins. The north-trending quartz-calcite veinlets range in width from thin seams to 15 cm. They contain up to 5 percent pyrite and small amounts of galena and molybdenite. The molybdenite is typically concentrated in very thin films at the vein walls and in fractures within the veins. These veins often yield showy specimens with negligible molybdenum content. The largest vein exposed is from 3 to 15 cm wide and extends 36.6 m from a pit at the edge of rubble cover, north to the crest of cliffs overlooking Through Glacier. Its strike averages due north, and it dips 75°–82° W. It contains pyrite, galena, molybdenite, and a trace of chalcopyrite in a quartz-calcite gangue. Sample 2P162 was cut across the largest vein, in the pit, where the vein's width and sulfide content were greatest. Other seams and veinlets of this system range in width from paper thin to 12 cm and are usually less than 9 m long. Sample 2P161 is a composite of chips from several of these veinlets at and near the opencut. Samples 2P163–167 were continuous moiled chip samples taken across the deposit exposure. Except for the pit vein, most of the west-dipping veinlets are practically barren of sulfide minerals.

A system of fractures striking S. 45°–60° E. has veinlets dipping 65°–85° NE. that range from barren to well mineralized. Other veinlets with this strike dip about 75° SW. and are generally barren. A third system of veinlets striking N. 60° E. and dipping 65°–85° NW. rarely contains visible sulfides.

The veins exposed are too low in metal content and too narrow to mine individually. Chip samples moiled across the exposed area of veins and hornfels are low in metal content (fig. 23). Average values across 29 m were 400 ppm lead, 65 ppm molybdenum, and 2.4 ppm silver. The 6.1-m section crossing the pit vein contained over 80 percent of the lead and over 60 percent of the molybdenum and silver. Copper values ranged from 15 to 150 ppm. Sample 2P165 assayed




Assay data

| Sample | Width (cm) | Spectrographic/Atomic absorbtion, ppm Pb | Mo | Ag | Description |
|---|---|---|---|---|---|
| 2P160 | Composite | 200/55 | 100/ | 3/ | Small quartz-calcite stringers |
| 2P161 | Composite | 3,000/ 2,000 | 1,000/ | 20/ | Quartz-calcite-molybdenite stringers |
| 2P162 | 15 | 2,000/ 1,600 | 300/ | 30/ | Quartz-pyrite-molybdenite vein, at pit |
| 2P163 | 610 | 100/25 | 30/ | 1.5/ | Hornfels; quartz-sulfide veinlets |
| 2P164 | 610 | 200/75 | 20/ | 3/ | Do. |
| 2P165 | 610 | 1,500/ 1,800 | 150/ | 7/ | Hornfels; pit vein, and veinlets |
| 2P166 | 610 | 70/15 | 30/ | N/ | Hornfels; sparse veinlets |
| 2P167 | 457 | 30/30 | L/ | N/ | Do. |

L, an undetermined amount of the element is present below the sensitivity limit.
N, looked for but not found.

FIGURE 23.—Sketch map and assay data, Greenpoint group prospect.

1,100 ppm zinc, and the other samples contained 10 to 80 ppm. Gold was not detected. The most interesting geochemical feature of the deposit was the presence of silver in amounts ranging from 3 to 30 ppm in the veinlet samples.

About 230 m north of this deposit, an area of Hazelton(?) schist contains a similar network of seams and stringers. It is just south of the top of the cliffs above the terminus of Greenpoint Glacier. Vein filling is quartz and calcite. Pyrite was the only suflide mineral observed. Sample 2P160 is a composite chip sample collected from these veinlets.

### Heckla Prospect (P–12)

Vein outcrops at the Heckla prospect are at elevations of about 1,160 to 1,280 m (3,800–4,200 ft) on the westerly slope of a mountain 1.6 km south-southwest of the junction of Through and Greenpoint Glaciers. The prospect is on the southern part of the 12-claim Greenpoint group located in 1970. The locator of the Greenpoint group explored the property by geologic mapping, sampling, some ground geophysics, and shallow drilling.

The Heckla prospect is described in detail because it is the best exposure of a type of deposit characteristic of this part of the study area. Vein widths range from 18 to 116 cm in veins No. 1 through No. 4 and the south section of vein No. 5. Assay values generally are low (table 7). The northern section of vein No. 5 (Heckla vein) is from 27 to 113 cm wide along the exposed strike length of about 30 m. Sample values on this part of the vein are somewhat higher.

Early exploration consisted of a small amount of stripping and excavation of several small, shallow opencuts on vein outcrops (fig. 24). A 1-ton lot of ore mined from cuts on the Heckla vein was hand sledged to the end of the West Fork trail in September 1925 for a test shipment to a smelter. A small lot of ore that may be part of this shipment still lies at the end of the West Fork trail. Results of an assay of a picked sample, probably from the shipment, are shown on table 1 (No. 12).

The mineral deposits are narrow sulfide-bearing quartz veins in Hazelton(?) Group metasedimentary rocks. Bedrock is mostly hornfels, typically dark gray, moderately hard, fine grained to locally gneissic or schistose, and slightly banded. Foliation strikes range from N. 45° to 70° W. A 60-cm-wide northwest-trending calcareous layer adjacent to vein No. 5 southeast of the Heckla opencut may represent an original sedimentary unit. Small amounts of graphite, pyrite, and pyrrhotite occur in the hornfels.

Dikes from a few centimetres wide up to a sill-like body about 30 m thick intrude the hornfels. They are mostly dioritic or andesitic rocks.

A few apparently are of the same composition as the Hyder Quartz Monzonite in contact with the hornfels about 200 m east of the vein outcrops.

Quartz veins range in width from a fraction of a centimetre to almost 1.2 m. Veins Nos. 1, 2, and 3 strike about N. 25° E. Veins No. 4 and 5 North trend about N. 25° W. Vein No. 5 South strikes between these limits. Outcrop strike lengths of the five veins sampled could not be determined because of snow cover. The exposed outcrop lengths were 85 m on vein No. 1, 15 m on vein No. 2, and 43 m on vein No. 4. Vein No. 5 (Heckla vein) was exposed as a 30-m-long north section and a 37-m-long south section with 40 m of snow cover between the two sections. The south section could be part of another vein.

The vein consists chiefly of dense white quartz carrying small amounts of pyrite, galena, and molybdenite as small lenses, veinlets, or isolated crystal groups. The quartz is vuggy locally and stained in some sections by goethite and limonite. Small amounts of anglesite are in some of the more oxidized areas. Chalcopyrite and a small amount of malachite are present locally. Traces of covellite and digenite were identified under the microscope. In the high-sulfide area at vein No. 5, sphalerite and pyrrhotite are abundant. Very little sulfide is present in the wallrocks adjacent to the quartz vein, except for a sheared, altered, and impregnated zone a little over 1 m wide in the footwall of vein No. 5 at the Heckla opencut.

Copper and molybdenum were detected in all samples. Copper ranged from 40 ppm to 10,000 ppm (1.0 percent) in atomic absorption (AA) assays; molybdenum values ranged from 10 ppm to 1,500 ppm (0.15 percent) by semiquantitative spectrographic methods, which were confirmed by atomic absorption assays on selected samples. Lead is the most abundant metal, ranging from 80 ppm to 90,000 ppm (9.0 percent) in a selected 21-cm-wide section of almost massive sulfides.

Gold values are low and spotty; two samples at the north end of vein No. 5 each contained 0.8 ppm (0.23 oz/ton). The next two highest samples each contained 0.2 ppm (0.006 oz/ton). Semiquantitative spectrographic (spec.) determinations of silver ranged from 3 to 700 ppm (0.09–20.4 oz/ton), but only 13 contained over 30 ppm (0.9 oz/ton); of the 13 samples, two in the north section of vein No. 5 yielded 300 ppm (8.7 oz/ton) silver, and another two 700 ppm (20.4 oz/ton). Fire assays of most of the 33 samples cut on the five veins confirmed the atomic absorption gold and spectrographic silver determinations. Small amounts of bismuth are in some of the samples from all veins except vein No. 5 North. Samples 2P139 and 2P141 from vein No. 1 each yielded 300 ppm of bismuth (spec.). Traces of cadmium were

TABLE 7.—*Assay data, Heckla prospect*

[L, an undetermined amount of the element is present below the sensitivity limit. N, looked for but not found. G, the amount of the element present is greater than the sensitivity limit]

| Sample | Channel width, cm. | Spec/AA, ppm | | | | | | Description |
|---|---|---|---|---|---|---|---|---|
| | | Cu | Pb | Zn | Au | Ag | Mo | |
| Vein No. 1 | | | | | | | | |
| 2P129 | 61 | 30/150 | 500/800 | N/20 | N/N | 5/ | 10/ | White quartz with no sulfides observed. |
| 2P130 | 67 | 30/60 | 150/130 | N/20 | N/N | 7/ | 70/ | do. |
| 2P131 | 73 | 15/90 | 700/1,500 | N/10 | N/N | 15/ | 300/ | do. |
| 2P132 | 85 | 20/95 | 5,000/5,500 | N/20 | N/N | 50/ | 150/ | Sparse galena. |
| 2P122 | 91 | 30/150 | 2,000/6,500 | N/15 | N/0.15 | 30/ | 150/ | Scattered molybdenite. |
| 2P133 | 79 | 20/110 | 5,000/6,500 | N/5 | N/N | 20/ | 70/ | Sparse sulfides. |
| 2P134 | 91 | 200/210 | 20,000/22,000 | N/10 | N/0.10 | 150/ | 300/ | Galena and limonite. |
| 2P135 | 116 | 15/75 | 1,500/2,300 | N/L | N/N | 15/ | 700/ | No sulfides observed. |
| 2P136 | 55 | 20/100 | 10,000/13,000 | N/10 | N/N | 50/ | 1,000/ | Sparse galena and molybdenite. |
| 2P137 | 52 | 100/110 | 10,000/12,000 | N/45 | N/N | 50/ | 700/ | Sparse galena and pyrite. |
| 2P138 | 61 | 10/85 | 1,500/2,800 | N/40 | N/0.10 | 15/ | 500/ | Limonite, galena, and molybdenite. |
| 2P139 | 40 | 70/140 | 10,000/10,000 | N/130 | N/0.10 | 50/ | 1,500/ | Limonite, pyrite, chalcopyrite. |
| 2P140 | 27 | 7/50 | 1,500/2,100 | N/60 | N/N | 10/ | 1,500/ | Vein fractured; limonite-stained. No visible sulfides. |
| 2P141 | 40 | 30/65 | 15,000/11,000 | N/400 | N/N | 70/ | 1,500/ | do. |
| Vein No. 2 | | | | | | | | |
| 2P142 | 18 | 10/40 | 3,000/1,500 | N/70 | N/N | 15/ | 1,000/ | Quartz, locally stained. Sparse galena and pyrite. |
| 2P143 | 67 | 30/75 | 2,000/1,400 | 200/170 | N/N | 15/ | 1,000/ | do. |
| Vein No. 3 | | | | | | | | |
| 2P144 | 64 | 1,000/900 | 50/200 | N/110 | N/0.05 | 20/ | 300/ | Quartz lens in stringer lode. |
| 2P145 | 30 | 700/600 | 200/600 | N/30 | N/N | 15/ | 150/ | do. |
| Vein No. 4 | | | | | | | | |
| 2P146 | 18 | 50/100 | 1,500/1,000 | N/15 | N/N | 15/ | 20/ | Vuggy quartz; minor pyrite. |
| 2P147 | 30 | 20/90 | 150/80 | N/20 | N/N | 3/ | 30/ | Vuggy, rusty quartz. |

| Sample | Channel width, cm. | Spec/AA, ppm Cu | Pb | Zn | Au | Ag | Mo | Description |
|---|---|---|---|---|---|---|---|---|
| Vein No. 5, Heckla vein | | | | | | | | |
| 2P148 | 27 | 15,000/10,000 | G(20,000)/30,000 | G(10,000)/10,000 | N/0.80 | 700/ | 150/ | Vuggy limonitic quartz, pyrite, galena, and molybdenite. |
| 2P149 | 46 | 3,000/3,500 | 15,000/14,000 | G(10,000)/35,000 | N/0.80 | 300/ | 1,000/ | do. |
| 2P123 | 67 | 10/60 | 7,000/10,000 | N/15 | N/0.10 | 30/ | 300/ | Quartz vein with pyrite, galena, and molybdenite. |
| 2P150 | 9 | 200/300 | 3,000/4,500 | 1,500/1,000 | N/0.05 | 100/ | 300/ | Gray quartz, low sulfide vein, headwall 0-9 cm. |
| 2P151 | 21 | 7,000/8,500 | G(20,000)/90,000 | G(10,000)/85,000 | N/N | 700/ | 70/ | Sheared argillite (?), massive vein, headwall 10-21 cm; sulfides. |
| 2P152 | 101 | 700/600 | 200/1,500 | 3,000/4,000 | N/0.10 | 20/ | 70/ | Soft, sheared wallrock, into footwall 0-101 cm; iron stained. |
| 2P153 | 113 | 2,000/1,600 | 10,000/11,000 | 5,000/5,500 | N/0.20 | 100/ | 200/ | Vein; quartz, sheared rock, sulfides. |
| 2P154 | 34 | 7,000/7,000 | 15,000/20,000 | G(10,000)/35,000 | N/N | 300/ | 15/ | Quartz, pyrite, and galena. |
| 2P155 | 21 | 150/170 | 5,000/8,500 | N/55 | N/0.20 | 70/ | 1,500/ | Iron-stained vuggy quartz. |
| 2P156 | 34 | 7/65 | 500/900 | N/20 | N/N | 7/ | 200/ | do. |
| 2P157 | 27 | 5/20 | 300/300 | N/10 | N/N | 7/ | 70/ | Quartz with sparse blebs of galena and pyrite. |
| 2P158 | 27 | 70/230 | 3,000/9,000 | N/20 | N/0.05 | 150/ | 1,500/ | Quartz, galena, and pyrite. |
| 2P159 | 24 | 30/60 | 3,000/2,200 | N/10 | N/N | 100/ | 1,000/ | Quartz, few sulfides. |

detected in a few of the samples from these veins. Vein No. 5 North samples yielded bismuth values of 15 to 700 ppm (spec.) and, except for sample 2P154, cadmium values of 50 to over 500 ppm (spec.).

## BANDED MOUNTAIN AREA

### Marmot Claim Group

The 51 Marmot claims staked in 1969 on the southeast side of Banded Mountain form a block just below the summit icefield, roughly bounded by Chickamin and Through Glaciers and a small,

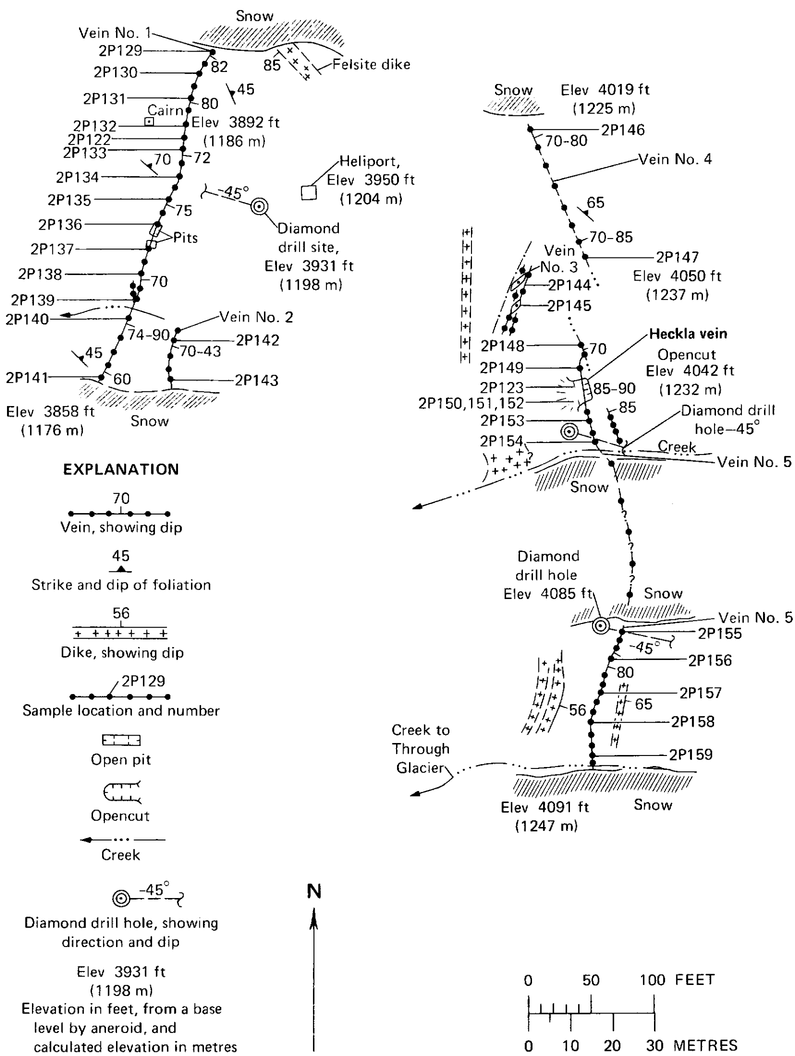



Figure 24.—Heckla prospect.

unnamed valley glacier east of the Banded Mountain summit. In this report, the small unnamed glacier is informally called Basin Glacier. The mountainside is rugged and partly inaccessible. Most metallic minerals seen and most accessible rock exposures lie in a heavily iron stained area in the southeastern part of the claim group near Basin Glacier. The Jumbo prospect and the Edelweiss (see "Edelweiss prospect, P–15"), long inactive, are now included in the Marmot group.

Sampling was done in four separate areas on the Marmot group: the lower basin, the upper basin, Edelweiss, and Galena prospects. Results are discussed under the headings "Lower Basin (Jumbo Area) (P–13)," "Upper Basin (P–14)," "Edelweiss Prospect (P–15)," and "Galena Prospect (P–16)."

During the investigation, samples were moiled across vein widths. Where host rocks were particularly iron stained or where veins were more concentrated than elsewhere, bedrock sample chips were collected at uniform intervals of 30 to 60 cm along lines crossing foliation. Samples are grouped in the tables by numbered vein or by bedrock chip line.

### LOWER BASIN (JUMBO AREA) (P–13)

The lower basin area is located near the pond at the terminus of Basin Glacier (figs. 25, 26, 27, 28). Elevations of the area range from 1,100 m (3,600 ft) to 1,160 m (3,800 ft).

The Jumbo prospect (Buddington, 1929, p. 101) lies a short distance east of the present terminus of Basin Glacier. The present investigation was unsuccessful in locating the exact position of this prospect or the Jumbo adit, reportedly driven sometime after Buddington's work. Old tools were found near a probable cabin site at the head of a steep snow-filled gully. The abnormally heavy snow probably covered the Jumbo workings on the original two claims that were staked in 1925. The Jumbo prospect as a six-claim group was relocated and restaked in 1933, 1935, and again in 1941.

Graywacke, argillite, and banded hornfels with minor amounts of pyrite generally strike northwest to west and dip steeply south. Quartz veins with pyrite and lead, silver, and molybdenum values cut the foliation of the country rock obliquely. The veins also contain minor copper, zinc, and gold.

In general, with the exception of pyrite disseminated in the enclosing Hazelton(?) rocks, the metallic minerals are in or adjacent to quartz veins or breccia zones. The veins range in width from 6 to 70 cm, strike N. 20° E. to N. 40° W., and dip nearly vertical. Pyrite is erratically distributed in the veins as individual grains, knots, and irregular pods, and it occurs as parallel stringers in the enclosing rocks adjacent to one or both vein walls. Visible molybdenite may occur in narrow discontinuous stringers just inside or outside the

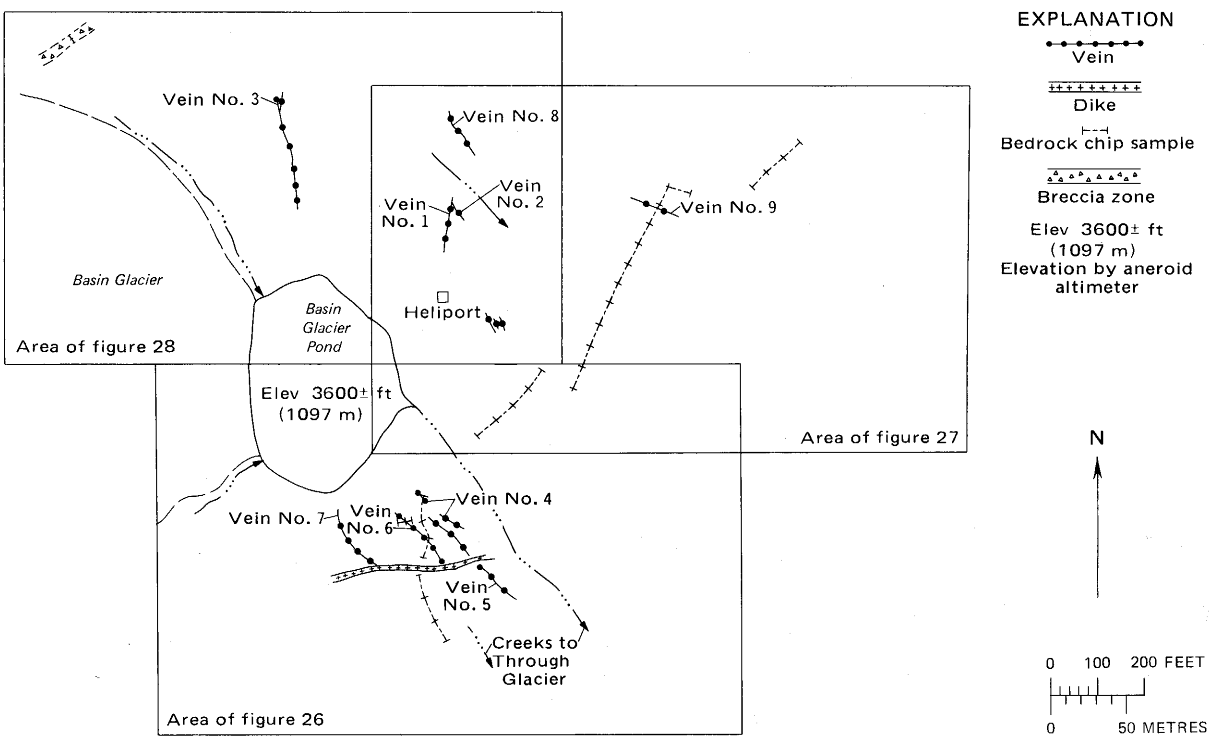



FIGURE 25.—Marmot group prospect, lower basin, P–13.

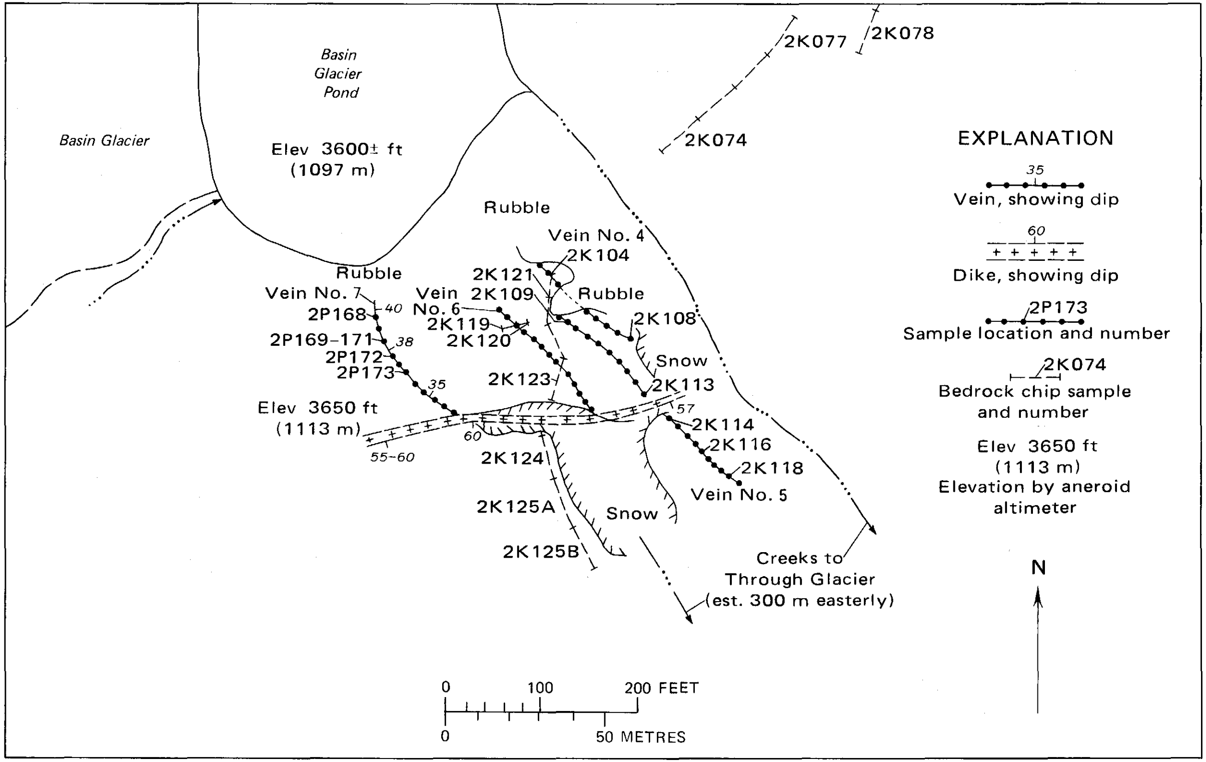



FIGURE 26.—Southeastern part of Marmot group prospect, lower basin, P–13.

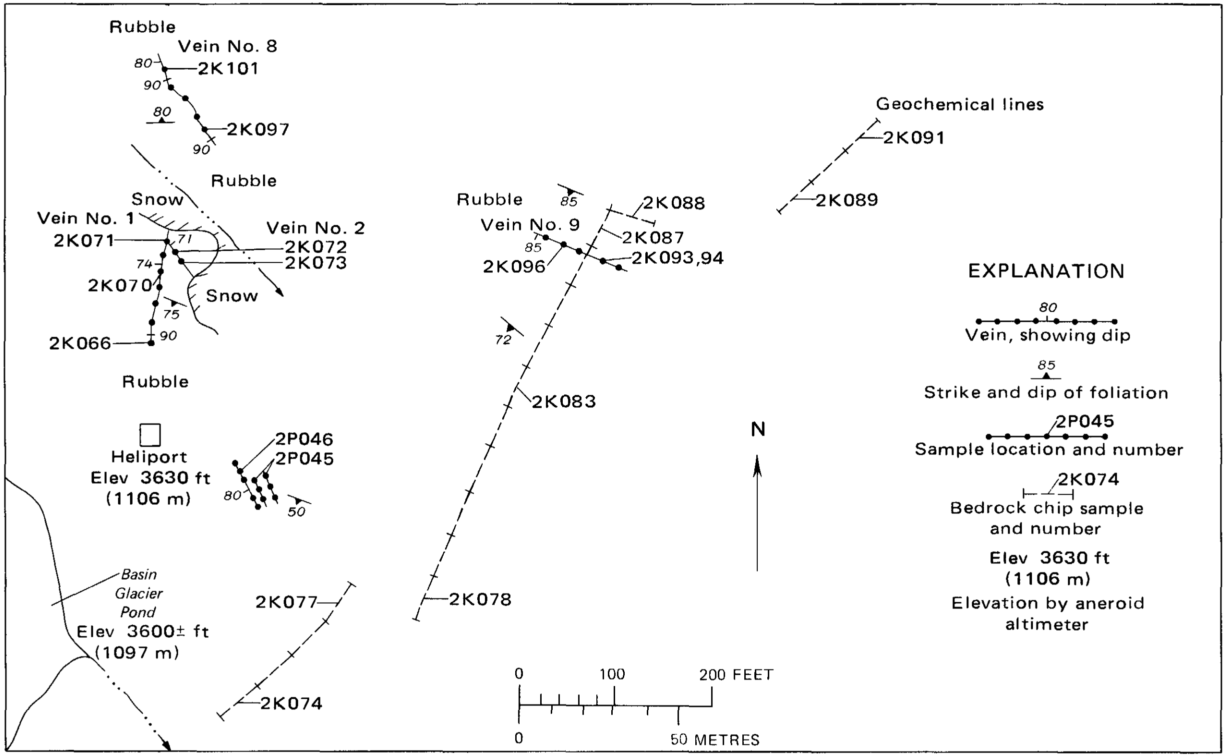



FIGURE 27.—Northeastern part of Marmot group prospect, lower basin, P–13.

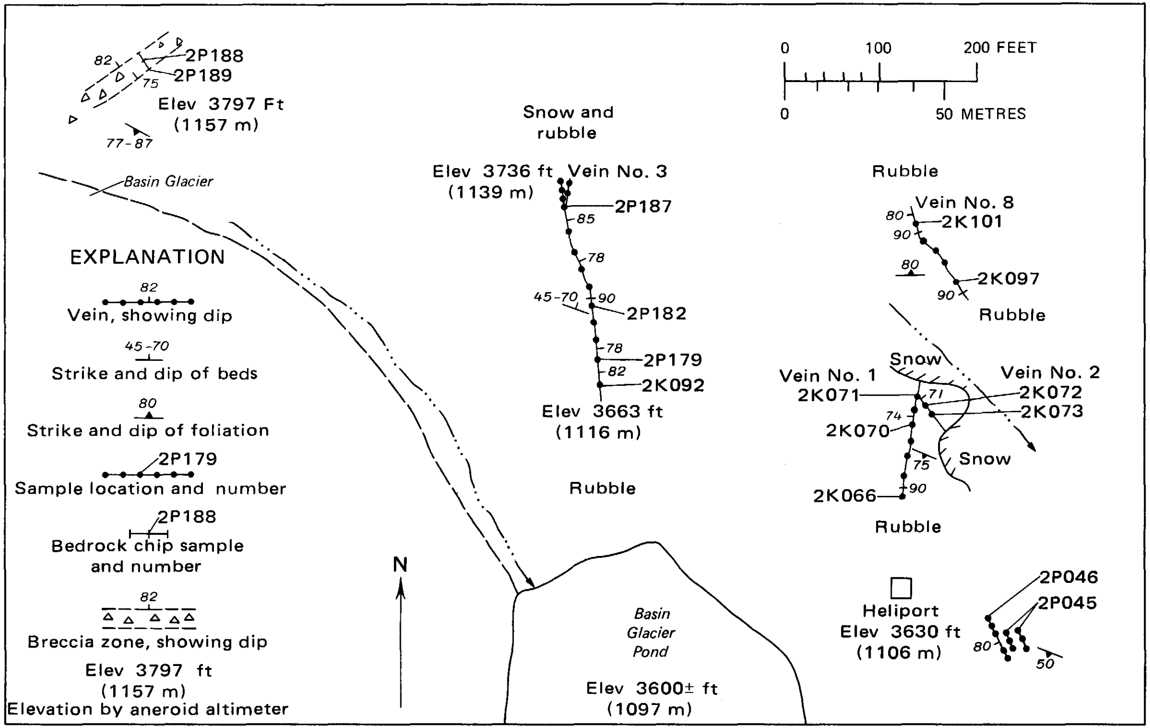



FIGURE 28.—Northwestern part of Marmot group prospect, lower basin, P-13.

pyrite stringers. Galena is rarely seen, but most samples contain minor amounts of lead and silver. Most quartz veins are iron-stained and contain calcite and rare traces of sphalerite and chalcopyrite.

Eight veins (Nos. 1–5 and 7–9) were sampled with channel-cut samples generally taken every 6 to 7.5 m of exposed vein length. Vein No. 6 was poorly exposed, and chip samples (2K119, 120) were taken in two increments along a 9.2-m width across it and along an associated group of closely spaced subparallel quartz veins 30 m southeast of the pond. Although assay values up to 200 ppm (5.8 oz/ton) silver, 60,000 ppm (6 percent) lead, and 80,000 ppm (8 percent) zinc were obtained from the 44 channel samples on the veins, the average values were less than 10 percent of these figures, and the higher-than-average values showed no lateral continuity. Eleven of these samples contained 1,000 to 2,000 ppm (0.10 to 0.20 percent) molybdenum, and two samples contained over 2,000 ppm. Only two of the higher molybdenum values were from adjacent channel cuts, and the average width of the vein at this point was 22 cm.

A breccia zone, 92 to 275 cm wide and 200 m northwest of the Basin Glacier terminus pond, contains traces of copper and lead. Samples 2P045 and 2P046, taken across a concentration of closely spaced subparallel quartz veins and on an altered zone in pyritic massive hornfels 75 m east of the pond, both contain a trace of copper.

Twenty-four country rock chip samples were collected by taking chips at 60-cm intervals and compositing these chips into larger samples. Two sample lines were established: one 200 m long east of the pond in heavily iron stained rocks and the other 83 m long south of the pond outlet. Nine samples contained more than 20 ppm molybdenum, and four of these were greater than 150 ppm. The easternmost sample line delineated a 121-m-wide zone averaging 97 ppm molybdenum.

Assay values from the lower basin portions of the Marmot group prospect are given in tables 8 and 9.

### Upper basin (P–14)

Quartz veins are exposed 1,070 m northwest of Basin Glacier pond by the recent retreat of a glacial tongue of the summit icefield on Banded Mountain. The veins are situated between the lateral moraine and the present ice face at an elevation ranging from 1,400 to 1,450 m (4,600 to 4,750 ft). No attempt was made to sample other veins that stripe the cirque walls to the west above Basin Glacier. Because vein continuity was unclear owing to snow cover, all veins at this site are tabulated together.

The veins at the upper Marmot site are similar in character and attitude to those near the pond. They strike from N. 20° E. to N. 25°

TABLE 8.—*Assay data, Marmot claim group—lower basin; veins and breccia zones*

[L, an undetermined amount of the element is present below the sensitivity limit. N, looked for but not found. G, the amount of the element present is greater than the sensitivity limit]

| Sample | Width, cm. | Spec/AA, ppm Cu | Pb | Zn | Mo | Ag | Description |
|---|---|---|---|---|---|---|---|
| Vein No. 1 (northeast of pond), channel samples. | | | | | | | |
| 2K066 | 15 | - | 150/240 | - | 30/ | 1.5/ | Quartz, minor pyrite. |
| 2K067 | 12 | - | 20/25 | - | 700/ | L/ | Quartz, rusty. |
| 2K068 | 46 | - | 30/55 | - | 30/ | N/ | Quartz and calcite. |
| 2K069 | 28 | - | 50/40 | - | 15/ | N/ | Quartz-calcite breccia. |
| 2K070 | 37 | - | 7,000/5,000 | - | 1,000/ | 70.0/ | Quartz and calcite, pyrite knots. |
| 2K071 | 21 | - | 150/300 | - | 150/ | 3.0/ | Quartz and calcite. |
| Vein No. 2 (northeast of pond), channel samples. | | | | | | | |
| 2K072 | 31 | - | 150/230 | - | 500/ | 5.0/ | Quartz and calcite with sulfides. |
| 2K073 | 12 | - | 70/120 | - | 150/ | 1.0/ | Quartz. |
| Vein No. 3 (northwest of pond), channel samples. | | | | | | | |
| 2K092 | 24 | - | 3,000/4,500 | 70/110 | G(2,000)/ | 30.0/ | Quartz, pyrite and molybdenite. |
| 2P179 | 21 | - | 3,000/200 | 1,500/1,700 | 1,500/ | 20.0/ | do. |
| 2P180 | 15 | - | 100/65 | N/10 | 70/ | 0.7/ | Quartz, sparse pyrite and molybdenite. |
| 2P181 | 18 | - | N/20 | N/10 | 500/ | L/ | Quartz, trace pyrite and molybdenite. |
| 2P182 | 9 | - | 15,000/12,000 | N/150 | 2,000/ | 70.0/ | Quartz, trace pyrite, molybdenite and galena. |
| 2P183 | 21 | - | 150/200 | N/15 | 70/ | 2.0/ | Quartz, trace pyrite. |
| 2P184 | 21 | - | 70/170 | N/15 | 700/ | 1.5/ | Quartz, trace pyrite and molybdenite. |
| 2P185 1/ | 24 | - | G(20,000)/60,000 | 2,000/6,000 | 2,000/ | 200.0/ | Quartz, trace pyrite, molybdenite and galena. |
| 2P186 | 28 | - | 700/1,800 | N/10 | 150/ | 15.0/ | Quartz. |
| 2P187 | 24 | - | 3,000/3,600 | N/130 | 150/ | 150.0/ | do. |

TABLE 8.—*Assay data, Marmot claim group—lower basin; veins and breccia zones*—Continued

| Sample | Width, cm. | Spec/AA, ppm Cu | Pb | Zn | Mo | Ag | Description |
|---|---|---|---|---|---|---|---|
| Vein No. 4 (southeast of pond), channel samples. | | | | | | | |
| 2K104 | 52 | - | 40/40 | - | 1,500/ | 3.0/ | Quartz vein, in places slightly mineralized. |
| 2K105 | 61 | - | 150/120 | - | 300/ | 5.0/ | do. |
| 2K106 | 55 | - | 100/180 | - | 1,500/ | 3.0/ | do. |
| 2K107 | 18 | - | 30/35 | - | 500/ | L/ | do. |
| 2K108 | 9 | - | 200/130 | - | 300/ | 5.0/ | do. |
| Vein No. 5 (southeast of pond). | | | | | | | |
| 2K109 2/ | 28 | - | 1,500/1,600 | - | G(2,000)/ | 30.0/ | Quartz vein with scattered pyrite and traces molybdenite along boundaries. |
| 2K110 | 31 | - | 700/600 | - | 700/ | 10.0/ | do. |
| 2K111 | 31 | - | 15/10 | - | 200/ | N/ | do. |
| 2K112 | 24 | - | 700/400 | - | 1,500/ | 15.0/ | do. |
| 2k113 | 28 | - | N/15 | - | 300/ | N/ | do. |
| 2K114 | 6 | - | 70/70 | - | 1,500/ | L/ | do. |
| 2K115 3/ | 31 | - | 20/45 | - | 300/ | L/ | |
| 2K116 | 24 | - | N/20 | - | 700/ | N/ | do. |
| 2K117 | 15 | - | 15/30 | - | 700/ | L/ | do. |
| 2K118 | 24 | - | 200/150 | - | 1,500/ | 7.0/ | do. |
| Vein No. 5 (southeast of pond) cuts crossing concentration of small quartz veins. | | | | | | | |
| | m. | | | | | | |
| 2K119 | 4.9 | - | 150/380 | - | 150/ | 1.0/ | |
| 2K120 | 4.9 | - | 700/360 | - | 700/ | 5.0/ | |
| Vein No. 7 (south of pond), channel samples. | | | | | | | |
| | cm. | | | | | | |
| 2P168 4/ | 15 | 1,500/1,500 | 15,000/16,000 | G(10,000)/80,000 | 1,000/ | 150.0/ | Quartz vein, several sulfide minerals. |
| 2P169 | 12 | 300/320 | 300/500 | 500/130 | 500/ | 15.0/ | Quartz vein, pyrite, and molybdenite. |
| 2P170 | 46 | 15/25 | 70/45 | N/55 | 5/ | L/ | Bleached hanging wall, trace pyrite. |

| Sample | Width, cm. | Cu | Pb | Zn | Mo | Ag | Description |
|---|---|---|---|---|---|---|---|
| | | Spec/AA, ppm | | | | | |
| Vein No. 7 (south of pond), channel samples--continued. | | | | | | | |
| 2P171 | 46 | 10/35 | 100/70 | N/35 | 7/ | 1.5/ | Bleached footwall, trace pyrite. |
| 2P172 | 12 | 150/150 | 700/450 | 200/85 | 700/ | 15.0/ | Quartz vein, trace molybdenite and pyrite |
| 2P173 | 15 | 70/110 | 700/1,400 | N/30 | 1,000/ | 20.0/ | do. |
| Vein No. 8 (northeast of pond), channel samples. | | | | | | | |
| 2K097 | 46 | - | 50/35 | - | 7/ | L/ | Quartz, rusty. |
| 2K098 | 31 | - | 5,000/8,500 | - | 70/ | 70.0/ | Quartz, pyrite and galena. |
| 2K099 | 52 | - | 700/800 | - | 70/ | 10.0/ | Quartz, minor pyrite, galena and molybdenite. |
| 2K100 | 70 | - | 30/60 | - | 30/ | 0.5/ | Quartz, minor pyrite. |
| 2K101 | 67 | - | 20/20 | - | 7/ | N/ | do. |
| Vein No. 9 (northeast of pond), channel samples. | | | | | | | |
| 2K093 | 31 | 300/420 | 70/110 | - | 300/ | - | Quartz, rusty. |
| 2K094 | 152 | 500/460 | 100/100 | - | 50/ | - | Hanging wall, pyritic graywacke. |
| 2K095 | 70 | 150/210 | 70/20 | - | 7/ | - | Pyrite stringers. |
| 2K096 | 120 | 150/180 | 15/20 | - | 7/ | - | Graywacke and quartz, rusty. |
| Breccia Zone (northwest of pond), channel samples. | | | | | | | |
| 2P188 | 275 | 100/300 | 100/100 | - | 15/ | - | Breccia zone, rusty weathering. |
| 2P189 | 92 | 200/300 | 100/100 | - | 7/ | - | do. |

1/ Au /0.10 and Bi 500/.

2/ Au N/0.05.

3/ Au N/0.10.

4/ Cd G(500).

TABLE 9.—*Assay data, Marmot claim group—lower basin; chip samples*

[L, an undetermined amount of the element is present below the sensitivity limit. N, looked for but not found. Chips taken at 0.6-m intervals]

| Sample | Length, m. | Cu | Spec/AA, ppm Pb | Mo | Ag | Description |
|---|---|---|---|---|---|---|
| Rock chip sample line (east of pond), chips taken at 0.6-m intervals. | | | | | | |
| 2K074 | 15.2 | - | - | 15/ | - | ( |
| 2K075 | 15.2 | - | - | 7/ | - | ( |
| 2K076 | 15.2 | - | 150/150 | 15/ | 0.7/ | ( |
| 2K077 | 15.2 | - | - | 150/ | - | ( |
| 2K078 | 15.2 | - | - | 50/ | - | ( |
| 2K079 | 15.2 | - | - | 7/ | - | ( |
| 2K080 | 15.2 | - | - | 300/ | - | (Dark fine-grained metasedimentary |
| 2K081 | 15.2 | - | - | 20 | - | (rocks usually thinly bedded or |
| 2K082 | 15.2 | - | - | 150/ | - | (banded. Many rusty-weathered |
| 2K083 | 15.2 | - | - | 30/ | - | (surfaces; some thin quartz veins |
| 2K084 | 15.2 | - | 100/60 | 70/ | 0.7/ | (with minor associated pyrite |
| 2K085 | 15.2 | - | - | 5/ | - | (and/or molybdenite along |
| 2K086 | 15.2 | - | - | 5/ | - | (boundaries. |
| 2K087 | 15.2 | - | - | L/ | - | ( |
| 2K088 | 15.2 | - | - | 70/ | - | ( |
| 2K089 | 8.2 | - | - | 5/ | - | ( |
| 2K090 | 15.2 | - | - | 5/ | - | ( |
| 2K091 | 15.2 | - | - | L/ | - | ( |
| Rock chip sample line (south of pond), chips taken at 0.6-m intervals. | | | | | | |
| 2K121 | 15.2 | 100/150 | 300/300 | 200/ | 1.0/ | ( |
| 2K122 | 15.2 | 200/350 | 100/25 | 15/ | 1.5/ | ( |
| 2K123 | 7.0 | 100/230 | 70/35 | 5/ | N/ | (Slightly pyritic banded meta- |
| 2K124 | 15.2 | 100/95 | 20/15 | L/ | N/ | (sedimentary rocks. |
| 2K125A | 15.2 | 20/70 | 50/50 | 7/ | 5.0/ | ( |
| 2K125B | 15.2 | 30/65 | 70/40 | N/ | N/ | ( |

W. and have very steep to vertical dips (fig. 29). Widths range from less than 3 to 90 cm. Enclosing rocks are mostly very hard, dark hornfels of the Hazelton(?) Group that strike northwest and dip 75° S. Minor iron staining and disseminated pyrite are present.

These quartz veins contain less calcite, pyrite, and visible molybdenite than those near the pond. Molybdenum values however, were similar (table 10). The vein samples contain 100 to 2,000 ppm (0.01–0.2 percent) molybdenum, and the silver values range from 0.5 to 150 ppm (0.01–4.3 oz/ton). Silver and lead values are somewhat lower than those in the pond area.

Three chip samples, with chips taken at 30-cm intervals over a 46-m line and composited into 15-m lengths, crossed 29 sporadically mineralized quartz veins from 3 to 90 cm wide. The veins represent 11 percent of the length of the three samples, but the relative number of sample points on veins and country rocks is not known. Sample 2K134 assayed 30 ppm (0.9 oz/ton) silver and 3,100 ppm (0.3 percent) lead (table 10), higher than any of the cut samples at this site. The general aspects of the mineralization at this upper site are similar to those near the pond.

### EDELWEISS PROSPECT (P–15)

A galena-bearing quartz vein N. 30° E., vertical, and 30 cm wide is exposed in a small cut at about 1,370 m (4,500 ft) elevation on Banded

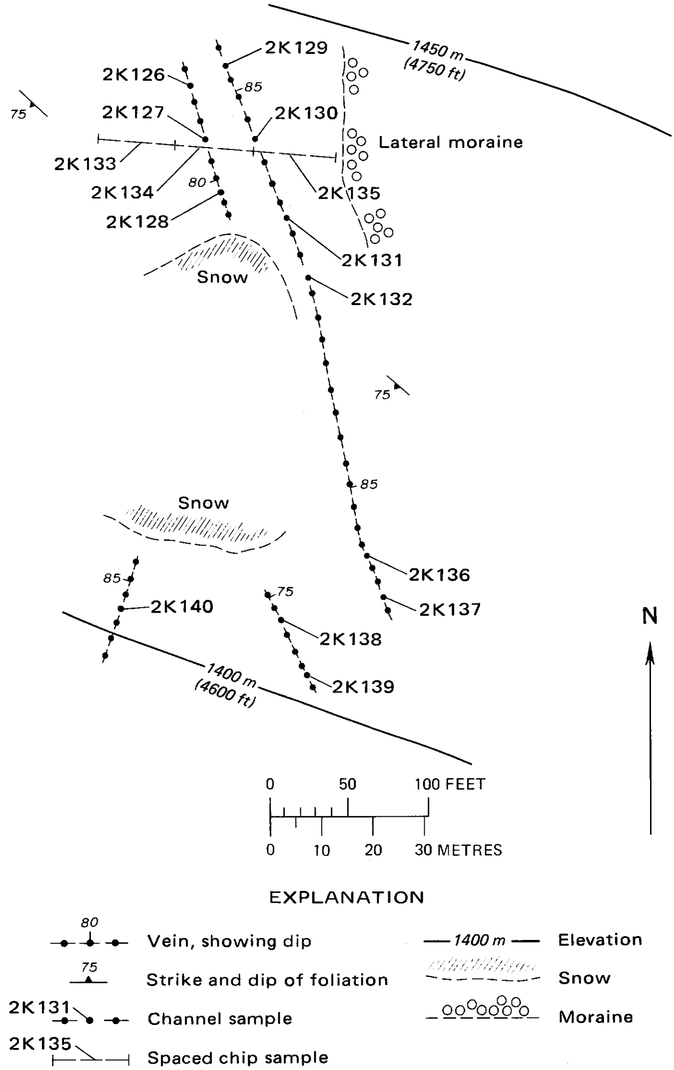



FIGURE 29.—Marmot group, upper basin.

Mountain overlooking Through Glacier. This occurrence may be on the Edelweiss claim mentioned, but not visited, by Buddington (1929, p. 101). He reported assay values of 10.2 oz silver and 1.5 oz gold per ton from picked material. Select grab samples of both vein and pit rubble (fig. 30) verify the silver but not the gold values. The galena-bearing quartz samples contained traces of pyrite and pyrrhotite. No molybdenite was seen at this prospect. Galena-bearing quartz float is found higher on the hillside a short distance above the vein between extensive snow patches.

The Edelweiss was originally staked in 1925 and relocated in 1928

TABLE 10.—*Assay data, Marmot claim group—upper basin*

[N, looked for but not found]

| Sample | Width, cm. | Spec/AA, ppm Pb | Ag | Mo | Description |
|---|---|---|---|---|---|
| Sulfide-bearing quartz veins | | | | | |
| 2K126 | 79 | 300/440 | 5.0/ | 700/ | Quartz, rusty; pyrite blebs. |
| 2K127 | 92 | 70/85 | 2.0/ | 300/ | Quartz, minor pyrite. |
| 2K128 | 52 | 150/180 | 3.0/ | 700/ | Quartz, sparse pyrite. |
| 2K129 1/ | 55 | 150/180 | 5.0/ | 300/ | Quartz, rusty; pyrite knots. |
| 2K130 | 76 | 500/300 | 15.0/ | 1,000/ | do. |
| 2K131 1/ | 58 | 1,000/2,200 | 150.0/ | 700/ | Quartz, disseminated pyrite. |
| 2K132 1/ | 67 | 700/1,100 | 20.0/ | 500/ | Quartz, minor pyrite blebs. |
| 2K136 | 70 | N/80 | 0.5/ | 30/ | Quartz, pyrite, molybdenite? |
| 2K137 | 55 | 70/80 | 3.0/ | 300/ | Quartz, pyrite, trace molybdenite. |
| 2K138 | 79 | 100/130 | 2.0/ | 1,500/ | Pyritic quartz, sparce molybdenite. |
| 2K139 | 61 | 300/400 | 7.0/ | 2,000/ | Pyritic quartz, molybdenite on footwall. |
| 2K140 2/ | 6 | 150/100 | 7.0/ | 100/ | Rusty quartz, pyrite, and chalcopyrite. |
| Bedrock chip samples, chips taken at 3.0-m. intervals. | Length m. | | | | |
| 2K133 | 15.2 | 150/80 | 2.0/ | 50/ | Dark banded hornfels with many sulfide-bearing quartz veins. |
| 2K134 | 15.2 | 5,000/3,100 | 30.0/ | 50/ | do. |
| 2K135 | 15.2 | 70/110 | 0.5/ | 30/ | do. |

1/ Au N/0.05

2/ Cu 3,000/2,000

when three more claims were staked. Active claims of the Marmot group staked in 1969 now cover this whole area.

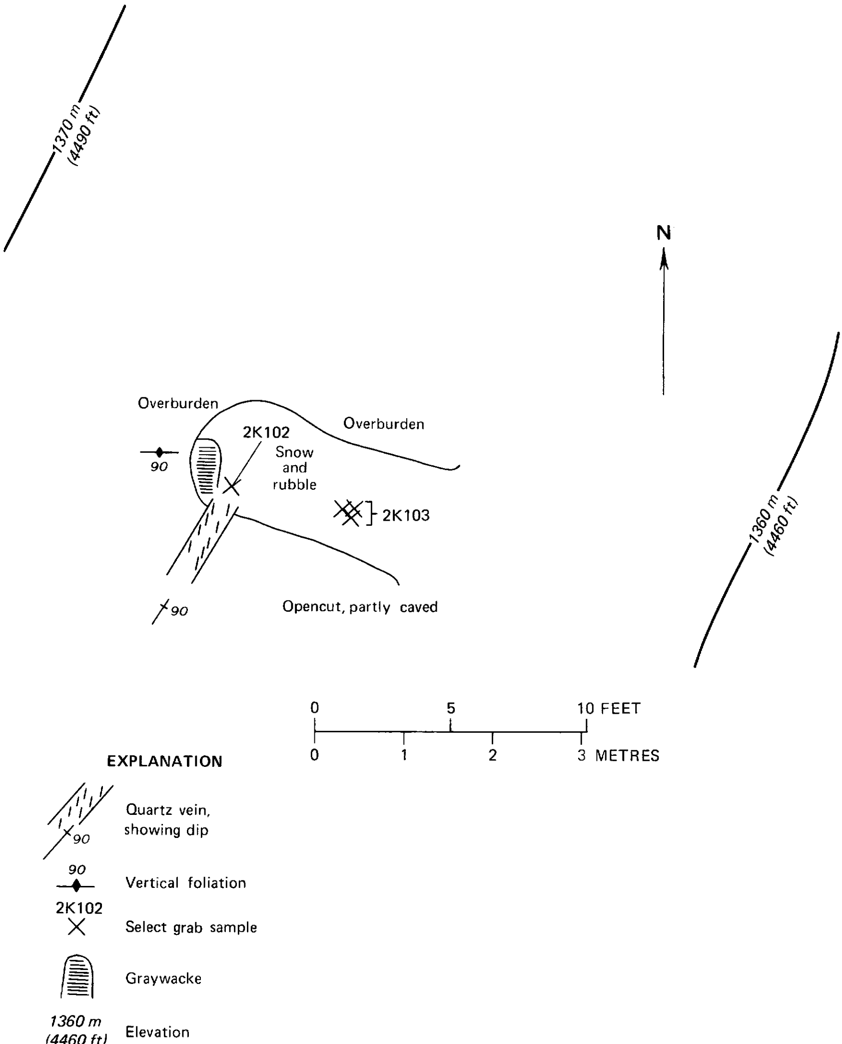
### GALENA PROSPECT (P–16)

The Galena prospect is on the Marmot group of lode claims, on the eastern slope of Banded Mountain opposite the junction of Greenpoint and Through Glaciers, at about 790 m (2,600 ft) elevation (P–16, fig. 16). Narrow galena-bearing quartz veins were reported in this general area by locators of the Marmot claims.

An exposed area of hornfels about 180 m long is crisscrossed by fracture systems having several different orientations. Many of the fractures contain quartz seams and veinlets carrying small amounts of unevenly distributed sulfides. The highest sulfide concentrations are often adjacent to fracture intersections. The highest sulfide mineral content observed is in quartz veinlets 3 to 15 cm wide that strike N. 15° E. and dip 50°–60° E. They locally contain visible pyrite, galena, molybdenite, and sphalerite. Sample 3P084, a composite of cuts across higher grade sections of these veinlets, contains 20 ppm (0.6 oz/ton) silver, 500 ppm (0.05 percent) molybdenum, 6,500 ppm (0.65 percent) lead, and 2,000 ppm (0.20 percent) zinc.

A system of quartz veinlets with widths up to 21 cm strike N.

10°–25° W. and dip 75°–85° E. They show small amounts of pyrite, chalcopyrite, galena, and molybdenite. Composite sample 3P085 across the better parts of several of these veinlets yielded 300 ppm copper, 1,400 ppm lead, 70 ppm zinc, 30 ppm (8.7 oz/ton) silver, and




Assay data

| Sample | Select grab | Spectrographic/Atomic absorbtion, ppm Pb | Ag | Au | Mo | Bi | Description |
|---|---|---|---|---|---|---|---|
| 2K102 | Vein | 10,000/ 7,500 | 300/ | N/0.10 | 50/ | 700/ | Quartz, rusty, pyrrhotite-and galena-bearing |
| 2K103 | Pit | 15,000/ 14,000 | 300/ | N/N | 100/ | 700/ | |

N, looked for but not found.

FIGURE 30.—Sketch map and assay data, Edelweiss prospect.

500 ppm (0.05 percent) molybdenum. No gold was detected. Fractures in many other directions and attitudes but of lesser widths contain similar quartz seams and veinlets with sparse sulfides. A series of narrow quartz-calcite veinlets intersects and often offsets the quartz veinlets. These contain only sparse pyrite. The system strikes about N. 75° W. and dips average 70° N. Several small brecciated areas up to 1 m long at fracture intersections have molybdenite facings in seams and on fracture faces.

The total volume of sulfide-bearing quartz seams and veinlets in the best 30-m width of the exposure probably would not exceed 2 percent of the mass. Metal content of the exposed veins in this area is very low.

Metamorphic rocks of the Hazelton(?) Group form the steep cliffs and bluffs at the foot of Banded Mountain and above Through Glacier for a distance of 4 km southwest of the eastern end of the mountain (pl. 1). Several concentrations of small veins and light-colored dikes were inspected for sulfide mineralization along this mountain face. No concentrations of valuable minerals were observed.

### Goat prospect (P–17)

The Goat prospect (fig. 31), consisting of two claims, was staked in 1969 on the western edge of the Banded Mountain summit icefield about 1,430 m (4,700 ft) in elevation overlooking the Chickamin valley to the northwest. Sulfide-bearing quartz-calcite veins 9 to 15 cm wide in slightly pyrrhotitic, hornfelsic graywacke were channel sampled across the more mineralized parts. The veins locally contain abundant pyrrhotite and very minor amounts of valuable metals (fig. 31). They vary greatly in width and moderately in strike and dip. Traces of chalcopyrite are in the more heavily mineralized sections. No molybdenite was identified. Composite chip samples across the foliation of the metagraywacke at 30-cm intervals contain only traces of valuable metals.

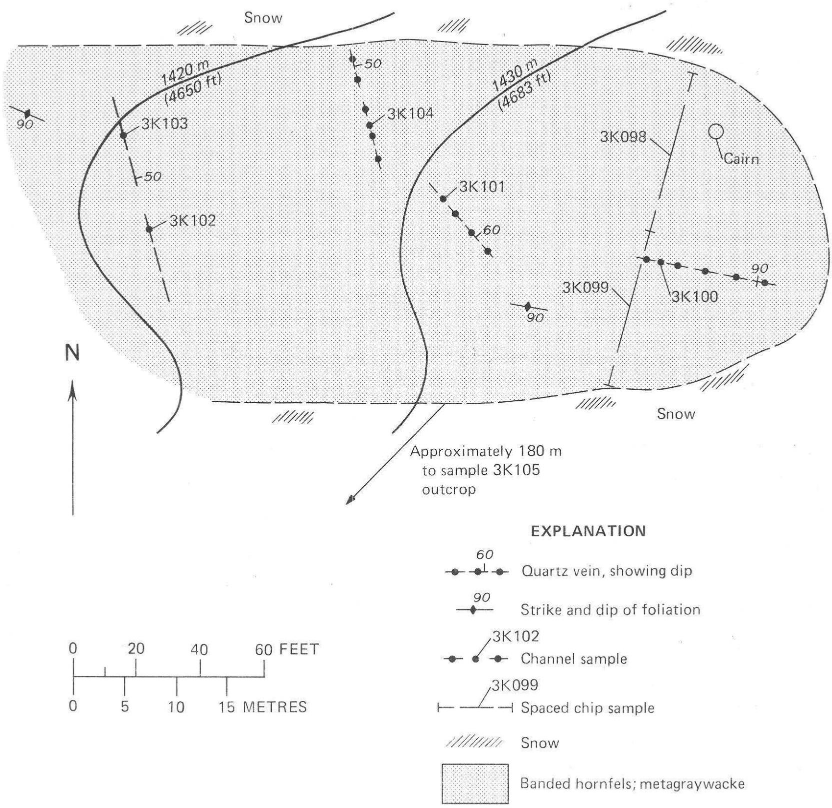
A cairn near the edge of the outcrop containing the quartz veins marks two claim corners beyond the limit of the rocks visible above snow at the time of the visit.

Geological Survey rock geochemical sample 55 (table 3) reporting 15.0 ppm (0.4 oz/ton) silver probably came from the immediate prospect area.

### Glacier prospect (P–17)

The Glacier group (17b, pl. 2; 17, fig. 16) of seven lode claims was located and recorded in 1923. The claim description indicates that they are on the northwest slope of Banded Mountain in a block extending three claim lengths upslope. Buddington, (1929, p. 120–121) reported that they were on the north side of Banded Mountain at the foot of Chickamin Glacier at an elevation of 370 m (1,200 ft). By 1925 a cabin had been built on the property, and development consisted of 7.6 m of stripping and 2.4 m of tunnel. Buddington's description of the prospect is summarized in table 1 (17b).

The Glacier deposit, tunnel, and stripping were not identified in the




Assay data

| Sample | Width (m) | Ag | Au | Cu | Mo | Bi | Co | Description |
|---|---|---|---|---|---|---|---|---|
| | | Spectrographic/Atomic absorbtion, ppm | | | | | | |
| Bedrock chip samples, 30-cm chip interval | | | | | | | | |
| 3K098 | 15.2 | N/ | N/N | 70/60 | 70/ | N/ | 15/ | Pyritic metagraywacke or hornfels |
| 3K099 | 15.0 | 0.5/ | N/N | 150/80 | 5/ | N/ | 30/ | Do. |
| 3K105 | Random chip | L/ | N/N | 100/55 | 10/ | N/ | 10/ | Metagraywacke |
| Channel samples | (cm) | | | | | | | |
| 3K100 | 12 | 0.5/ | N/N | 100/55 | 50/ | 100/ | 7/ | Quartz-calcite vein |
| 3K101 | 15 | 3.0/ | N/0.80 | 1,000/1,000 | 7/ | 200/ | 50/ | Quartz vein, pyrrhotite |
| 3K102 | 9 | N/ | N/0.05 | 70/150 | 70/ | 10/ | 10/ | Quartz, calcite, trace sulfide |
| 3K103 | 12 | 1.5/ | N/0.30 | 150/500 | 20/ | L/ | 10/ | Quartz vein, trace pyrrhotite |
| 3K104 | 12 | 3.0/ | N/0.20 | 1,500/1,200 | 10/ | 50/ | 500/ | Quartz-pyrrhotite vein |

L, an undetermined amount of the element is present below the sensitivity limit.
N, looked for but not found.

FIGURE 31.—Sketch map and assay data, Goat prospect.

field. Aerial and ground search did not reveal a vein system fitting Buddington's description. A ruined log cabin is at about 380 m (1,250 ft) elevation on a ridge just east of a large deeply incised canyon running from the summit glacier on Banded Mountain to the Chickamin River. The mouth of this canyon is 2.6 km southwest of the present terminus of Chickamin Glacier. Locators of the Cub and Goat groups of claims spent much time and effort unsuccessfully searching for this prospect on foot and by helicopter. The position of the terminus of Chickamin Glacier in 1923 is not definitely known. It has probably retreated a kilometre or more, as it was reported to have melted back 183 m between 1923 and 1925 (Buddington, 1929, p. 114).

The forest-covered ridge area was traversed to an elevation of 470 m (1,550 ft). The outwash fans of the six gorges between the present toe of Chickamin Glacier and this ridge were inspected for mineralized float that might have originated in the Glacier prospect veins. Float at the mouth of the gulch, 0.3 km east of the cabin ridge, probably came from veins similar to those described. Pieces of quartz up to 15 cm in diameter contained considerable pyrite and visible chalcopyrite and molybdenite. Composites of the best grade and lower grade float were gathered as samples 3P82 and 3P83. The highest grade sample assayed 300 ppm copper, 0.7 ppm silver, and 20 ppm molybdenum (spec.). Atomic absorption analyses yielded 110 ppm copper, 5 ppm lead, 20 ppm zinc, and 0.3 ppm (0.008 oz/ton) gold. If the deposit and the old cabin were both on the Glacier claims as originally staked, the prospect may be up the gulch from the sampled float. All the gulches were filled with avalanche snow during both of our field seasons.

Small pieces of quartz with similar but lower sulfide content were found at the fan near the position shown on plate 2 for the Glacier prospect.

## WALKER COVE AREA

### ALAMO PROSPECT (P–18)

The Alamo copper prospect is in a steep gorge that enters the north side of Walker Cove from the northwest and is about 11.3 km east-northeast of Hut Point and Behm Canal (18, pl. 2; 18, fig. 16). The deposit was located as the Glacier in 1954 and explored by a small amount of opencutting and some core drilling with a portable diamond drill. The deposit area was restaked in 1969 by another locator as the Alamo group of six lode claims. Exploratory work since the restaking included some stripping, several shallow opencuts, trenches, and five drill holes. Four of the holes reportedly were 60 m long, and one was 30 m long. Two additional claims were located in September 1973.

The deposit is a sulfide-bearing zone in paragneiss. The strike is about N. 30° W., and dips range from 50° to 80° NE. This zone parallels the general foliation in the country rock crossing Walker Cove (pl. 1). These gneissic rocks are in contact with foliated granodiorite to the east. Granodiorite to diorite dikes intrude the gneiss along the trend of foliation and in places crosscut it. The sulfide-bearing zone is exposed in cliffs along the northeast wall of the gorge on the Alamo claims (fig. 32). Cliffs along the lower part of the gorge range in height from about 30 to over 60 m. The sulfide-bearing zone is only lightly stained with limonite and other oxidation products, making it difficult to recognize. This staining is exposed for about 25 to 40 m above talus and avalanche snow at the foot of the cliffs. It is most apparent about 75 m northwest of drill hole No. 5 to 45 m southeast of the hole, a strike length of 125 m. This exposure may be displaced by fractures that cross its upstream end at an apparent strike of about N. 10° E. and dip of 55° W. Similar staining was observed up the gorge at several places higher up on cliffs to the northwest.

A couloir enters the main gorge from the northeast at an elevation of about 290 m. A bed of dolomite marble 6 m thick crops out in the northeast cliff wall of the couloir. From 0 to 6 m above the marble, the gneiss contains small amounts of pyrite and subordinate chalcopyrite. The next 3 m contain sparse pyrite and a trace of chalcopyrite. The marble appears to be barren. The 5.2 m of gneiss underlying the marble carries a trace of chalcopyrite. Samples 2P013–17 were cut across this zone. Samples across 6 m of gneiss overlying the marble assayed up to 3,000 ppm (0.3 percent) copper, 500 ppm zinc, and 0.7 to 3.0 ppm silver by spectrographic methods (table 11).

Drill hole No. 1 and No. 2 stations were reached by climbing a steep cleft north of drill hole No. 5. These sites are close to the tops of the cliffs at elevations of 133 m (435 ft) and 104 m (340 ft), respectively. Small areas had been stripped to gneiss bedrock at each site. The upper edge of the sulfide-bearing zone is exposed below the tops of the cliffs west of the drill sites. Some stripping has been done on the upper edge of this zone by working below the drill sites from fixed ropes. Drilling equipment and supplies apparently were landed and removed by helicopter, and workmen used fixed ropes in the cleft to gain access to the drill sites. A dense growth of bushes and small timber covers the slopes and ridge east of the drill sites. East-trending cliffs extend from the gorge across the mountain a short distance north and upslope from drill hole No. 1. Holes No. 1 and No. 2 are vertical, each reported to be 61 m deep. No assay values or logs have been released for any of the drill holes.

A station for holes No. 3 and No. 4 has been blasted out of the foot of the cliff, just above the talus slope. This station is at an elevation of 82 m (270 ft), southwest of hole No. 1. Hole No. 3 was drilled N. 60° E.

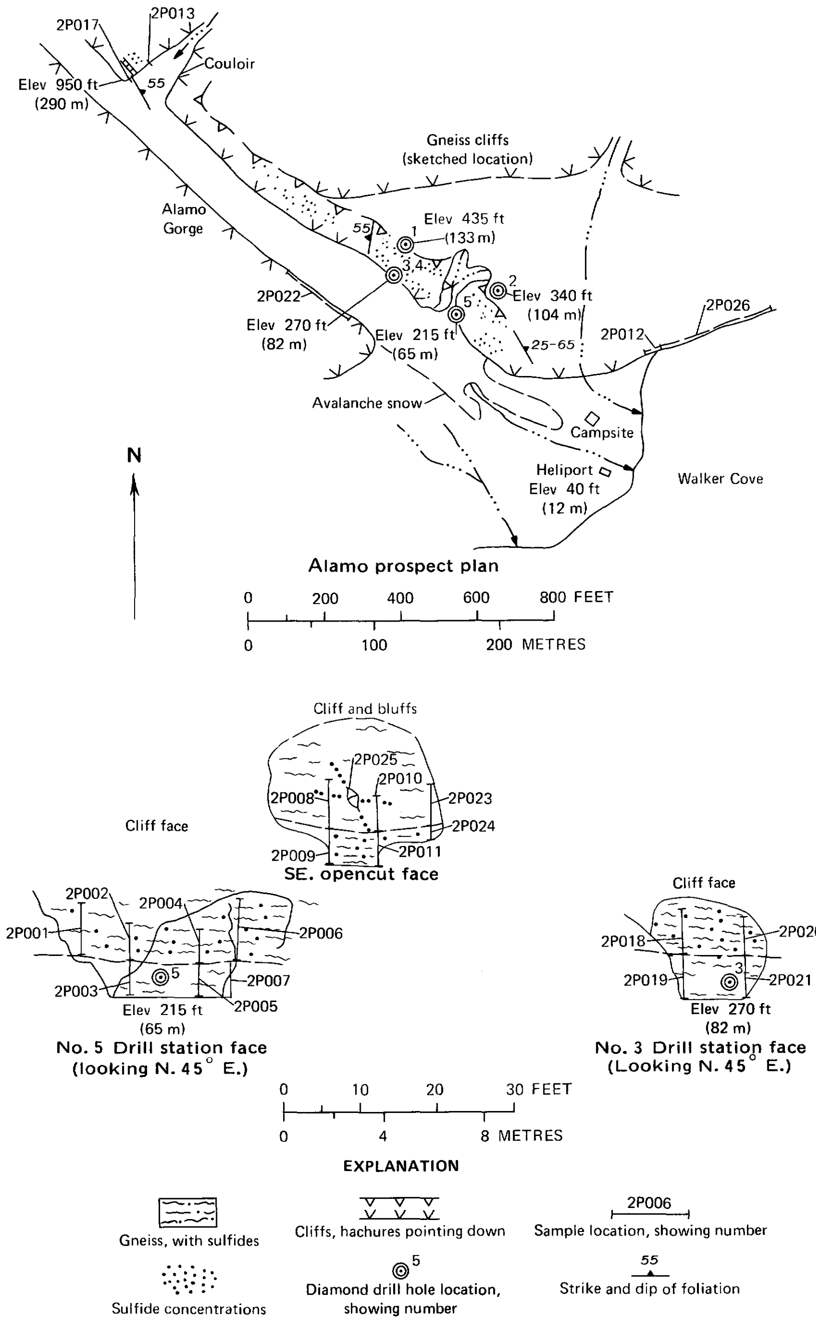



FIGURE 32.—Sketch map and sections of the Alamo prospect.

TABLE 11.—*Assay data, Alamo prospect*

[L, an undetermined amount of the element is present below the sensitivity limit. N, looked for but not found]

| Sample | Channel length, cm. | Cu | Pb | Zn | Au | Ag | Mo |
|---|---|---|---|---|---|---|---|
| | | | Spec/AA, ppm | | | | |
| Station face, drillhole No. 5 area | | | | | | | |
| 2P001 | 213 | 7,000/5,000 | 20/25 | 10,000/21,000 | N/N | 3.0/ | L/ |
| 2P002 | 152 | 15,000/14,000 | 10/25 | 7,000/6,000 | N/N | N/ | 0/ |
| 2P003 | 143 | 1,500/850 | 30/35 | 500/200 | N/N | L/ | L/ |
| 2P004 | 134 | 5,000/5,000 | 20/25 | 1,500/1,800 | N/N | L/ | 5/ |
| 2P005 | 134 | 300/250 | 50/30 | 700/320 | N/N | N/ | L/ |
| 2P006 | 244 | 3,000/2,200 | 30/20 | 5,000/4,800 | N/N | L/ | 15/ |
| 2P007 | 152 | 300/250 | 30/20 | 300/180 | N/N | N/ | N/ |
| 2P008 | 204 | 7,000/5,000 | 30/25 | 1,000/900 | N/N | 3.0/ | L/ |
| 2P009 | 152 | 1,500/1,400 | 20/20 | 700/160 | N/N | 0.5/ | 5/ |
| 2P010 | 155 | 7,000/6,500 | 30/20 | 1,000/500 | N/N | 7.0/ | L/ |
| 2P011 | 143 | 7,000/5,000 | 30/20 | 2,000/1,800 | N/N | 1.0/ | 7/ |
| 2P023 | 152 | 700/250 | 30/10 | 1,000/120 | N/N | N/ | L/ |
| 2P024 | 61 | 5,000/4,000 | 20/15 | 1,500/800 | N/N | 1.5/ | 7/ |
| 2P025 | 37 | 20,000/100,000 | 30/30 | 2,000/1,900 | N/0.2 | 50.0/ | 7/ |
| Station face, drillhole No. 3 area | | | | | | | |
| 2P018 | 189 | 3,000/3,300 | 10/20 | 700/170 | N/N | 0.7/ | 5/ |
| 2P019 | 177 | 3,000/1,800 | 30/20 | 300/170 | N/N | 1.0/ | L/ |
| 2P020 | 165 | 3,000/2,000 | 20/15 | 700/130 | N/N | L/ | 7/ |
| 2P021 | 165 | 1,500/1,100 | 30/20 | 500/160 | N/N | 0.5/ | L/ |
| North face of east couloir | | | | | | | |
| 2P013 | 366 | 500/180 | 30/15 | N/50 | N/N | N/ | N/ |
| 2P014 | 305 | 2,000/1,400 | 20/10 | 500/55 | N/N | 0.7/ | L/ |
| 2P015 | 305 | 3,000/1,500 | 50/20 | 500/60 | N/N | 3.0/ | 10/ |
| 2P016 | 610 | 30/40 | 70/50 | N/40 | N/N | N/ | N/ |
| 2P017 | 518 | 70/75 | 70/75 | N/70 | N/N | N/ | N/ |
| West wall, Alamo gorge | | | | | | | |
| | m. | | | | | | |
| 2P022 | 67.4 | 50/75 | 20/10 | N/70 | N/N | N/ | N/ |
| Cliff face east of Alamo gorge | | | | | | | |
| 2P012 | 12.2 | 150/100 | 15/10 | N/60 | N/N | N/ | N/ |
| 2P026 | 91.4 | 150/90 | 15/10 | N/65 | N/N | N/ | L/ |

at +7° inclination to a reported depth of 61 m. Hole No. 4 is vertical and 30.5 m deep. Samples 2P018–21 were cut vertically from the relatively fresh face of the drill station. Spectrographic determinations show that samples 2P018 and 19 contain an average of 3,000 ppm (0.3 percent) copper, 500 ppm zinc, and 0.85 ppm silver for 3.7 m above the station floor, north of hole No. 3. Samples 2P020 and 21 average 2,250 ppm (0.25 percent) copper, 600 ppm zinc, and 0.5 ppm silver for 3.3 m above the floor south of hole No. 3. Lead content is less than 100 ppm, and molybdenum less than 20 ppm.

Hole No. 5 was drilled from a station blasted out of the cliff above the talus slope at 65 m (215 ft) elevation. This station is at the foot of cliffs and bluffs southwest of hole No. 2. The station face and cut adjoining it to the south were sampled by moiling vertical cuts.

Samples 2P001–7 are from the station face. The lower part of the face is a fairly massive, coarse-grained gneiss with little apparent shearing or sulfide content. Copper values range from 300 to 500 ppm. The upper 134–244 cm of the face is a fractured, finer grained, gneissic to schistose rock with pyrrhotite and chalcopyrite in seams, patches, and disseminated grains. Copper content ranges from 3,000 to 15,000 ppm (0.3–1.5 percent), and zinc from 1,500 to 10,000 ppm (0.15–1.0 percent). An opencut south of the drill station and about 5 m above it yielded samples containing from 700 to 7,000 ppm (0.07–0.7 percent) copper, 700 to 2,000 ppm zinc, and up to 7.0 ppm silver. Cadmium values of 500, 100, and 70 ppm were present in samples 2P001, 2, and 6, respectively.

The highest grade material seen during the Alamo examination was a small lens of sulfides with some quartz and breccia, about 37 m thick and 76 cm long, in the face of the south cut at the intersection of two small veins. Sample 2P025 was cut across this lens. Atomic absorption assays showed 100,000 ppm (10 percent) copper, 1,900 ppm zinc, and 0.2 ppm (0.006 oz/ton) gold, which was the only gold detected in the Alamo samples. Spectrographic analyses showed 50 ppm (1.5 oz/ton) silver.

Three chip samples were taken for background content of copper in the gneiss away from the enriched zone. Sample 2P022 consists of chips taken at 30-cm intervals for 67.4 m above avalanche snow along the southwest wall of the gorge opposite the hole No. 3 drill station. This sample covered 9.8 m across the observed foliation and contained 50 ppm copper. Samples 2P012 and 2P026 are horizontal chip samples taken on the northwest trending beach and sea cliffs toward the contact with the foliated granodiorite. These samples each yielded 150 ppm copper.

The Alamo deposit has a higher copper content and tonnage potential than any of the other deposits examined in the study area. It is adjacent to deep salt water, making access relatively easy and inexpensive. Available information indicates a possible copper content between 2,000 and 7,000 ppm (0.2–0.7 percent) in a large body of sulfide-bearing paragneiss. Exploration sampling by drilling and detailed geologic mapping are required before any valid estimate of copper grade and tonnage reserves can be made.

Results from private exploration of this property have not been released. Cut sample values were unofficially reported as ranging from 2,500 ppm to 13,000 ppm (0.25–1.3 percent) copper in the limited areas sampled. Several drill-hole intersections of 6- to 9-m zones containing over 10,000 ppm (1.0 percent) copper were reported. Continuity of these intersections between holes is uncertain.

### Marble copper prospect (P–19)

A shallow cut on the north shore of Walker Cove 2.4 km from its mouth exposes malachite and traces of chalcopyrite in a marble-skarn zone in paragneiss near a contact with dioritic rock (fig. 33). Dioritic rocks are exposed 15 m to the east and beyond. A 55-cm-long channel sample of the most heavily stained part of the zone assayed 4,000 ppm (0.4 percent) copper, 30 ppm (0.9 oz/ton) silver, and 3.5 ppm (0.102 oz/ton) gold. Adjacent channel samples have much lower assay values (fig. 33). Traces of copper minerals were found in a marble-skarn bluff north along strike approximately 30 m above beach elevation. The mineralized zone was covered with overburden elsewhere. No evidence that claims were staked was found in the field or in courthouse records.

A second band of marble on the shore 0.4 km to the southwest was sampled (2K017). Assay results show only traces of copper.

### CHICKAMIN RIVER AREA

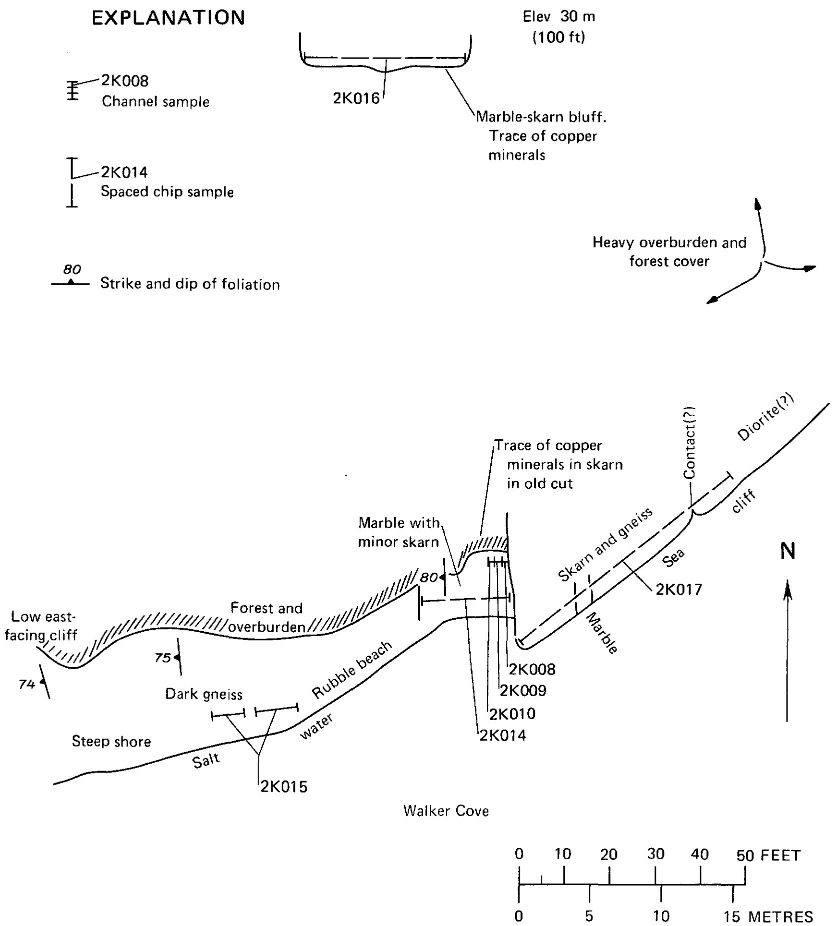
#### GNAT PROSPECT (P–20)

The Gnat vein is in a narrow gorge 1.6 km northeast of the head of the saltwater cove and tidal flat at the mouth of the Chickamin River (20, pl 2 and fig. 16). A brief description of the prospect has been published, but the location was not specific (Buddington, 1929, p. 120). The prospect is about 420 m N. 22° W. of Wolf cabin. The vein is exposed in a steep section of the gorge at about 50 m (150 ft) elevation about 75 m from the north wall of the Chickamin canyon. The floor of the gorge is covered by a layer of boulders and gravel to this point. The vein exposure was about 9 m long, partly under a waterfall. The gorge was choked with avalanche snow above the falls. The prospect was found by scouting the outwash fans and cliffs east of Clear Creek until sulfide-bearing float was found. No similar float was seen in the next 800 m east of the Gnat gorge.

The vein ranges in width from 1.83 to 3.14 m where exposed from the top to the bottom of the falls. It strikes N. 20° W. and dips from 59° to 80° NE. The vein material is mostly quartz, with locally abundant albite feldspar. Chalcopyrite, molybdenite, galena, and pyrite are relatively abundant for about 0.5 m below the hanging wall. The rest of the vein is low in visible sulfides. The vein is in gneissic quartz diorite that encloses some remnants of metamorphosed sedimentary rocks. An altered felsite dike 0.7 m wide crosses the gorge south of the vein outcrop; it strikes N. 70° E. and dips 74° S.

The vein was sampled across its 3.1-m width where it emerges from the debris-filled floor of the gorge. Sample J71–996 represents the upper 0.5 m of the vein immediately below the hanging wall that contains most of the visible sulfides. Sample J71–997 represents the remaining 2.6 m of sulfide-poor vein material. A grab sample (2P027) was obtained from the hanging wall of the vein at the east edge of the top of the waterfall. J71–994 was taken from a quartz boulder about

0.6 m in diameter at the west edge of the outwash fan. Composite sample J71–995 was collected from sulfide-bearing quartz float in and




Assay data

| Sample | Width (cm) | Cu | Pb | Zn | Au | Ag | Description |
|---|---|---|---|---|---|---|---|
| | | Spectrographic/Atomic absorbtion, ppm | | | | | |
| Cut channel samples | | | | | | | |
| 2K008 | 24 | 50/30 | 70/70 | N/30 | N/N | N/ | Green marble-skarn |
| 2K009 | 55 | 7,000/4,000 | 150/65 | 300/70 | N/3.5 | 30/ | Marble-skarn, sulfides |
| 2K010 | 55 | 20/40 | 30/20 | N/10 | N/N | N/ | Gray-white marble |
| Bedrock chip samples | (m) | | | | | | |
| 2K014 | 6.1 | L/20 | 20/60 | N/10 | N/N | N/ | Gray-white marble |
| 2K015 | 4.9 | 100/95 | 30/10 | N/30 | N/N | N/ | Dark gneiss, amphibolitic |
| 2K016 | 10.7 | 700/600 | 20/20 | N/30 | N/0.1 | N/ | Skarn, trace copper minerals |
| 2K017 | 18.3 | 200/110 | 30/10 | N/25 | N/N | N/ | Skarn and gneiss |

L, an undetermined amount of the element is present below the sensitivity limit.
N, looked for but not found.

FIGURE 33.—Sketch map and assay data, Marble copper prospect.

near the mouth of the gorge. These materials appeared to contain more abundant sulfides than observed at the outcrop. They may indicate the character of other outcrops further up the snow-choked gorge. The assay data are presented in table 12.

### LEDUC RIVER AREA

#### JOKER PROSPECT (P–21)

The Joker group of 20 claims was located as a molybdenum prospect in 1954. It is near the foot of the ridge north of the Leduc River, west of Clara Smith Glacier gorge, and just west of the Canadian boundary (21, pl. 2 and fig. 16). Quartz- and calcite-filled veinlets occur in fine-grained schists and gneissic metamorphic rocks of the Hazelton(?) Group. No molybdenite or copper, lead, or zinc minerals were observed.

Rock foliation varies from N. 45° W. to due north, dipping 45°–75° E. Small aplitic quartz monzonite dikes typically strike about N. 30° W. and dip about 25° SW. There is a conspicuous zone of rusty-weathering schist on the west flank of the ridge, just north of the river. The brownish coating on these rocks is very thin. Freshly broken faces show little or no oxidation and usually no pyrite. The intense color of weathered surfaces is apparently caused by oxidation of relatively unstable micas or other iron-bearing, rock-forming minerals. No samples were assayed from this prospect.

Gray schists and gneissic rocks containing some quartz-calcite seams crop out on the northwesterly ridge just above dense timber at and above 1,000 m (3,300 ft) elevation. Molybdenite was not found during inspection of this upper area.

Records of the Alaska Division of Geological and Geophysical Surveys indicate that no assessment work has been recorded on this claim group and no subsequent relocation or restaking has been recorded. No excavations, claim monuments, or marked stakes were found in the upper or lower areas visited.

## MINERAL OCCURRENCES

### UNNAMED MINERALIZED AREAS

#### AREA M–1

A band of reddish-brown, iron-stained paragneiss 4.8 km long and about 150 to 300 m wide is west of the Leduc River and north of Leduc Lake (pl. 2). During geologic mapping, molybdenite was observed at an outcrop in this zone in a pass at an elevation of 1,200 m (3,900 ft), 4.5 km north of Leduc Lake and 4.2 km west-northwest of the Leduc River. Anomalous amounts of molybdenum were present in a Geolog-

TABLE 12.—*Assay data, Gnat prospect*

[L, an undetermined amount of the element is present below the sensitivity limit. N, looked for but not found]

| Sample | Channel width, m. | Spec/AA, ppm Cu | Pb | Zn | Mo | Description |
|---|---|---|---|---|---|---|
| J71-994 | - | /87 | - | - | /4,700 | Float boulder. |
| J71-995 | - | /1,400 | /L(20) | /L(20) | /890 | Gorge float composite. |
| J71-996 | 0.49 | /170 | /420 | /420 | /910 | Vein, headwall section. |
| J71-997 | 2.65 | /50 | /340 | /L(20) | /160 | Vein, footwall section. |
| 2P27 | 0.37 | 70/130 | 1,500/1,000 | N/5 | 150/ | Vein, headwall grab. |

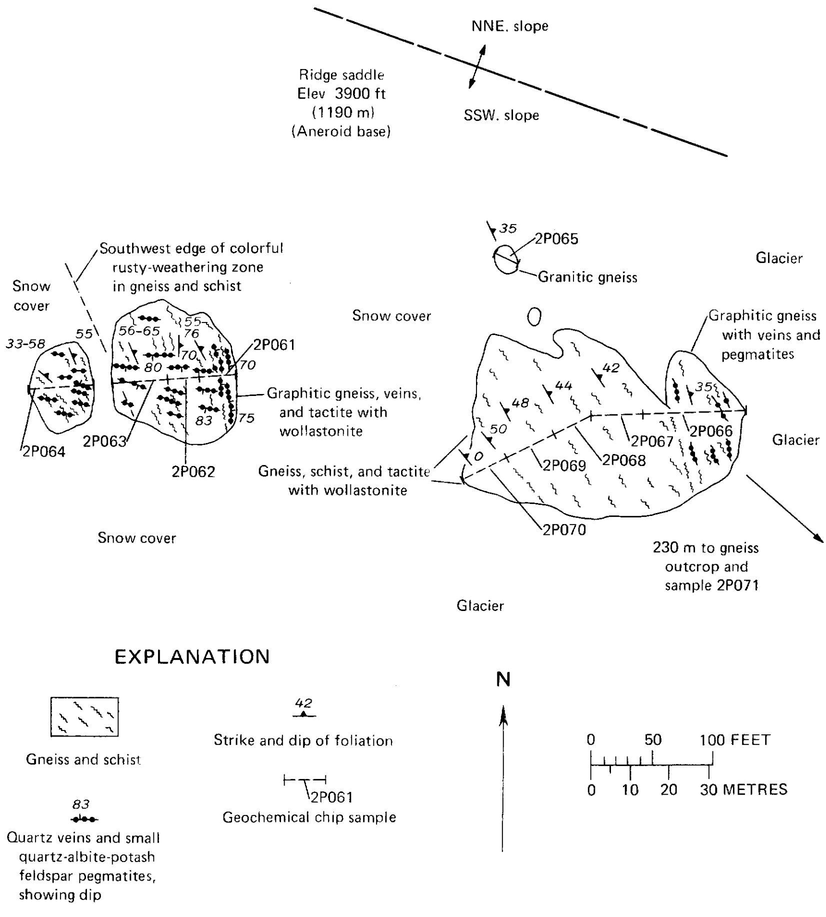
ical Survey rock sample (16, table 3) collected at the pass and in three stream-sediment samples from drainages intersecting the band farther south (figs. 9, 12).

Outcrops of iron-stained gneiss, schist, and minor tactite at the pass are interlayered and intruded by small pegmatite and diorite dikes and sills and contain small quartz veins and stringers that both parallel and intersect the schistosity. The relations of what may be larger masses of intrusive rocks were obscured by snow during the examination. The average strike of the foliation is about N. 30° W.; the dip is 45°–55° NE. Cross fractures strike east and dip 80°–85° S. Graphite occurs as coarse flakes along some of the cross veins and as small, disseminated particles in some of the gneiss and schist. Several concordant lenses of amphibolite up to 60 cm wide and 460 cm long contain small amounts of pyrrhotite and a trace of chalcopyrite; they weather dark chocolate brown.

Eleven samples were taken at the only accessible exposure (fig. 34) and may not be representative of the zone. Metal content of the samples is low, with values up to 110 ppm copper, 15 ppm lead, 60 ppm zinc, 1.5 ppm silver, and 100 ppm molybdenum. A trace of tungsten was detected in one sample by emission spectroscopy (detection limit 50 ppm).

### AREA M–2

A poorly exposed, rusty-weathering paragneiss zone about 4 km long and 300 to 600 m wide is partly accessible in the canyon walls of the stream draining Leduc Lake just before it enters Leduc River, 3.2 km above the Leduc-Chickamin confluence. Some of the rocks contain a little pyrrhotite and traces of chalcopyrite. Four chip samples covering the width of the exposed accessible iron-stained rocks were collected, two on each side of the river. These samples, which represent two separate horizons totaling 67 m thick, yielded values of 30–160 ppm copper, 10–90 ppm lead, 80–400 ppm zinc, 5–50 ppm molybdenum, and 0.5–2.0 ppm silver. A 2.1-m band of graphitic marble contained negligible amounts of these metals. The foliation ranges in




Assay data

| Sample | Sample length (m) | Spectrographic, ppm Ag | Spectrographic, ppm Mo |
|---|---|---|---|
| [1] 2P061 | 8.8 | N | 15 |
| 2P062 | 8.5 | N | L |
| 2P063 | 13.7 | N | L |
| 2P064 | 16.4 | N | N |
| 2P065 | 6.1 | N | N |
| 2P066 | 26.2 | L | 15 |
| 2P067 | 14.0 | 1.0 | 100 |
| 2P068 | 10.3 | L | 7 |
| 2P069 | 12.8 | 0.5 | 30 |
| 2P070 | 12.8 | 1.5 | 20 |
| 2P071 | 32.9 | N | L |

[1] Tungsten was detected (spectrographic 50L).

FIGURE 34.—Sketch map and assay data, mineralized area M–1, north of Leduc Lake.

strike from N. 45° to 60° W. and has moderate to steep northeastward dips.

### AREA M–3

A rusty-weathering zone in paragneiss is exposed in the walls of a steep avalanche gully west of the Chickamin River approximately 4 km north of its confluence with the South Fork. The 50-m-thick zone is approximately 400 m (1,300 ft) in elevation and parallels the gneissic foliation, which averages N. 10° W. and has a 55°–80° E. dip. This zone probably is the northwest extension of a similar rusty zone, M–4, on the other side of the river.

Chip samples at 30-cm intervals were obtained across 42 m of section perpendicular to the foliation (fig. 35). Assay results up to 340 ppm copper and 2.0 ppm silver were obtained. The rocks contain a little pyrrhotite in places. A trace of chalcopyrite was seen in one sample section and identified under the microscope in four others.

A second, much narrower, rusty section sampled several hundred feet down the gorge gave negligible assay values, although a trace of chalcopyrite was detected under the microscope.

### AREA M–4

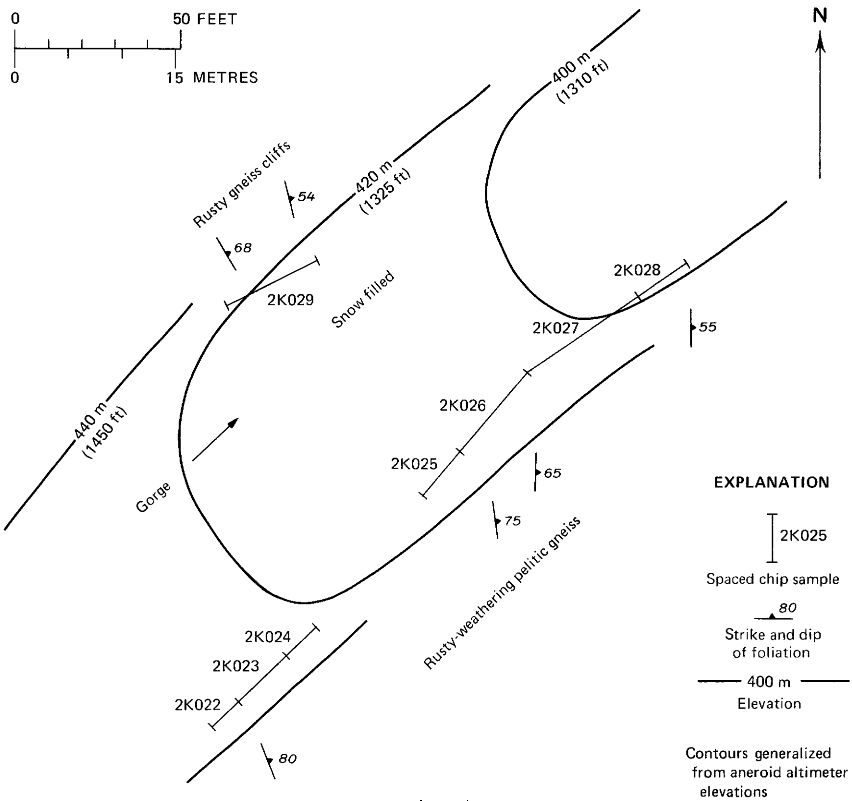
A pyritic rusty-weathering zone in pelitic schist and gneiss is a conspicuous feature in cliffs east of the Chickamin River, 3.2 km north of the mouth of the South Fork (fig. 36). It is accessible for sampling along the base of the cliffs at an average elevation of 185 m (600 ft). The foliation strikes N. 30° W. and dips 55° E. Estimated width of the highly colored part of the zone is a little over 153 m. Thirteen chip samples, each 15 m long, where collected from a rock face exposed for 200 m. The samples represent 150 m of the zone normal to the foliation. Three areas sampled, from 15 to 61 cm wide, contained relatively high concentrations of pyrite. The only sulfide minerals found were pyrite and sparse chalcopyrite.

Spectrographic analyses (fig. 36) showed molybdenum content up to 150 ppm. Atomic absorption assays showed 15 to 95 ppm copper, trace to 15 ppm lead, and trace to 80 ppm zinc; only one sample contained any gold (less than 0.05 ppm). Two samples assayed 0.7 ppm and 1.0 ppm silver.

### AREA M–5

An intensely iron stained area in paragneiss and gneissic diorite is 1.5 to 2.3 km east of the Chickamin River and 3.2 km northeast of the mouth of King Creek (pl. 2). The zone passes under the west edge of a small glacier that descends from an unnamed mountain to the east. This mountain crests at 1,387 m (4,550 ft) elevation. The intensely colored zone is about 335 m wide at an elevation of 1,020 to 1,080 m (3,350 to 3,550 ft) along the west edge of the glacier.

The rusty-weathering zone contains banded gneiss, gneissic quartz diorite, biotite gneiss, and biotite schist. Foliation commonly strikes N. 35°–60° W. and dips 45°–65° NE. but varies locally because of folding and minor faulting. A large number of narrow quartz veins

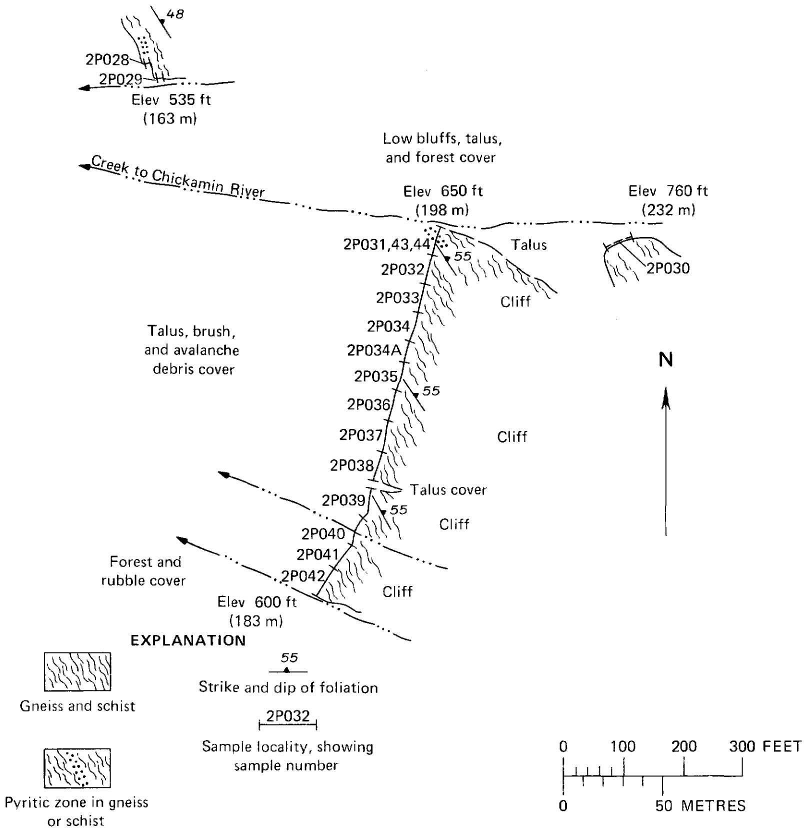



Assay data

| Sample | Length (m) | Spectrographic/Atomic absorbtion, ppm Cu | Ag | Au | Description |
|---|---|---|---|---|---|
| Bedrock chip samples, taken at 30-cm intervals | | | | | |
| 2K022 | 4.6 | 150/180 | L/ | N/L | Rusty gneiss, trace chalcopyrite |
| 2K023 | 6.7 | 150/240 | .5/ | N/L | Rusty gneiss |
| 2K024 | 6.7 | 200/340 | 1.0/ | N/L | Rusty gneiss, trace chalcopyrite |
| 2K025 | 19.0 | 70/65 | .7/ | N/N | Rusty gneiss |
| 2K026 | 6.7 | 70/30 | 2.0/ | N/N | Do. |
| 2K027 | 10.7 | 70/15 | .5/ | N/N | Do. |
| 2K028 | 15.2 | 70/30 | N/ | N/N | Do. |
| 2K029 | 6.7 | 150/180 | .5/ | N/N | Do. |

L, an undetermined amount of the element is present below the sensitivity limit.
N, looked for but not found.

FIGURE 35.—Sketch map and assay data, mineralized area M–3, west of Chickamin River.




Assay data

| Sample | Length (m) | Spectrographic, ppm Mo | Description |
|---|---|---|---|
| 2P028 | .6 | 10 | Pyritic vein |
| 2P029 | 3.0 | N | Andesitic gneiss |
| 2P030 | 15.2 | N | Gneiss |
| 2P031 | 15.2 | 20 | Sillimanite schist |
| 2P032 | 15.2 | 5 | Biotite schist, pyritic |
| 2P033 | 15.2 | 10 | Biotite schist |
| 2P034 | 15.2 | N | Do. |
| 2P034A | 10.6 | N | Do. |
| 2P035 | 15.2 | N | Biotite schist, pyritic |
| 2P036 | 15.2 | 150 | Gneiss, pyritic |
| 2P037 | 15.2 | L | Biotite gneiss and schist |
| 2P038 | 15.2 | N | Biotite schist |
| 2P039 | 15.2 | 15 | Biotite gneiss |
| 2P040 | 15.2 | 20 | Do. |
| 2P041 | 15.2 | N | Sillimanite schist |
| 2P042 | 15.2 | N | Biotite schist; gneiss |
| 2P043 | .2 | 10 | Pyrite, quartz, sillimanite |
| 2P044 | .1 | 15 | Sillimanite, quartz, pyrite |

L, an undetermined amount of the element is present below the sensitivity limit.
N, looked for but not found.

FIGURE 36.—Sketch map and assay data, mineralized area M–4, east of Chickamin River.

and small andesite or diorite dikes follow foliation planes, or crosscut the foliation, usually at small angles. Disseminated pyrite is visible in some of the rocks but not in other rock that may be equally iron stained. Part of the strong coloration may be due to iron oxides derived from biotite. A body of foliated granodiorite parallels this zone a short distance to the north.

The rust-colored zone was sampled where it crosses a bare, rounded ridge along the west edge of the glacier. Twelve 30.5 m-long chip samples, Nos. 2P072 through 2P082 (fig. 37), were taken across the zone. Values ranged from 25 to 80 ppm copper, trace to 10 ppm lead, and 30 to 90 ppm zinc. Molybdenum was present in four of the samples in amounts of 5, 7, 7, and 15 ppm.

Geological Survey rock sample 22 (figs. 9 and 13; table 3) was collected in this area. It assayed 370 ppm copper by atomic absorption methods.

### AREA M–6

A conspicuous band of rusty-weathering pyritic paragneiss crops out in a cliff face on the south wall of the canyon of the South Fork of the Chickamin River. The outcrop, estimated to be about 300 m wide, is about 3 km southeast of the mouth of the South Fork. The exposure is from the top of a talus slope at about 120 m (400 ft) elevation to the top of the canyon wall at about 600 m (2,000 ft). This face was unsafe to sample because of falling rock and ice. A limited exposure, probably near the west edge of the band, was sampled at the foot of a waterfall on the valley floor (sample site G–24, fig. 16). Accessible outcrops were sampled at locations 2.4, 2.9, and 3.2 km southeast of the South Fork canyon exposure. These outcrops are in the upper basins at the heads of two creeks that drain into the South Fork and near the ridge between the basins (fig. 38).

This zone extends at least 5 km along a strike averaging N. 45° W. (pl. 2). Foliation dips range locally from 43° NE. to 80° SW. but probably average about 70° NE. Petrographic studies show that the rocks range in composition from granitic to dioritic gneiss, with some biotite schist and pelitic gneiss. They contain pyrite in amounts ranging from a trace to several percent, and a few grains of chalcopyrite. Atomic absorption analyses show values up to 400 ppm copper, 30 ppm lead, 180 ppm zinc, 5.0 ppm silver, and less than 0.05 ppm gold. Assay data for 36 chip samples from the three upland outcrops are shown in table 13.

A steep, narrow gorge 2.4 km southeast of the South Fork cliff outcrop, bearing N. 45° E., cuts into the southwestern part of the pyritic zone and exposes the footwall. The zone is in the west wall of a basin at the head of a north-flowing creek. Six chip samples (2P085–

90) were cut from the near-vertical walls of the gorge by working from the surface of avalanche snow. The samples covered an interval from the footwall to 20.4 m and from the footwall plus 59 m to 159 m, projected to horizontal distance at right angles to the strike. Sample

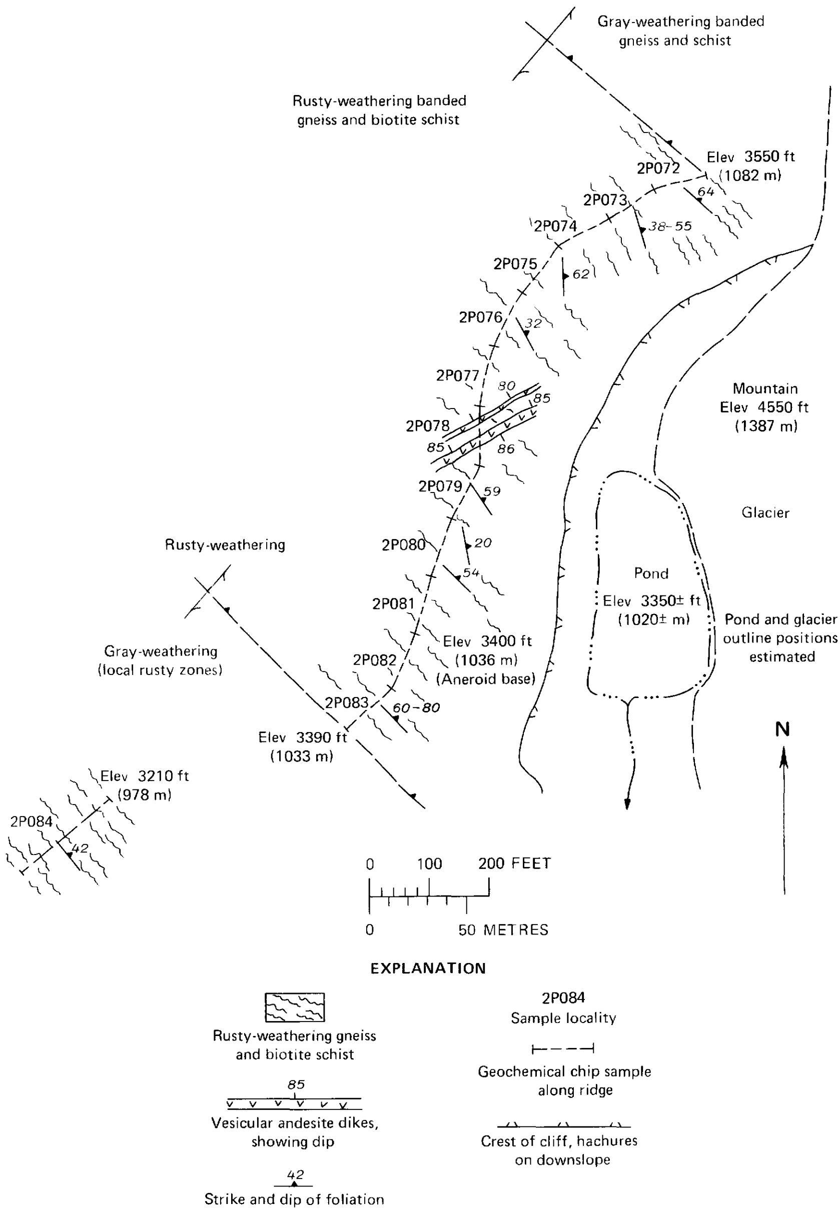



FIGURE 37.—Mineralized area M-5 on 1,390-m (4,550-ft) mountain.

elevations ranged from 985 m (3,230 ft) to 844 in (2,770 ft). One sample contained 30 ppm molybdenum. Three other samples had 1.5, 1.5, and 5.0 ppm silver.

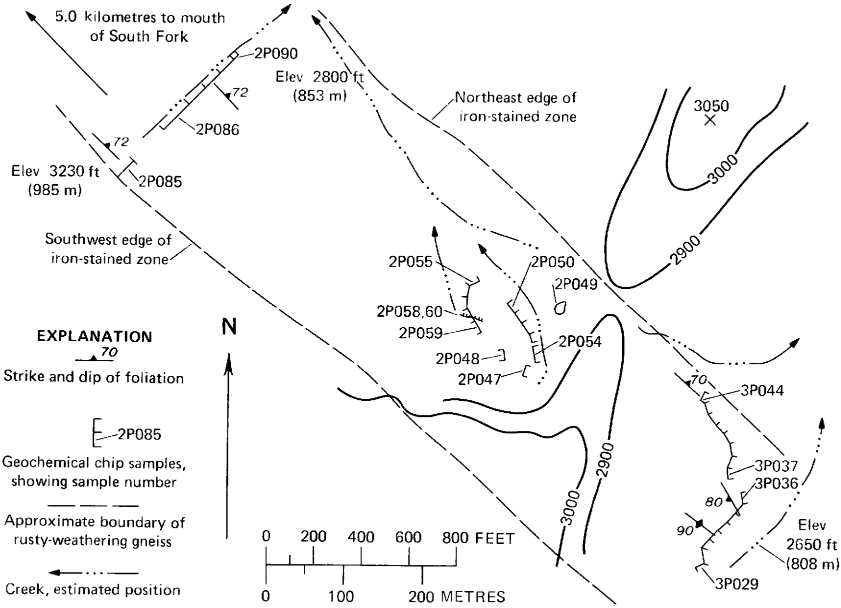



FIGURE 38.—Mineralized area M–6, south of South Fork.

On the south side of the basin 2.5 km southeast of the South Fork cliff outcrop, 11 samples were taken at the base of cliffs that are probably just south of the central part of the zone. These samples were from elevations between 870 m (2,850 ft) and 890 m (2,925 ft), projecting to about 88 m across the zone. They included two samples containing 20 and 30 ppm molybdenum. Two samples near the ridge at 936 m (3,070 ft) elevation covered 25 m. One of these assayed 70 ppm molybdenum and 2.0 ppm silver.

On the west wall of a basin 3.2 km farther to the southeast, 16 samples were cut covering a projected distance of about 200 m across the zone to a point at or near its northeast wall. These samples were at altitudes ranging from 810 to 880 m (2,650 to 2,900 ft). Three samples each assayed 20 ppm molybdenum, and one carried 1.5 ppm silver.

Geological Survey rock sample 27 (fig. 9; table 3) from the ridge sample locality was anomalous in lead (450 ppm). A stream-sediment sample from the creek draining the gorge sample site was anomalous in copper, lead, zinc, molybdenum, gold, and silver.

TABLE 13.—*Assay data, mineralized area M–6, south of South Fork*

[L, an undetermined amount of the element is present below the sensitivity limit. N, looked for but not found]

| Sample | Sample length m. | Spec/AA, ppm Cu | Pb | Zn | Ag | Mo |
|---|---|---|---|---|---|---|
| 2P047 | 13.7 | 70/100 | 20/10 | N/80 | 1.0/ | 5/ |
| 2P048 | 11.2 | 150/85 | 50/10 | N/180 | 2.0/ | 70/ |
| 2P049 | 3.6 | 10/20 | 50/5 | N/60 | N/ | N/ |
| 2P050 | 15.2 | 100/160 | 20/10 | N/120 | N/ | 20/ |
| 2P051 | 15.2 | 150/210 | 15/5 | N/150 | N/ | 30/ |
| 2P052 | 15.2 | 150/100 | 20/10 | N/90 | 1.0/ | 10/ |
| 2P053 | 12.1 | 20/75 | 20/15 | N/150 | N/ | N/ |
| 2P054 | 21.3 | 100/120 | 20/15 | N/130 | N/ | L/ |
| 2P055 | 15.2 | 30/55 | 30/10 | N/170 | L/ | 5/ |
| 2P056 | 15.2 | 150/150 | 30/10 | N/100 | N/ | 5/ |
| 2P057 | 15.2 | 30/60 | 30/10 | N/100 | N/ | N/ |
| 2P058 | 15.2 | 70/50 | 30/10 | N/100 | 0.7/ | N/ |
| 2P059 | 15.2 | 70/80 | 30/30 | N/120 | L/ | 7/ |
| 2P060 | 1.5 | 7/70 | N/10 | N/25 | N/ | N/ |
| 2P085 | 21.0 | 30/20 | 100/15 | N/30 | 1.5/ | L/ |
| 2P086 | 57.9 | 30/20 | 70/10 | L/100 | N/ | L/ |
| 2P087 | 39.6 | 100/100 | 50/10 | N/90 | 0.5/ | 30/ |
| 2P088 | 30.4 | 700/400 | 100/10 | N/95 | 5.0/ | 15/ |
| 2P089 | 29.8 | 30/45 | 150/20 | 200/100 | 0.7/ | L/ |
| 2P090 | 9.1 | 100/100 | 70/30 | N/95 | 1.5/ | L/ |
| 3P029 | 13.7 | 70/70 | 50/30 | 200/110 | 1.5/ | 7/ |
| 3P030 | 18.9 | 150/70 | 30/5 | N/80 | 1.0/ | 5/ |
| 3P031 | 15.2 | 100/70 | 30/10 | N/90 | 1.0/ | 5/ |
| 3P032 | 15.2 | 70/100 | 20/5 | N/65 | 0.5/ | 7/ |
| 3P033 | 15.2 | 100/100 | 20/5 | N/70 | 0.5/ | 5/ |
| 3P034 | 15.2 | 100/110 | 20/5 | N/80 | 0.5/ | 5/ |
| 3P035 | 15.2 | 100/75 | 15/5 | N/70 | 0.5/ | N/ |
| 3P036 | 15.2 | 70/65 | 15/5 | N/90 | L/ | N/ |
| 3P037 | 15.2 | 100/60 | 30/5 | N/110 | 0.7/ | 20/ |
| 3P038 | 15.2 | 30/45 | 20/5 | N/70 | N/ | N/ |
| 3P039 | 15.2 | 20/15 | 20/L | N/75 | N/ | N/ |
| 3P040 | 15.2 | 70/35 | 20/5 | N/90 | L/ | 5/ |
| 3P041 | 15.2 | 70/55 | 20/10 | N/90 | L/ | 20/ |
| 3P042 | 15.2 | 200/60 | 20/5 | N/70 | 1.0/ | 20/ |
| 3P043 | 15.2 | 200/75 | 20/5 | N/85 | 0.7/ | 5/ |
| 3P044 | 12.1 | 150/130 | 20/5 | N/85 | 0.7/ | 15/ |

### AREA M–7

A wide band of highly colored, rusty-weathering paragneiss is conspicuously exposed on cliffs at the head of Davis River amid rocks that appeared granodioritic from a distance but were not visited. Assays of one of two random chip samples covering about half of a 40-m section perpendicular to foliation showed 2.0 ppm silver and 260 ppm zinc. Traces of pyrite and pyrrhotite seen in some places were nearly always in sparsely distributed small pods or knots elongated parallel to the gneissic foliation. An analysis of one such pod showed calcite, hornblende, diopside, pyrrhotite, and a trace of chalcopyrite. This rusty-weathering zone had to be sampled outside the study area because its continuation within the study area was inaccessible.

### AREA M–8

A vivid-orange-weathering zone crops out in cliffs on the north side of Banded Mountain 1.6 km due west of the summit. It is visible in cliffs from the base of Chickamin Glacier from about 1,310 m (4,300 ft) down to about the 900-m (3,000-ft) level. A large cleft crosses the zone and provides an accessible outcrop along a short bench at an elevation of 1,100 m (3,600 ft).

The rocks are gneiss and schist of the Hazelton(?) Group. In the iron-stained zone they contain pyrite and pyrrhotite in amounts up to 2 percent. Graphite content is as high as 5 percent locally. No base-metal sulfides were observed. The colored zone has an apparent strike of N. 50° W., and it dips 70° SW. Foliation at the northeast edge of the zone at the sample site strikes N. 70° W. and dips 76° NE. Three chip samples, taken along a southwest line, cover 24 m of outcrop to a debris-filled depression 8.2 m wide. Another 12.2-m sample was obtained beyond this covered area. No significant metal values were found. Assay ranges were 10 to 60 ppm copper, 10 to 15 ppm lead, 30 to 150 ppm zinc, and up to 10 ppm molybdenum. No gold or silver was detected.

### AREA M–9

A quartz pod in conspicuously iron-stained metagraywacke at the east edge of the Chickamin River valley 1½ km below the glacier terminus contains pyrrhotite and traces of chalcopyrite. A sample 64 cm long moiled across the thickest part of the pod containing the most abundant sulfides assayed 1,200 ppm copper and 1.5 ppm silver. The pod strikes N. 30° E. and dips 80° SE. It pinches out in both directions; total length is less than 10 times its maximum width. Foliation in the host rock in the immediate area is N. 60° E., dipping 70° NW. A grab sample of a much smaller parallel pod (or vein) 15 cm thick had a similar silver value but much less copper and 0.05 ppm gold. No other sulfide minerals were seen, and no evidence of workings was noted. The pods were found during inspection of gully debouchment fans for mineralized float.

Twenty or more claims were staked in 1928 or 1929 by Metcalf and Fendley on the northwest side of Banded Mountain adjacent to Chickamin Glacier. Records are not sufficiently specific to determine whether site M–9 was included. Although iron staining is conspicuous, it is possible that this low cliff face was covered by the ice of Chickamin Glacier at that time.

### AREA M–10

A small area of Hazelton(?) metamorphic rocks cut by a quartz-albite vein and an intersecting zone of quartz stringers is exposed at the 1,070-m (3,500-ft) level on the ridge 2.4 km north of Disappearing Lake. The quartz-albite vein strikes N. 50° W., dips 55° SW., and is about 60 cm wide. The footwall is a distinct plane. The hanging wall is indistinct and merges with a system of fractures and veinlets that strikes about N. 80° E. and dips steeply to the north. This fracture zone is covered with overburden from 1.5 to 4.5 m west of the footwall. The quartz-albite vein and the fracture system veinlets contain up to about 2 percent pyrite and very small amounts of galena and chalcopyrite. A composite chip sample across the vein and about 1.2 m of the stringer lode in the hanging wall contained 70 ppm copper, 80 ppm lead, 30 ppm zinc, and 0.05 ppm gold.

This area and a small opencut nearby may be on ground covered by the four-claim Blasher Extension group located in 1937 and described as adjoining the Sunset or Blasher prospect group (P–7, fig. 16).

## ROCK GEOCHEMICAL ANOMALIES

Sample locality site numbers in the following sections correspond to "G" numbers in figure 16 and to map numbers in figure 9 and table 3.

### SITE G–5

A Geological Survey background sample of quartz diorite anomalous in zinc (350 ppm) was collected on a ridge 0.8 km south-southeast of Gilbert Lake and 7.4 km northeast of the entrance to Walker Cove.

Garnet-bearing gneissic quartz diorite containing a few small quartz veins and lenses, and massive featureless quartz diorite, crop out on this ridge at an elevation of 640 m (2,100 ft). Composited random chip samples across 45.6 m of each rock type assayed 50 and 60 ppm zinc, respectively. No sulfide minerals were observed, and no anomalous metal values were obtained.

### SITE G–7

Paragneiss from Geological Survey site G–7 was anomalous in silver (3.0 ppm). The site is on the north shore of Walker Cove 3.1 km east-northeast of the entrance. A small creek enters the cove along the eastern contact of a north-trending band of paragneiss with quartz diorite.

Quartz diorite containing a few apparently barren quartz stringers is exposed in a low cliff along the east wall of the creek canyon. The cliff west of the creek is composed of banded gneiss carrying small amounts of pyrite in patches, layered stringers, and disseminated crystals. Small pegmatitic stringers and dikes up to 24 cm wide cut the gneiss at various angles. Several of them strike N. 70° E. and have nearly vertical dips. Quartz stringers and veins up to 61 cm wide traverse the gneiss, striking N. 70° E. and dipping about 65° SE.

One of these quartz veins, 55 cm wide at stream level, carries several percent pyrite and minor amounts of chalcopyrite and molybdenite. The vein is 70 cm wide 2.4 m higher; the only visible sulfide is pyrite. Apparent mineralization is too lean to encourage exploration on any of the veins. Chip samples across 8.2 m of quartz diorite, two 11.0-m sections of gneiss, and the quartz vein above creek level have negligible metal values. The quartz diorite assayed 50 ppm copper, 5 ppm lead, and 60 ppm zinc. Gneiss samples run 80 to 110 ppm copper, 10 ppm lead, 80 to 100 ppm zinc, 5 ppm molybdenum, and 0.05 to 1.0 ppm silver. The most highly mineralized section of the quartz vein, just above stream gravel, contained 900 ppm copper, less than 5 ppm lead, 20 ppm zinc, 70 ppm molybdenum, 0.1 ppm gold, and 1.0 ppm silver.

### SITE G–8

Geological Survey site 8, obtained from a slot in the south shore of Walker Cove 3 km east of Hut Point, assayed 20 ppm molybdenum, the anomalous threshold. A 6.25-m follow-up chip sample of clean, hard, unmineralized quartz diorite assayed no detectable molybdenum (less than 5 ppm). No evidence of mineralization was seen in the rocks that could be inspected from this landing point at the time of the Bureau of Mines visit. The slot could not be climbed for more than a short distance, and the nearby shore was vertical.

### SITE G–9

Anomalous amounts of copper (280 ppm) and silver (1.5 ppm) were reported in a sample of Geological Survey paragneiss on the south shore of Walker Cove 1.9 km east of Hut Point. A chip sample collected by the Bureau of Mines across a 12.8-m thickness of dark gneiss with light, slightly pyritic banding assayed 1,000 ppm copper and nearly 1 ppm silver. A second sample of an adjacent section had lower values. Chalcopyrite was present, although no concentrations were found. The sulfide-bearing gneiss is covered by rubble above the steep, narrow beach exposure and strikes into the sea.

### SITE G–10

Geological Survey site 10, on dark-gray paragneiss 2.4 km south of Ledge Point on the east shore of Behm Canal, gave anomalous lead (30 ppm) and zinc (160 ppm) values. Three chip samples crossing 15 m of section perpendicular to foliation contained up to 10 ppm lead and 80 ppm zinc. Some iron staining follows thin quartz foliation bands, but no sulfide minerals were noted.

SITE G–11

A lead-gold anomaly was found in iron-stained paragneiss on the northwest shore of Rudyerd Bay during geologic mapping. The original Geological Survey rock sample assayed 150 ppm lead by spectrographic methods but 10 ppm lead and 0.05 ppm gold by atomic absorption. The site is near the mouth of a small creek with a cascade about 300 m high opposite Punchbowl Cove 2.1 km N. 7° W. of the cove's west entrance and 1.2 km northwest of the eastern entrance.

A band of paragneiss in the quartz monzonite contains the iron-stained zone. Foliation is N. 55° W. and dips 68°–80° NE. A black vesicular dike cuts the dark-gray-green gneiss west of the creek. Samples across 15 m of the rusty-weathering gneiss and the dark gneiss assayed 10 ppm and 5 ppm lead, respectively, by atomic absorption methods. No gold or silver was detected.

SITE G–14

A grab sample of paragneiss containing 30 ppm molybdenum was collected during geologic mapping on the Leduc River–Klahini River divide 8 km north of Leduc Lake. A composite random chip sample of gneiss from the vicinity assayed 5 ppm molybdenum. A 30-m-thick lens(?) of altered dunite and lesser olivine marble about one-third kilometre to the east parallels foliation in enclosing gneiss. Composite chip samples of two exposures 180 m apart separated by snow cover, and on strike, each contain 2,000 ppm and 5,000 ppm nickel and chromium. These values are not anomalous for such rocks.

SITE G–15

A gold anomaly (0.35 ppm) on a narrow, cliff-flanked ridge of paragneiss was investigated. The 900-m (3,000-ft) ridge is 2.7 km north of the east end of Leduc Lake. The paragneiss contains several quartz stringers and small veins up to 24 cm wide. No pyrite or other sulfide minerals were observed in the paragneiss or the veins. Occasional iron-stained patches occurred in some quartz veins. A large composite chip sample of the gneiss and channel samples of the two largest veins did not contain detectable amounts of gold or silver.

SITE G–20

A weak gold anomaly (0.05 ppm) was reported in a Geological Survey grab sample of paragneiss at 740 m (2,420 ft) elevation 3.1 km north of the junction of the Leduc and Chickamin Rivers.

The gneiss rocks near the sample site are cut by small quartz-feldspar pegmatite veins and by irregular quartz stringers. Separate composite chip samples were collected by the Bureau of Mines from the paragneiss, coarsely crystalline granodiorite gneiss, pegmatite, and quartz stringers and veins. The samples do not contain detectable amounts of gold or silver.

SITE G–24

Pyritic grandiorite gneiss reported as slightly anomalous in copper, molybdenum, and zinc is exposed at the base of a waterfall on a large creek entering the Chickamin River from the south about 2.8 km southeast of the confluence of the South Fork with the Chickamin River. Chip samples perpendicular to foliation were taken in accessible places along both left and right banks in 14- and 13.7-m sections, respectively. Assay results of 95–200 ppm copper, 5–50 ppm molybdenum, and 70–200 ppm zinc roughly substantiate the results obtained by the Geological Survey. Foliation in the rocks has a general northwestward strike and moderate northeastward dip.

SITE G–29

Slightly anomalous silver (2 ppm) and copper values (100 ppm) were reported in paragneiss at Geological Survey site 29. The outcrops lie between 1,100 and 1,250 m (3,600 and 4,100 ft) elevation just north of a small icefield capping a 1,391-m (4,656-ft) peak northwest of Walker Lake. Five chip samples were taken of rusty-weathering paragneiss, some highly colored, some decomposed, and some slightly pyritic. A sixth was from an 18- by 60-cm quartz-pyrite pod. The quartz-pyrite pod gave no significant assay values. However, all five chip samples representing 1.2 to 18 m of section along 0.8 km of strike length, where rock exposures and snow conditions permitted sampling, yielded 1 to 2 ppm silver. The total width of the section is unknown.

SITE G–31

Geological Survey site 31 yielded samples that were slightly anomalous in silver and that assayed 300 ppm copper (spec.). Copper content by atomic absorption analysis was 50 ppm. This sample site is 6.0 km southeast of the mouth of Walker Creek and 4.3 km south-southwest of the west end of Walker Lake. It is at an elevation of about 1,040 m (3,400 ft) on a ridge north of the divide between Walker Cove and Walker Lake watersheds. The ridge is paragneiss with rusty-weathering pyritic bands and quartz veinlets parallel to the foliation. Foliation ranges from N. 35° to 55° W., and dips are 45°–55° NE. A sample of widely spaced chips of paragneiss carried 35 ppm copper and no detectable silver. A 30-cm sample across two pyrite stringers 21 cm apart assayed 0.7 ppm silver and 160 ppm copper.

SITE G–33

A sample of pyritic paragneiss containing anomalous copper (350 ppm) was collected during geologic mapping at the summit of a 1,117-m (3,666-ft) mountain 0.8 km east of the head of Rudyerd Bay. The summit was inaccessible because of snow when checked by the Bureau of Mines. Samples were obtained 0.3 km north of the 1,000-m (3,250-ft) elevation line on a snow-free section of ridge. Locally iron-stained paragneiss contains small amounts of disseminated pyrite and some garnet. Foliation is generally N. 35° W. and dips 62° NE. Several lenticular quartz veins up to 55 cm wide parallel the foliation in the gneiss. They are practically barren of metallic sulfides. Very low metal values were found in three composite chip samples across gneiss and in channel cuts across a quartz vein 55 cm wide (up to 35 ppm copper, 25 ppm lead, 55 ppm zinc, and 7 ppm molybdenum).

SITE G–36

A Geological Survey background sample of paragneiss 5 km northeast of the head of Rudyerd Bay contained an anomalous amount of gold (1.3 ppm). The site was inspected by the Bureau of Mines the following July. Although the area was largely snow covered at that time, four random chip samples from available outcrops between 820 and 940 m (2,700 and 3,100 ft) elevation were obtained, two of vein quartz and two of rusty-weathering gneiss. Three grab samples of gneiss particularly iron stained along dark foliation banding were also obtained. Gold values in all samples were below the 0.05-ppm limit of detection. One grab sample of a 3-cm-thick, heavily iron stained foliation band containing goethite, slightly pyritic quartz, and hornblende assayed 550 ppm copper. Although it was not clear from the topography and snow cover precisely where the Geological Survey background sample was obtained, freshly broken rusty gneiss was found and collected as one of the grab samples.

SITE G–42

A red-weathering pyritic zone 30 m or more wide in gneissic rock is exposed 3 km east of the mouth of Barrier Creek at an elevation of 1,430 m (4,700 ft) between a broad snowfield to the south and gray bluffs to the north. The Geological Survey sample from this site assayed 330 ppm molybdenum. The Bureau of Mines subsequently cut two chip samples perpendicular to the foliation of the rusty gneissic rock for approximately 15 m. Values of 30 to 50 ppm molybdenum and 110 to 450 ppm copper were obtained. The remainder of the zone could not be sampled safely. The red weathering generally was surficial and followed foliation, joints, and fracture planes. No molybdenite was identified, and no concentrations of sulfides were found.

SITE G–43

The Geological Survey sample at site 43 indicated a fairly strong lead anomaly (450 ppm) in epidote veinlets cutting granodiorite on the eastern boundary of the study area 2.8 km south of the eastern branch of the South Fork of the Chickamin River. The site is at 1,700 m (5,550 ft) elevation, at the southwest corner of a glacier.

Epidote occurs in seams, small veinlets, and on fracture faces cutting foliated grandiorite in many directions and attitudes. No lead minerals or metallic sulfides were observed. A large sample was collected by compositing chips from a great number of epidote-bearing veinlets and fracture faces. This sample contained 10 ppm copper, 10 ppm lead, and 60 ppm zinc.

#### SITE G–44

A Geological Survey sample of a small quartz vein in quartz monzonite on the eastern border of the study area yielded an anomalous value in molybdenum (70 ppm). The site is on top of a 1,860-m (6,100-ft) mountain 4.7 km north of the easternmost branch of the South Fork of Chickamin River. The summit is closely surrounded by a southern lobe of Through Glacier.

A subsequent examination of the area did not yield detectable molybdenum values in composite samples of the small, irregular quartz and quartz-feldspar veins or of the quartz monzonite. No sulfides were visible. The samples assayed 10 and 15 ppm copper, 5 ppm lead, and 15 and 60 ppm zinc.

#### SITE G–46

A background sample of gneiss and granodiorite containing 20 ppm molybdenum was collected by the Geological Survey at 1,070 m (3,500 ft) elevation about 1½ km northeast of where Indian Creek enters the Chickamin River. A 7.6-m followup bedrock chip sample perpendicular to foliation in gneiss just above a gneiss-granodiorite contact assayed 30 ppm molybdenum, whereas a random chip composite of the adjacent granodiorite contained none. The gneiss contained flakes of graphite thought to be molybdenite during field inspection, but molybdenite was not detected during petrographic analysis.

#### SITE G–47

A 30-ppm molybdenum anomaly was reported at the 1,220-m (4,000-ft) level just west of a glacier 2.1 km east of the Leduc River and 5.5 km N. 23° W. of the mouth of Indian Creek.

Rusty-weathering paragneiss at the sample site contains many small quartz monzonite dikes and sills. Sparsely distributed veinlets and boudins of quartz and epidote contain a few garnets. No sulfides were found in the paragneiss, intrusive rocks, or veins. A large composite chip background sample assayed 15 ppm molybdenum, 35 ppm copper, 5 ppm lead, and 100 ppm zinc.

#### SITE G–49

At site G–49 a Geological Survey random chip sample of quartz-epidote veinlets in paragneiss contained anomalous amounts of lead (1,500 ppm), zinc (450 ppm), molybdenum (70 ppm), and silver (70 ppm). This site is at the south end of a small glacier 5.1 km northwest of the Leduc River and 2.7 km south-southwest of the southern terminus of Gracey Creek Glacier. The elevation is about 1,300 m (4,250 ft).

The broad ridge below the glacier was almost completely covered by snow when examined by the Bureau of Mines and when checked during a later flight. Foot traverses were made along crests of the cliffs bordering the east and west sides of the relatively broad ridge. Outcrops observed were foliated and locally gneissic Hyder Quartz Monzonite. The paragneiss containing sparsely disseminated pyrite and small quartz-epidote veinlets was still covered by snow and was not sampled.

### SITE G–50

A weak molybdenum anomaly (20 ppm) was reported from a quartz vein in hornblende gneiss on a ridge 2.1 km northwest of the Leduc River and 2.7 km south-southeast of the south terminus of Gracey Creek Glacier. The outcrop is at 1,580 m (5,200 ft) elevation in a small exposure between two small glaciers.

The Bureau of Mines sampled two sets of quartz-epidote veinlets up to 30 cm wide at the site, one at an angle to the gneissic banding and one parallel to it. Small amounts of pyrite are distributed erratically in both sets of veins. A little malachite staining was observed.

Composite samples of the two sets of veins assayed 130 and 120 ppm copper, 10 and 10 ppm lead, 35 and 20 ppm zinc, 0 and 5 ppm molybdenum, 0 and 50 ppm tungsten, and 0.5 and 2.0 ppm silver. The sample containing 50 ppm tungsten is unusual in that tungsten was detected by emission spectroscopy in only a few samples in the study area.

### SITE G–51

Silver (1.5 ppm) and copper (700 ppm) in slightly anomalous quantities were reported in a random composite chip sample of epidote-quartz-calcite veinlets collected by the Geological Survey in the gorge of a glacial stream flowing westward into the Leduc River 6.5 km from the international boundary. Search of hard, dark, slightly schistose metasedimentary(?) rocks between 460 and 490 m (1,500 and 1,600 ft) elevation revealed a 0.5- to 2-cm-thick shear zone or fracture cutting across foliation and containing calcite, quartz, epidote, and inconspicuous copper staining. No sulfides were found. No similar zones were found in nearby rocks, which contained only sparsely disseminated pyrite. Assay samples were not taken.

SITE G–54

An anomalous value of 20 ppm molybdenum was obtained from a small quartz vein in phyllite on the west ridge of Banded Mountain at an elevation of about 1,225 m (4,020 ft). The site is 3.1 km S. 70° W. of the summit of Banded Mountain and 2.4 km south of the Chickamin River.

Similar irregular, commonly lenticular quartz veins, practically barren of pyrite and other sulfide minerals, were examined along the ridge from 1,190-m (3,900 ft) to the 1,300-m (4,260-ft) level. The veins are up to 55 cm wide. Many of them are parallel to the foliation, but others alternately parallel and cross the foliation. Composite chip samples of veins above and below the original anomaly site assayed 15 and 10 ppm copper, a trace of lead, 10 and 5 ppm zinc, and up to 7 ppm molybdenum and 0.5 ppm silver. A general random chip background sample of the phyllite assayed 50 ppm copper, 10 ppm lead, 70 ppm zinc, 10 ppm molybdenum, and 0.7 ppm silver.

SITE G–56

A threshold silver anomaly (1.5 ppm) was obtained in an area 1 km southeast of the Heckla prospect. The anomalous Geological Survey sample was from a 15-cm quartz monzonite dike in iron-stained hornfels, east of Through Glacier at about the 1,250-m (4,100-ft) level.

Rusty-weathering hornfels borders a gray, banded, coarse-grained gneissic rock at the small outcrop clear of snow at the time of the Bureau of Mines examination. A 6-m contact zone contains several narrow quartz monzonite dikes and streaks of pyrrhotite, pyrite, and chalcopyrite parallel to the banding and foliation. Foliation strikes N. 30° W. and dips 70°–80° SW. A continuous chip sample across this zone assayed 350 ppm copper, 10 ppm lead, 30 ppm zinc, and 0.5 ppm silver.

SITE G–57

Anomalous molybdenum (150 ppm) was reported in the sample collected at site 57 by the Geological Survey at the base of high steep cliffs on the east shore of Punchbowl Cove in Rudyerd Bay. The shoreline is relatively featureless in this area, and the Bureau of Mines sample may not have been collected from the same site. A composite chip sample of dark, slightly pyritic granodiorite gneiss was collected from bedrock just above the beach. No significant metal values were obtained.

## CONCLUSIONS

Despite intermittent prospecting for gold, silver, and other metals since about 1900, little production has come from within the proposed boundary of the Granite Fiords wilderness study area. The present investigation largely confirmed the presence of metalliferous lodes in the northeastern and western parts of the study area.

In the northeast corner of the study area, veinlets, lenses, and disseminated grains of sulfide minerals occur at or near the contacts of the Hazelton(?) Group metasedimentary rocks with the Texas Creek Granodiorite and the Hyder Quartz Monzonite. These deposits have been known and prospected for more than 50 years. Neither past prospecting nor reconnaissance sampling during this study revealed important deposits of minable grade. However, the extreme ruggedness of the terrain, the severity of the climate, and the heavy snow cover has limited the amount of prospecting and hampered reconnaissance sampling during this investigation. Failure to find minable deposits in the contact area has by no means proved that they do not exist. The information obtained during this investigation suggests that lode mines that may be developed on veins or aggregates of veins in the northeastern area probably would be underground operations producing less than 500 tons per day.

The deposits in western Granite Fiords are associated with altered zones in the paragneiss. The paragneiss mainly forms a northwest-trending belt up to 20 km wide that extends the length of the study area. The altered zones are bleached and iron stained. During this study about 60 such zones were noted. Sampling identified widespread traces of copper, molybdenum, lead, zinc, and silver associated with them. The only known exploration of the altered zones in the paragneiss has been a few shallow diamond drill holes and trenches on the Alamo prospect. The zone at this prospect appears similar to the others, and it probably received attention because sulfide-bearing float was found below the lode in an area accessible by boat. Sampling at the Alamo prospect revealed disseminated sulfides and small sulfide veins and lenses having grades ranging from 0.3 to 1.5 percent copper and containing small amounts of zinc, gold, and silver. The results of this investigation suggest that sulfide deposits similar to the one at the Alamo probably occur elsewhere in the paragneiss. However, additional prospecting and detailed sampling are necessary to fully test its potential.

The distribution of geochemical samples containing anomalous amounts of gold, silver, molybdenum, copper, lead, and zinc corresponds closely to the outcrop areas of the geologic units most closely associated with the known mineral deposits: the Hazelton(?) Group, the Texas Creek Granodiorite, the paragneiss, and the Hyder Quartz Monzonite and other Tertiary plutons. The widespread distribution of anomalous metal values throughout the two metamorphic terranes suggests that their metal content is largely syngenetic in origin—

that is, the metals were original constituents of the sedimentary and volcanic parent rocks of the paragneiss and Hazelton(?) Group. In part, the present distribution of the metalliferous lodes within these units and in the Texas Creek Granodiorite probably resulted from local mobilization and redistribution of gold, silver, and other metals during subsequent metamorphism and plutonism. The degree of segregation resulting from these processes could vary widely, but there is little evidence that such segregation produced major concentrations of valuable metals anywhere within the study area.

In 1974–75, a potentially economic deposit of molybdenite was discovered by commercial interests near Smeaton Bay about 72 km east of Ketchikan. The deposit is about 13 km from the southern boundary of Granite Fiords wilderness study area. Preliminary mapping in this mineralized area by the Geological Survey in 1975 indicates that quartz-molybdenite veinlets and molybdenite fracture coatings occur in altered parts of a composite fine-grained granite and granite porphyry stock. The stock crops out in an area of about 18 $km^2$ at an average elevation of about 600 m. The pluton is not foliated or otherwise deformed. It intrudes paragneiss and older intrusives and in turn is cut by lamprophyre dikes. Its general geologic relations are similar to those of the 23-m.y.-old gabbro stock mapped just beyond the southern boundary of Granite Fiords (p. 24). The molybdenite deposit is being explored by commercial interests, but results of diamond drilling and other exploration have not been made public. According to newspaper accounts, the drilling indicates a potential ore body in excess of 100 million tons containing 0.20 percent to 0.35 percent of $MoS_2$.

Within the boundary of Granite Fiords wilderness study area, quartz and feldspar porphyry occurs locally as dikes and sills, and as apophyses(?) of larger plutons of nonporphyritic granodiorite and quartz monzonite of Tertiary age (p. 22–24). However, we found no intrusions of porphyry large enough to show on the geologic map. The occurrences that we observed are mainly in the northern part of the study area. Their geologic relations suggest that similar rocks may also occur in the extensive parts of the study area that were covered by snow at the time of our investigations.

Despite gross similarities in regional geology, geologic conditions in the Granite Fiords study area differ markedly from those in neighboring areas of Alaska and British Columbia that contain productive or once-productive mines. At the Granduc mine (Benson, 1971, p. 49–55) for example, the host rocks for the sulfide ore are a thick, persistent sequence of Hazelton(?) sedimentary and volcanic strata, whereas Granite Fiords contains only the thin, discontinuous southwesternmost fringe of this assemblage. The ore bodies at the Premier mine in British Columbia (Grove, 1971, p. 155–160) and at the Riverside mine in Alaska (J. G. Smith, unpub. data) are mainly in well-defined, persistent zones of intense cataclasis in Hazelton(?) and Texas Creek country rocks that underlie large areas. In Granite Fiords, however, the outcrop areas of these units are small, and the rocks generally show only incipient cataclasis.

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