UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

The Alaska Mineral Resource Assessment Program: Guide to information about the geology and mineral resources of the Ketchikan and Prince Rupert quadrangles, southeastern Alaska

by
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This report is preliminary and has
not been edited or reviewed for
conformity with Geological Survey
standards and nomenclature

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ABSTRACT

The Ketchikan and Prince Rupert 1° x 2° quadrangles, which encompass about 16,000 km^2 (6,000 mi^2) at the southern tip of southeastern Alaska, were investigated by integrated field and laboratory studies in the disciplines of geology, geochemistry, geophysics (aeromagnetics), and Landsat data interpretation for the purpose of determining its mineral resource potential. Mineral deposits in the study area have been mined or prospected intermittently since the turn of the century, with recorded production of small tonnages of ores containing gold, silver, copper, lead, zinc, and tungsten. Our mineral resource assessment shows that the area contains potentially significant resources of those metallic commodities, as well as of molybdenum, iron, antimony, and barite. The results of these studies are given in a folio of maps that are accompanied by descriptive texts, diagrams, tables, and pertinent references. This report serves as a guide to those investigations, provides relevant background information, and integrates the component maps and reports. It also describes revisions of the geology based on studies completed since the folio was published, and includes a list of specific and general references to the geology and mineral deposits of the study area.

INTRODUCTION

Purpose and scope

This report and a separately available folio of maps and accompanying tables are part of a series of U.S. Geological Survey reports prepared to provide public information on the mineral resources and mineral resource potential of Alaska. This work is being done as part of the Alaska Mineral Resource Assessment Program (AMRAP), and is intended to provide information both for long-range national minerals policy and for decisions by State, Federal, commercial, environmental, and Native interests concerning future use of Alaska lands and resources. In addition, the program aims to increase the geologic knowledge of the state and to provide guidance for mineral exploration.

Most of the basic data for the maps and tables in the Ketchikan-Prince Rupert folio were collected in 1975 and 1977, when an interdisciplinary team of earth scientists conducted field and laboratory investigations necessary for a mineral resource appraisal. The folio and this report describe the results of their individual investigations and the results of integrating those investigations for the resource assessment.

Geography and access

The Ketchikan-Prince Rupert study area (fig. 1) comprises all but a small part of the Alaskan parts of the Ketchikan and Prince Rupert 1:250,000-scale (1°x2°) topographic quadrangles. The area covers about 16,000 km^2 (6,000 mi^2) at the southern tip of the southeastern Alaska panhandle between lat. 54°45' and 55°00'N and long. 130°00' and 132°00' W. It is bounded on the east and south by the United States-Canada (British Columbia) International Boundary, and on the west by Clarence Strait.

The area lies mainly in the Pacific Coast Mountains physiographic province. It is characterized by islands and peninsulas deeply dissected by a complex network of coastal and inland tidal waterways. The terrain ranges from heavily forested rolling uplands on the southwest to bare rugged mountains with active glaciers on the northeast. The average relief increases from about 1,000 meters (3,000 feet) on the southwest to about 1,500 meters (4,500 feet) on the northeast; the highest point within the study area is a 2,200 meter- (6,510-foot-) high nunatak that rises above perennial snowfields and glaciers near the northeast corner of the Ketchikan quadrangle.

Landforms in the study area are dominated by glacially sculpted features

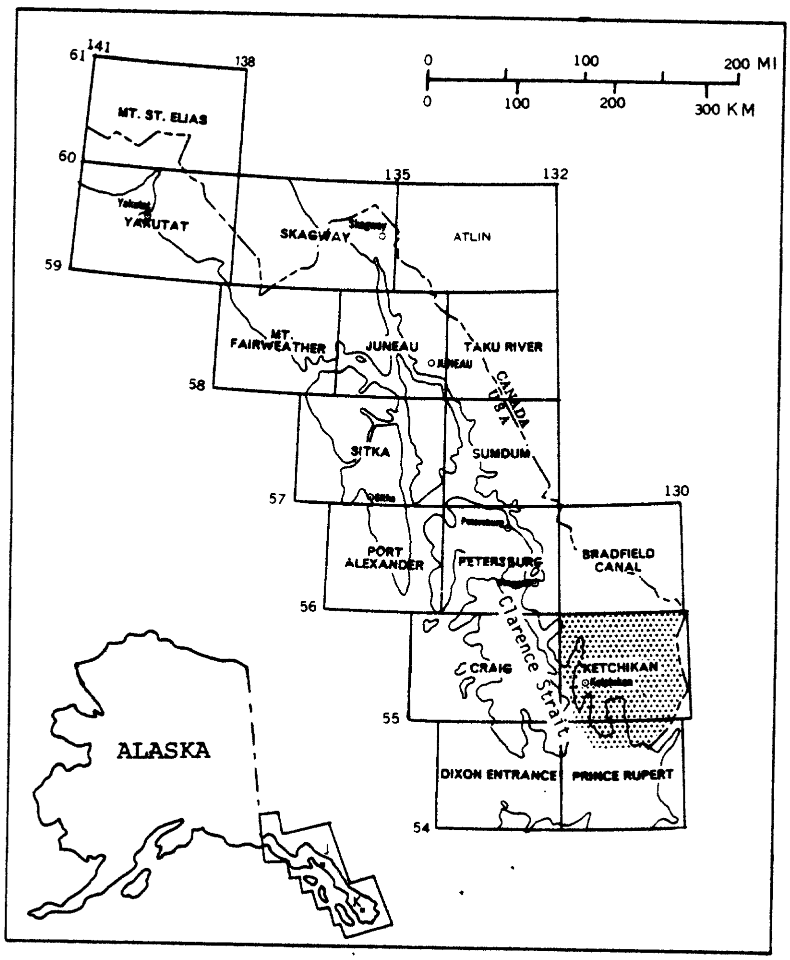

Figure 1. Index maps showing location of Ketchikan and Prince Rupert quadrangles, and area of this investigation (dot pattern).

such as deep fiords and broad U-shaped valleys walled by sheer cliffs 300 meters (1,000 feet) or more high. Most of the area was completely overridden by glacial ice, resulting in broad rounded ridge crests. In the northeastern corner, however, the mountain tops locally stood above the highest level of the ice and include many sharp pinnacles and knife-edge ridges.

The prevailing maritime climate is characterized by heavy precipitation, probably equivalent to more than 250 cm (100 inches) of rainfall per year. Vegetation consists of dense, nearly impenetrable rain forest at low elevations, and of brush, moss, and lichens at higher levels.

Except for scattered logging or mining camps and a few isolated cabins, nearly all of the permanent population in the study area is concentrated in and near Ketchikan and adjacent parts of Gravina Island (pop. approx. 10,000 in 1970), in and near the Indian village of Metlakatla (pop. approx. 1,000 in 1970), and at Hyder (pop. approx. 50 in 1970). The only town in the study area that can be reached by highway from Canada and the U.S. is Hyder, which is linked via Stewart, British Columbia, to western Canada, Alaska, and the Pacific northwest. Other than to Hyder, access to and throughout the study area is by boat or aircraft.

GEOLOGIC INVESTIGATIONS

Previous investigations

Before starting AMRAP systematic mineral appraisal of the Ketchikan and Prince Rupert quadrangles in 1975, the U.S. Geological Survey had conducted numerous reconnaissance and local investigations of the geology and mineral deposits in the study area beginning around the turn of the century (fig. 2). The most significant results of those investigations were published in reports by Brooks (1902), Wright and Wright (1908), Smith (1915), Chapin (1918), Buddington (1929), Robinson and Twenhofel (1953), West and Benson (1955), Byers and Sainsbury (1956), Sainsbury (1957a,b), Berg (1972a, b; 1973), Smith (1973), Berg and others (1977), and Smith (1977). In addition, information about the geology and mineral deposits in the study area is contained in regional reports by Martin (1926), Buddington and Chapin (1929), Berg and Cobb (1967), and Berg and others (1972).

AMRAP and subsequent investigations

AMRAP investigations in the Ketchikan and Prince Rupert quadrangles began in 1975, when an interdisciplinary team of earth scientists and technicians

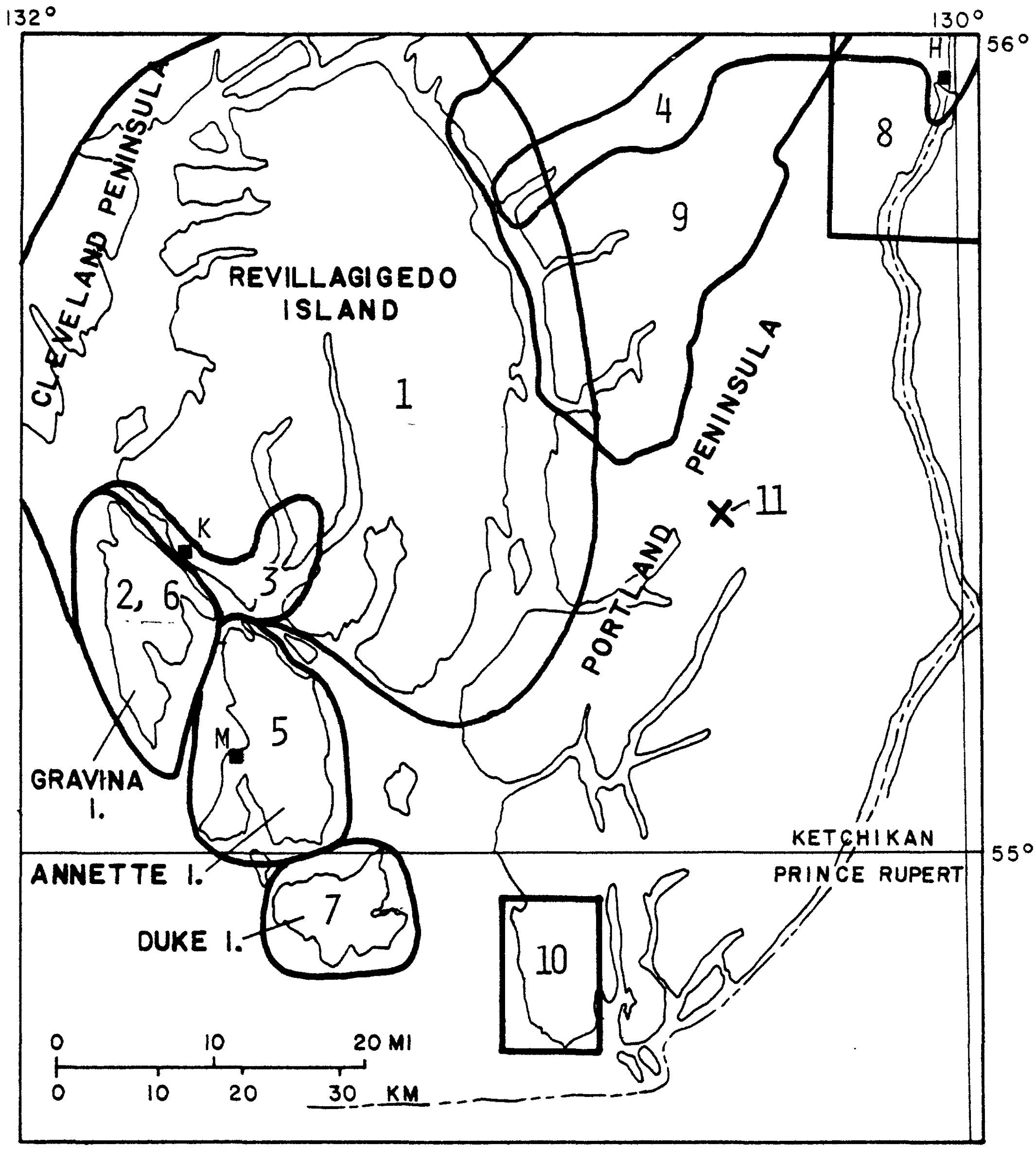

Figure 2.--Reference map of Ketchikan and Prince Rupert quadrangles showing areas described in selected geological reports (also see table 1). H, Hyder; K, Ketchikan; M, Metlakatla.

1. Brooks (1902)
2. Smith (1915)
3. Chapin (1918)
4. Buddington (1929)
5. Berg (1972a)
6. Berg (1973)
7. Irvine (1974)
8. Smith (1977)
9. Berg and others (1977)
10. Koch and others (1977)
11. Elliott and others (1976); Hudson and others (1977, 1978, 1979)

undertook systematic areal geologic mapping, geochemical, geophysical, Landsat, and mineral deposit studies leading to mineral resource assessment of the study area (table 1). These collateral field and laboratory studies were completed early in 1978, when the results were combined and integrated into the mineral assessment that culminated the AMRAP program in the study area. In addition, certain topical and regional geologic and mineral resource investigations begun by team members and guest scientists during the AMRAP study have been completed and the results published in several reports. These reports describe the tectonic and structural setting of the study area and neighboring parts of Alaska and Canada (Berg, Smith, and others, 1977; Berg, Jones, and Coney, 1978); the petrology and geologic setting of the porphyry molybdenum deposit at Quartz Hill (Elliott and others, 1976; Hudson and others, 1977, 1978, 1979); metamorphosed lower(?) Paleozoic trondhjemite on southern Portland Peninsula (Koch and others, 1977); and metallogenesis in accreted terranes in southeastern Alaska (Berg, 1979, 1980).

Acknowledgments

Throughout this report I use the term "we" in describing the scientific investigations and results of the AMRAP resource appraisal of the Ketchikan and Prince Rupert quadrangles. "We" includes my fellow members of the interdisciplinary team of energetic and talented earth scientists that successfully completed this difficult and complex investigation well within its tight budget and schedule, and I thank these colleagues for their collaboration, dedication, and professionalism. In particular, I am especially grateful to J. G. Smith, R. L. Elliott, R. D. Koch, R. B. Carten, M. F. Diggles, C. D. Holloway, R. J. Miller, R. J. Rudser, and B. D. Wiggins for their contributions to the geologic mapping; J. G. Smith for isotopically (K-Ar) dating scores of rocks throughout the study area; R. D. Koch for leading the geochemical program with singular dedication, skill, and energy; A. Griscom and D. F. Barnes for their aeromagnetic and other geophysical interpretations; W. C. Steele and N. R. D. Albert for their pioneering Landsat data interpretation of the study area; and W. D. Menzie and D. A. Singer for their advice and guidance on the culminating resource assessment.

I also gratefully acknowledge the special skills and contributions of my U.S.G.S. colleagues D. L. Jones, whose biostratigraphic studies led to new tectonic interpretations of the study area and neighboring regions; T. L.

Table 1. Component maps and reports of the Ketchikan and Prince Rupert quadrangles mineral resource assessment

Report	Subject
U.S. Geological Survey open-file reports:	
77-359 (U.S. Geological Survey, 1977)	Aeromagnetic contour map
78-73A (Berg and others, 1978)	Geologic map
B (Elliott and others, 1978)	Mineral deposit map and table
C (Koch and others, 1978a)	Geochemical anomaly map: Cu
D (Koch and others, 1978b)	Geochemical anomaly map: Pb
E (Koch and others, 1978c)	Geochemical anomaly map: Zn
F (Koch and others, 1978d)	Geochemical anomaly map: Mo
G (Koch and others, 1978e)	Geochemical anomaly map: Au, Ag
H (Koch and others, 1978f)	Geochemical anomaly map: Cr
I (Koch and others, 1978g)	Geochemical anomaly map: Co
J (Koch and others, 1978h)	Geochemical anomaly map: Ni
K (Steele and Albert, 1978)	Landsat interpretation map
*L (Griscom, 1978)	Aeromagnetic interpretation map
M (Berg, Elliott, and Koch, 1978)	Mineral resource assessment map and tables
*N (Smith and Diggles, 1978)	Map and table of potassium-argon (K/Ar) age determinations
78-156A (Koch and Elliott, 1978a)	Analyses of rock geochemical samples, Ketchikan quadrangle
B (Koch and Elliott, 1978b)	Analyses of rock and stream sediment geochemical samples, Prince Rupert quadrangle
C (Koch and Elliott, 1978c)	Analyses of stream sediment geochemical samples, Ketchikan quadrangle

*These reports will be published in 1980.

Hudson, who led our investigations at the Quartz Hill molybdenum prospect; J. G. Arth and T. W. Stern, for Pb-U geochronology and Rb-Sr isotope studies of the plutonic rocks; J. J. Criscione for pioneering Rb-Sr isotope studies of the metasedimentary rocks; and F. Barker for his rare-earth and trace element investigations of key volcanic units.

Finally, I thank the crew of the U.S.G.S. R/V Don J. Miller II and G. A. (Bud) Bodding, master of the charter vessel Mytime, for providing comfortable and efficient basecamps for our field investigations; Kenneth C. Eichner, Barry Roberts, and Mike Salazar of Temsco Helicopters in Ketchikan for providing us with outstanding helicopter support; and Ed Todd and Dixie Jewett of Todd's Air Service in Ketchikan for providing reliable fixed-wing aircraft support, often under adverse weather conditions.

DESCRIPTIONS OF COMPONENT MAPS AND REPORTS OF THE KETCHIKAN AND PRINCE RUPERT QUADRANGLES AMRAP FOLIO AND OF SUBSEQUENT RELATED INVESTIGATIONS

The following sections of this report briefly describe the six interdisciplinary components of the AMRAP mineral resource assessment of the Ketchikan and Prince Rupert quadrangles: (1) geology, (2) mineral deposit site studies, (3) geochemistry, (4) geophysics (aeromagnetics), (5) earth satellite (Landsat) data, and (6) resource analysis. The first five of these components were collateral field and laboratory research investigations that resulted in extensive new data in several branches of earth science relating to mineral resources. The sixth component integrates those data into the culminating resource assessment, which identifies tracts of land favorable for the occurrence of specific types of mineral deposits, and, where the data permit, predicts at different probabilities the number, size, and grade of those deposits.

The following sections also summarize the results of our geologic and mineral resource investigations in the study area since the AMRAP folio was published early in 1978.

Geology

(Open-file map 78-73A)

The geologic map of the Ketchikan and Prince Rupert quadrangles resulting from this investigation describes the rocks between the International Boundary and Clarence Strait (fig. 1). We did not map the small areas of rocks on the west side of the Strait because they are being studied as part of a separate investigation by the U.S. Geological Survey.

The rocks that we mapped include very diverse lithologies and range in age from Silurian or older to Quaternary. Our investigations show that they are most conveniently treated in three geographic areas, each underlain by a characteristic assemblage of rocks with distinctive lithologic, structural, or metamorphic features.

Gravina-Annette-Mary-Duke Islands area:

This area includes the islands bounded by Clarence Strait, Dixon Entrance, Tongass Narrows, and Revillagigedo Channel, and makes up about a sixth of the study area. It contains the most varied lithologies and most complete suite of stratified rocks in the Ketchikan and Prince Rupert quadrangles. It also includes the least metamorphosed and deformed pre-Tertiary rocks in the map area. The bedded rocks range in age from Silurian or older to Late Jurassic or Cretaceous. The mapped intrusive rocks range in age from Devonian or Silurian to Cretaceous. Pluglike gabbro plutons on northeastern Gravina Island too small to show on the map were previously assigned a tentative Cretaceous age (Berg, 1973), but instead probably correlate with presumed Oligocene or Miocene gabbro (Tmg) near Ketchikan. Especially distinctive units include a Devonian or Silurian stock of leucocratic trondhjemite, an Upper Triassic sequence of rhyolite, basalt, and sedimentary rocks, and a Jurassic or Cretaceous zoned ultramafic intrusive complex that contains spectacular zones of rhythmically layered dunite and peridotite (Irvine, 1974). Mineral occurrences include barite- and base-and-precious-metal-bearing volcanogenic sulfide deposits in the Upper Triassic rocks; veins carrying gold, silver, and other metals in Upper Jurassic or Cretaceous andesitic metatuff; and stratiform titaniferous magnetite deposits in the zoned ultramafic rocks.

New age assignment of rocks on Annette and Gravina Islands. The age of the Puppets Formation and its unnamed correlatives, and of an unnamed conformably overlying massive dolomitic limestone unit on Annette and Gravina Islands (fig. 3) herein is revised from mid-Paleozoic (Berg, 1973) and Devonian or

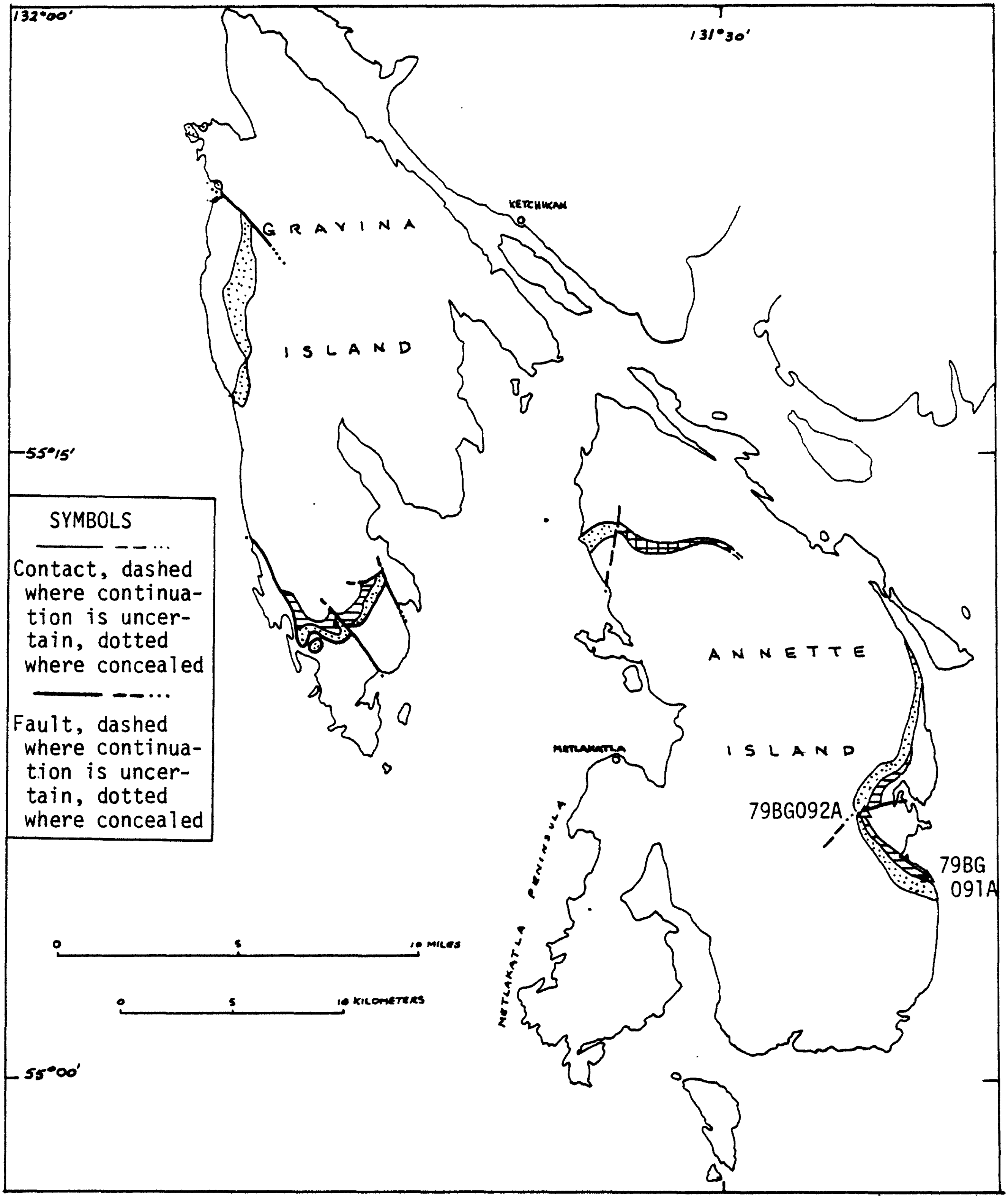

Figure 3.--Sketch map of Annette and Gravina Islands showing distribution of the Puppets Formation and its correlatives (dot pattern); of the conformably overlying unnamed massive limestone unit (line pattern); of an outcrop area where these units are not mapped separately (crosshatch pattern); and the locations of samples collected in 1979 containing Upper Triassic fossils. Geology modified from Berg (1972a, 1973), and Berg, Elliott, and others (1978a).

older (Berg, Elliott, and others, 1978a, b) to Late Triassic. This new assignment is based on the discovery in 1979 (H. C. Berg, unpublished field data) of Upper Triassic fossils in the limestone unit at two localities on eastern Annette Island (fig. 3). The fossils were identified by Anita G. Harris of the Geological Survey as follows (written communication, 2/20/80):

Field no. 79ABG091A: from east coast of Annette Island about 33.9 km S.E. of Ketchikan. Small cove about 1.6 km south of Kwain Bay, sec. 26, T. 78 S., R. 93 E. (Lat. 55°04'50", Long. 131°21'20"). Moderately massive to slaty very fine grained crystalline metacarbonate containing sparse corals. Metacarbonate overlies rhyolite metatuff; exposed thickness of carbonate about 30 m. 5.48 kg of metacarbonate was processed for conodonts (1.2 kg of +20 mesh insoluble residue) and yielded:

1 EPIGONDOLLELA sp.

This genus is restricted to the Late Triassic.

Field no. 79AGB092A: east side of Annette Island about 29.4 km S.E. of Ketchikan. Locality is a cave at outlet of lake at elev. approx. 70 m, sec. 16, T. 77 S., R. 92 E. (Lat. 55°06'35", Long. 131°23'55"). Massive to thinly bedded fine-grained dark-gray metacarbonate locally containing sandy lenses and layers, some of which seem to consist of comminuted organic material. Carbonate is about 100 m thick; overlies rhyolite metatuff; probably correlates with limestone at 79AGB091. 4.9 kg of metacarbonate was processed (330 g of +20 mesh insoluble residue) and yielded:

1 EPIGONDOLLELA sp.

Age: Late Triassic

Revillagigedo Island and Cleveland Peninsula

The central third of the map area is underlain by diverse plutonic rocks, and by multiply deformed and metamorphosed strata that include (a) very sparsely fossiliferous upper Paleozoic and Upper Triassic sedimentary and volcanic rocks; (b) one outcrop area of rocks tentatively correlated with Jurassic or Cretaceous andesitic metatuff of the Gravina Island Formation; and (c) by far the most widespread bedded unit, unfossiliferous dark gray metapelite and andesitic(?) metatuff whose premetamorphic age is unknown. Some of the undated rocks are lithically similar to the Jurassic or Cretaceous sedimentary and volcanic rocks on Annette and Gravina Islands, and may correlate with them; but we have assigned the entire unfossiliferous assemblage an age of late Paleozoic or Mesozoic because this assignment brackets the ages of the oldest fossiliferous strata known in this area (upper Paleozoic) and of the oldest isotopically dated plutonic rocks that intrude it (Upper Jurassic). The youngest rocks known are basalt and andesite lava flows, breccia, and tuff that mainly coincided with, or postdate, Quaternary glaciation, but may in part be as old as late Tertiary (5.5 m.y.). Key pre-Tertiary bedded units include light-gray, locally dolomitic marble that locally contains abundant crinoid discs and very sparse organic detritus of uncertain, but possibly fusulinacean origin (R. C. Douglas, written commun., 11/2/73); dark gray carbonaceous (graphitic) and locally concretionary (phosphatic?) limestone, mudstone, and siltstone locally containing poorly preserved but identifiable Upper Triassic fossils (N. J. Silberling, written commun., 4/10/80); basaltic pillow flows and pillow breccia that apparently are interbedded with the Upper Triassic strata; and quartz diorite- or trondhjemite-clast-bearing roundstone metaconglomerate that apparently is interbedded with crinoidal marble of presumed late Paleozoic age (H. C. Berg, unpublished field data, 1978).

The oldest radiometrically (K/Ar)-dated pluton in this area is a 140-m.y.-old (Upper Jurassic) granodiorite stock near Moth Bay. The largest pluton is a radiometrically-dated mid-Cretaceous foliated quartz diorite batholith on northern Revillagigedo Island and adjacent Cleveland Peninsula. Other radiometrically-dated plutons include a swarm of variously metamorphosed and deformed stocks, diapirs(?), dikes, and sills of garnet-bearing and locally plagioclase-porphyritic granodiorite that gives Late Cretaceous K/Ar (Smith and others, 1979) and Pb-U (T.W. Stern, personal commun., 1979) ages; and a composite Oligocene or Miocene gabbro to granodiorite intrusive complex near Ketchikan. Other intrusive rocks, mainly of known or assumed Cretaceous or older age, include stocks or sheets of aplite or alaskite, pluglike metadiorite bodies, a zoned ultramafic complex at Alava Bay, and several other small ultramafic bodies.

Regional structures in the pre-Tertiary strata include southwest-verging, overturned to recumbent, refolded isoclines cut by bedding-plane thrusts and blastomylonite zones, and by high-angle faults that postdate the thrusts. The rocks are regionally metamorphosed progressively from greenschist facies on the southwest to amphibolite facies on the northeast; this metamorphism, radiometrically dated as Cretaceous or older, locally is overprinted by up to hornblende-hornfels facies contact metamorphism. "Feather schist" or "garbenschiefer," a metamorphic rock distinguished by locally conspicuous feathery crystal aggregates of actinolite in a matrix of garnet-bearing silvery muscovite schist, is widespread on central and southwestern Revillagigedo Island; its distinctive mineralogy and texture suggest polymetamorphism of a bedded unit significantly different in original composition from the adjoining strata.

Mineral occurrences that have been productive or extensively explored include massive lead- and zinc-sulfide veins, auriferous quartz veins, and a stibnite vein in the undated metapelite and metatuff unit, and stratiform titaniferous magnetite deposits in the zoned ultramafic complex at Alava Bay.

Portland Peninsula

The east half of the Ketchikan-Prince Rupert study area is a peninsula, bounded by (east) Behm Canal, Revillagigedo Channel, and Portland Canal; we informally call this area Portland Peninsula (fig. 2). The youngest consolidated rocks known on Portland Peninsula correlate with the Quaternary or Tertiary basalt and andesite described on Revillagigedo Island. Except for small outcrop areas of these volcanic rocks, the peninsula is underlain mainly by the Coast Plutonic Complex (as defined by Brew and Ford, 1978, 1980), which is bordered on the west by a fringe of enigmatic metamorphosed bedded and plutonic rocks, and on the northeast by probably lower Mesozoic rocks that underlie only a small area at the northeastern corner of the map. Revisions of the geology of the southern part of Portland Peninsula based on investigations completed since the publication of open-file map 78-73A are shown on figure 4.

The Coast Plutonic Complex is a heterogeneous group of massive and foliated plutonic rocks and amphibolite facies regionally metamorphosed bedded rocks that form septa, screens, roof pendants, and xenoliths within or between the plutons. The premetamorphic ages of the bedded rocks are unknown; we assign them a Paleozoic or Mesozoic age to bracket the ages (a) of possibly correlative Paleozoic or older isotopically dated nearly identical metamorphosed bedded rocks of the "Central Gneiss Complex" (Hutchison, 1970) of the Coast Plutonic Complex in neighboring British Columbia (Armstrong and Runkle, 1979; Wanless and others, 1975) and (b) of the oldest isotopically dated (Jurassic) plutons known to intrude them.

According to our radiometric age data, the plutons were emplaced in Late

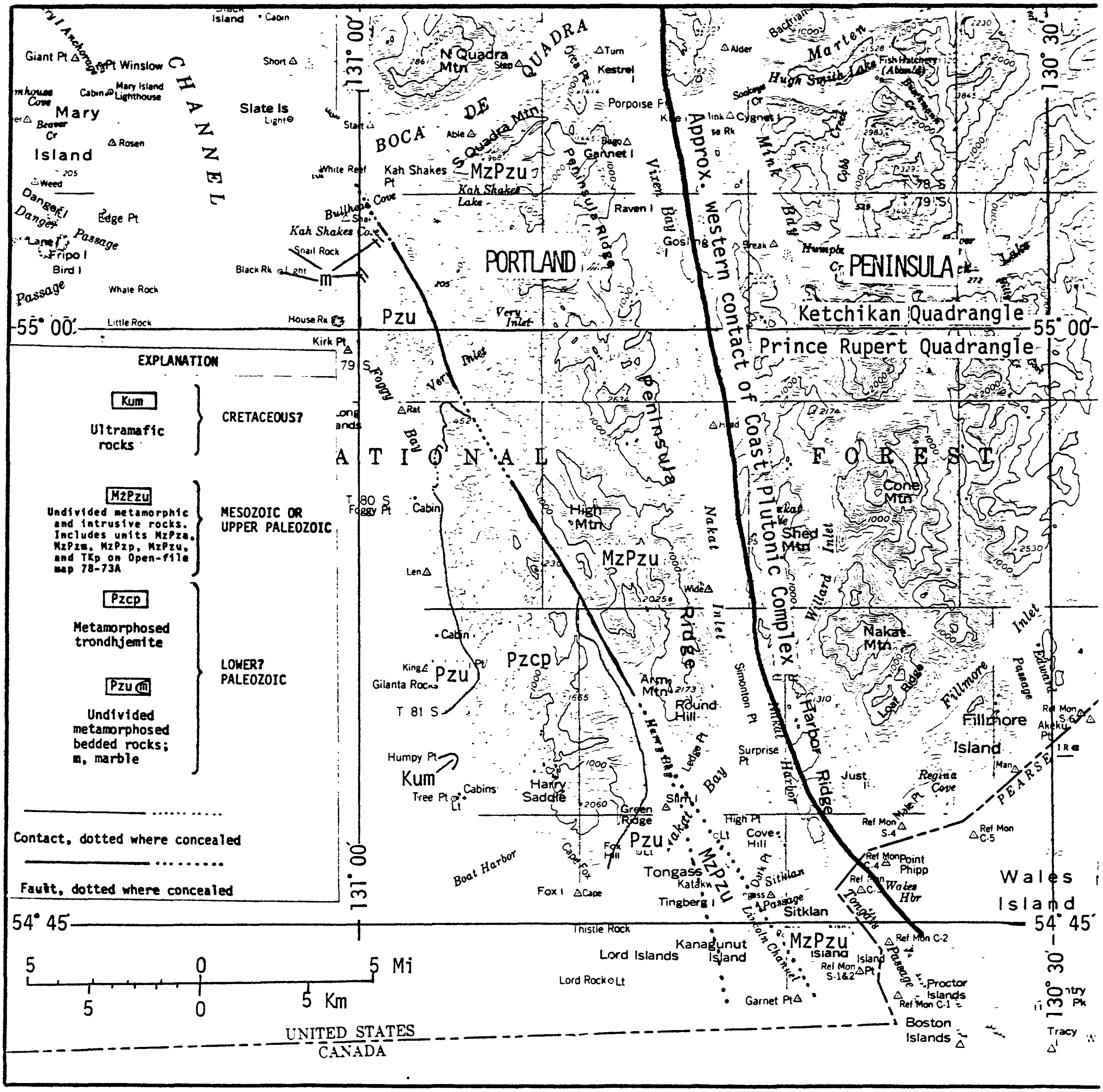

Figure 4--Map of southwestern Portland Peninsula showing revisions based on geologic investigations completed since publication of Open-file map 78-73A.

Jurassic, Eocene, and Oligocene or Miocene time (Smith and others, 1979). Their structure ranges from gneissic to massive; and their composition from gabbro to granite; the most abundant rock type is foliated granodiorite. Not shown on the map are myriads of Oligocene or younger lamprophyre (Smith, 1973; Hudson and others, 1979) and quartz porphyry (Hudson and others, 1979) dikes. The metamorphic age(s) of the foliated plutonic and bedded rocks is (are) Eocene or older (Smith and others, 1979). Structural trends, isograds, and lithologic units strike north to northwest. In the Ketchikan-Prince Rupert study area, the westernmost unit of the Coast Plutonic Complex is a north-trending set of elongate foliated quartz diorite or tonalite plutons (map unit TKq) that beyond the project area coalesce into a remarkably persistent sill that marks the southwestern limit of the Coast Plutonic Complex throughout southeastern Alaska (Brew and Morrell, 1979, 1980; Brew and Ford, 1980).

Adjoining the Coast Plutonic Complex on the west is a wedge-shaped outcrop belt of greenschist-to-amphibolite facies regionally metamorphosed bedded and intrusive rocks. The eastern limit of this belt is the western contact of the Coast Plutonic Complex, and the western limit is a northwest-trending linear fault zone that has been mapped from Harry Bay to beyond Kah Shakes Cove (fig. 4). The premetamorphic ages of the bedded and intrusive rocks are largely unknown. A discordant K/Ar determination for one of the plutons suggests that it was emplaced during or before Late Cretaceous time. Other K/Ar determinations suggest Cretaceous or Tertiary metamorphism for both the bedded and intrusive rocks. Very sparse objects doubtfully identified as crinoid discs implying a late Paleozoic age (H. C. Berg and C. D. Holloway, unpublished field data, 1976) occur in marble layers along Very Inlet, and most of the other strata are lithically similar to rocks on central and southwestern Revillagigedo Island to which we assign a late Paleozoic or Mesozoic age. For these reasons, we also assign these rocks an age of late Paleozoic or Mesozoic.

The most widespread unit southwest of the Harry Bay-Kah Shakes Cove fault zone is a leucocratic trondhjemite stock (Pzcp) that we correlate on the basis of similar lithology and texture with the Devonian or Silurian Annette pluton on Annette Island (Koch and others, 1977). If this correlation is correct, the strata intruded by this pluton also are Devonian or Silurian or older. Following this assumption, we tentatively assign these rocks an age of early(?) Paleozoic. However, most of the metamorphosed bedded rocks southwest of the fault are lithically indistinguishable from those northeast of it. This suggests (a) that nearly identical lithologies of different ages crop out on both sides of the fault, (b) that there has been at least local tectonic transport and mixing of possibly younger Paleozoic or Mesozoic metamorphosed bedded rocks from northeast of the fault with the presumed lower Paleozoic country rocks intruded by the trondhjemite, or (c) both a and b. In any case, intense deformation and metamorphism, and poor exposures, prevented us from mapping any outcrop areas of these possibly younger rocks southwest of the fault.

About 30 km^2 (20 mi^2) of the northeasternmost corner of the Ketchikan-Prince Rupert study area are underlain by recrystallized Upper Triassic and possibly Lower Jurassic volcaniclastic and plutonic rocks. These rocks were cataclastically deformed in Mesozoic or Early Cenozoic time, and then intruded and locally contact metamorphosed by Eocene plutons of the Coast Plutonic Complex, but they contrast markedly in degree of deformation and metamorphism from the more intensely deformed and higher grade regionally metamorphosed rocks to the southwest in the Coast Plutonic Complex. We infer that the boundary between these two contrasting assemblages was a moderately northeast-dipping thrust zone that subsequently was intruded and largely obliterated by the Eocene plutons (Berg, Elliott, and others, 1977, p. 29).

The currently (1980) most commercially attractive mineral deposit on Portland Peninsula is the large porphyry molybdenum lode in Oligocene granite porphyry at Quartz Hill (no. 11 on fig. 2). Other mineral deposits that have recently been explored include another porphyry molybdenum occurrence just across the mouth of Burroughs Bay from Portland Peninsula; gold, silver and basemetal veins and disseminated deposits in the Triassic or Jurassic volcanic and intrusive rocks near Hyder; massive basemetal sulfide deposits in the metamorphosed bedded rocks southwest of Smeaton Bay and near Humpback Lake; and copper-, zinc-, and silver-bearing sulfide veins and disseminations in paragneiss at Walker Cove.

Potassium-argon (K/Ar) age determinations

*(Open-file report 78-73N)

by

James G. Smith

This map and its accompanying table list all the known potassium-argon (K/Ar) age determinations on rocks and minerals from the Ketchikan-Prince Rupert study area as of mid-1980. All together, there are more than 130 determinations. Our report contains some 50 previously unpublished determinations. About 80 of the determinations have been published previously, most without complete analytical data. For our report, we made every effort to obtain all analytical data and the exact sample locations for the previously published but incomplete determinations. When different authors referred to the same sample with different numbers, we listed all sample numbers. When necessary, we contacted the original authors, who generously shared their data with us. We especially thank M. A. Lanphere of the U.S. Geological Survey for furnishing analytical data for samples from Annette and Duke Islands.

In 1976 a subcommission of the International Union of Geological Sciences recommended adopting a new set of abundance and decay constants (Steiger and Jager, 1977). Since then, most laboratories have adopted the new constants. For our report, we recalculated all ages using the new constants; therefore, age values published more than a few years ago will differ by a few percent from those listed in the table of open-file report 78-73N.

The K-Ar determinations in our report, as well as U/Pb determinations on zircons by T. W. Stern (Smith and others, 1979), show that at least three episodes of metamorphism and seven episodes of igneous intrusion have taken place in the study area, and that they extend in time from Devonian or Silurian through Miocene. As a result of the multiple episodes of metamorphism and igneous intrusion, most of the K/Ar determinations on mineral pairs are discordant, and must be interpreted with caution.

The oldest radiometrically dated rocks in the study area are from the Annette Pluton (Berg, 1972a), which has yielded a K/Ar age of 424 m.y. on hornblende, and a Pb-U (zircon) age of 375 m.y. (J. G. Arth, written commun., 5/25/78). Allowing for analytical uncertainty, this trondhjemite stock probably was emplaced in Earliest Devonian or Latest Silurian time. The difference in apparent radiometric ages is within the limits of analytical precision for the two methods, and probably can be accounted for by the locally moderate shearing and recrystallization that the pluton has undergone (J. G. Arth, written commun., 6/14/78).

*This report will be published in 1980.

Zoned ultramafic complexes yielding Jurassic or Cretaceous K/Ar ages occur on and near Duke Island and at Alava Bay. The determinations range from 177 m.y. to 76.1 m.y., but most are between 135 m.y. and 99.0 m.y. Apparent ages younger than 115 m.y. east of Revillagigedo Channel are discordant and therefore assumed to be partly reset.

Before our radiometric dating studies, all of the plutonic rocks on Revillagigedo Island and Portland Peninsula, and in adjacent areas to the south in Canada, were considered to be part of a single, poorly documented, Late Triassic to Late Cretaceous orogeny (Buddington and Chapin, 1929). Our studies show instead that plutonism occurred in several separate pulses, some more widespread and important than others. The oldest dated pluton in this part of the study area is the Texas Creek Granodiorite, which was emplaced about 205 m.y. ago. No other plutons are known on Revillagigedo Island or Portland Peninsula that are as old, but the subsequent intense metamorphic and plutonic events could have completely reset the radiometric clocks of older plutons to make them radiometrically indistinguishable from younger intrusions.

Jurassic (140 m.y.-old) quartz diorite and granodiorite intrude migmatite and gneiss on Portland Peninsula, and lower-grade metasedimentary and metavolcanic rocks on southern Revillagigedo Island. Heating by subsequent metamorphic-plutonic events was great enough to reset the argon clocks in these rocks, and only the U-Pb radiometric clocks in zircons still record this event (Smith and others, 1979).

During Cretaceous or earlier time, the bedded rocks on northern Revillagido Island and on neighboring Cleveland Peninsula were regionally metamorphosed. About 90 m.y. ago, they were intruded by a batholith of quartz diorite, and by numerous smaller plutons of garnet-bearing and plagioclase-porphyritic granodiorite, all of which are more or less foliated and recrystallized. Plutons of this age have not yet been identified east of (east) Behm Canal and the topographic low that marks its extension through Vixen and Nakat Inlets.

A suite of coalescing Eocene quartz monzonite to granodiorite batholiths intruded eastern Portland Peninsula about 52 to 42 m.y. years ago. Plutons in this age range are nearly all confined to that part of the study area, although a few are recognized elsewhere on Portland Peninsula. However, no plutons of this suite have been recognized on Revillagigedo Island, Cleveland Peninsula, or Portland Peninsula west of Vixen and Nakat Inlets.

The emplacement of the Eocene plutons was accompanied by resetting of K/Ar clocks throughout the Coast Plutonic Complex. This resetting has been attributed to widespread heating of enigmatic origin (Smith and others, 1979), or to regional uplift and cooling (Hutchison, 1970).

During Oligocene and Miocene time, 31 to 19 m.y. ago, a suite of widely scattered and volumetrically small epizonal plutons was emplaced. This suite ranges in composition from gabbro and syenodiorite to granite porphyry. The molybdenum deposits at Quartz Hill and Burroughs Bay are associated with the granite plutons.

Tectonostratigraphic terranes and structural framework of the Ketchikan and Prince Rupert quadrangles

Regional tectonic and biostratigraphic investigations completed since our preliminary geologic map was published in 1978 show that the pre-Cenozoic strata in the Ketchikan-Prince Rupert quadrangles area can be interpreted as five fault-bounded assemblages, each characterized by distinctive stratigraphy and tectonic history (Berg, Smith, and others, 1977; Berg, Jones, and Coney, 1978). Northeastward from Clarence Strait, these five tectonostratigraphic assemblages are named the Annette subterrane (of the Alexander terrane), Gravina-Nutzotin belt, Taku terrane, Tracy Arm terrane, and Stikine terrane (fig. 5).

Annette subterrane:

The Annette subterrane, typified by pre-Upper Jurassic strata on Annette and Gravina Islands, is a subdivision of the Alexander tectonostratigraphic terrane, which mainly lies west of Clarence Strait (Berg, Jones, and Coney, 1978). It is distinguished by a heterogeneous assemblage of Devonian, Silurian, and older intrusive, extrusive, clastic, and carbonate rocks and their assumed correlatives on and near Annette Island, and by the absence of any known post-Middle Devonian Paleozoic strata. The youngest pre-Cenozoic stratigraphic unit assigned to the Annette subterrane is the Upper Triassic Chapin Peak Formation (Berg, 1973).

These rocks record several episodes of magmatic arc-related volcanism, sedimentation, and intrusion that began at least as long ago as early Paleozoic time. They also record a history of deformation and metamorphism, that depending on their age and location, ranges from penetrative multiple folding and polymetamorphism as intense as amphibolite and hornblende-hornfels facies, to relatively simple folding, development of fracture or slaty cleavage, and only slight recrystallization.

The Annette subterrane is separated from the Craig subterrane of the Alexander terrane by the Clarence Strait fault and from the Taku terrane by eastward-dipping mapped and inferred thrust faults and zones of blastomylonite. On Annette and Gravina Islands, its contact with the Gravina-Nutzotin belt is a faulted unconformity.

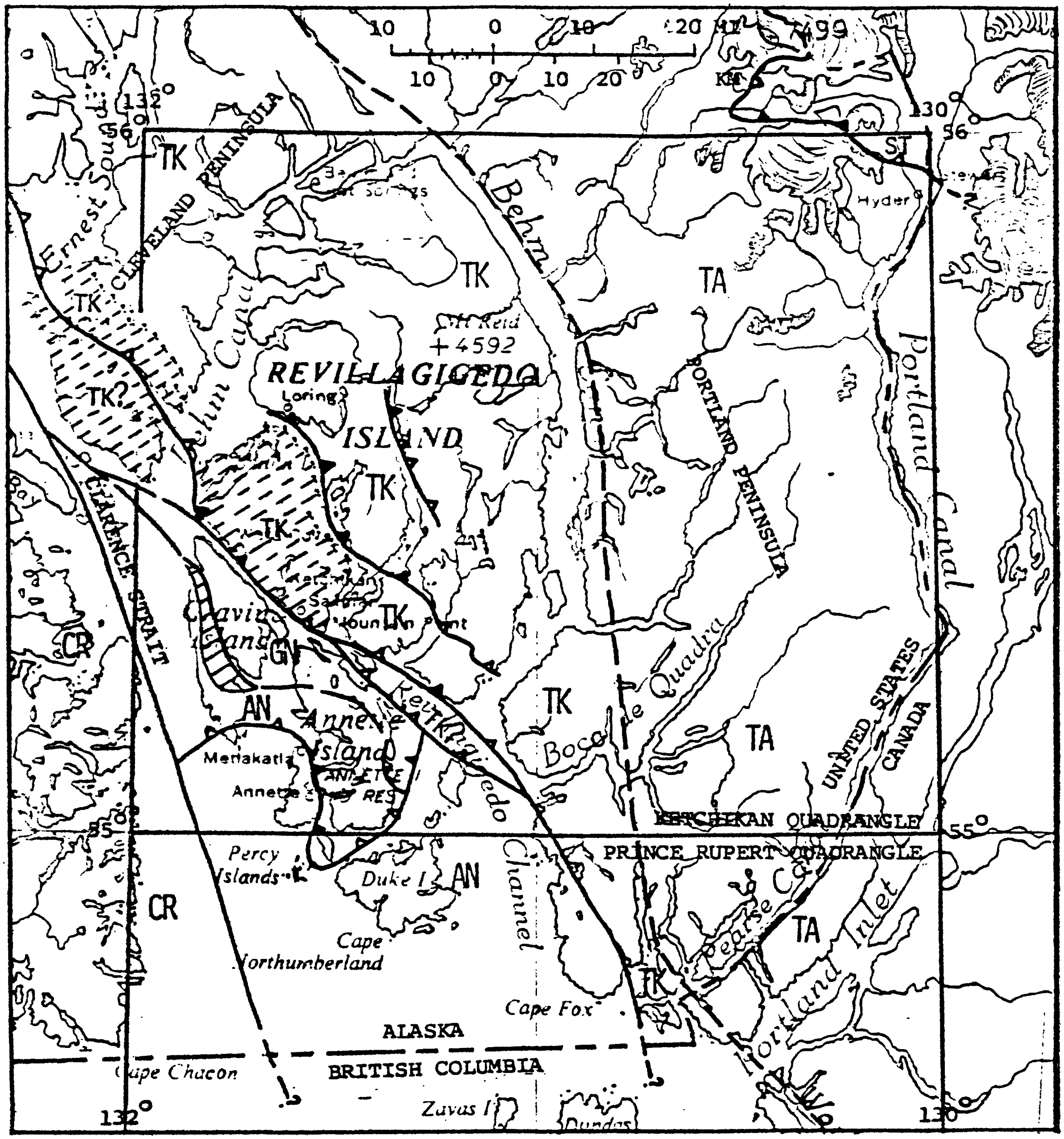

Figure 5.--Map showing tectonostratigraphic terranes and structural elements in the Ketchikan and Prince Rupert quadrangles.

EXPLANATION

TECTONOSTRATIGRAPHIC TERRANES
Queried where assumed

GN — Gravina-Nutzotin belt
Unpatterned, basement not exposed. Line pattern shows distribution of mapped (solid lines) and assumed (dashed lines) Gravina-Nutzotin belt rocks overlying subjacent terranes. Extent of assumed Gravina-Nutzotin belt rocks in Taku terrane is unknown

Alexander terrane:
- CR — Craig subterrane
- AN — Annette subterrane

TK — Taku terrane

TA — Tracy Arm terrane

ST — Stikine terrane

Contact

?— Undefined boundary of terrane; queried where continuation is uncertain or speculative

Mapped thrust fault, teeth on upper plate; may coincide in strike with high-angle fault

Mapped high-angle fault; may coincide in strike with reverse or thrust fault

Inferred thrust fault, teeth on upper plate; may coincide in strike with high-angle fault

Inferred fault

Gravina-Nutzotin belt:

This terrane comprises Upper Jurassic or Lower Cretaceous volcanic, sedimentary, and presumed subvolcanic dioritic to ultramafic plutons. The assemblage is interpreted as remnants of a collapsed upper Mesozoic volcanic arc (Berg and others, 1972). The bedded rocks are regionally metamorphosed to prehnite-pumpellyite and greenschist facies, and are folded into southwest-verging, locally refolded, isoclines whose axial surfaces dip moderately northeastward. On the southwest, the Gravina-Nutzotin belt is in faulted stratigraphic contact with the Annette subterrane; on the northeast it is separated from the Taku terrane by mapped and inferred northeast-dipping thrust faults and zones of blastomylonite.

Taku terrane:

The Taku terrane contains very sparsely fossiliferous upper Paleozoic and Upper Triassic volcanic and sedimentary rocks, and unfossiliferous pelitic and tuffaceous rocks that in part may correlate with Jurassic or Cretaceous strata in the Gravina-Nutzotin belt. The stratigraphic key to the terrane is a thick sequence of upper Paleozoic basaltic tuff and agglomerate that occurs in this terrane mainly north of the Ketchikan-Prince Rupert study area, and which is not known in any of the other terranes. The stratigraphic base of the Taku terrane is not known; clasts of leucocratic quartz diorite or trondhjemite in presumed upper Paleozoic metaconglomerate (unit MzPzc on our geologic map) on Revillagigedo Island are lithically similar to trondhjemite in the Devonian or Silurian Annette pluton (Berg, 1972a), which may have been their source, but there is no stratigraphic evidence of pre-upper Paleozoic crystalline basement beneath the presently mapped extent of the Taku terrane.

The Taku terrane is intruded by myriads of probably Upper Cretaceous dikes, sills, and stocks mainly of distinctive plagioclase-porphyritic and garnet-bearing granodiorite; by a batholith of Cretaceous quartz diorite; and by diverse other plutons ranging in age from Late Jurassic to Oligocene or Miocene and in composition from quartz monzonite to peridotite. The terrane is characterized by Upper Cretaceous or older northeastward-increasing regional metamorphism from greenschist to amphibolite facies, locally overprinted by contact metamorphism of up to hornblende-hornfels facies. Regional structures include northeast-dipping thrust faults and zones of blastomylonite cut by younger high-angle faults. The stratified rocks are complexly folded into southwest-verging overturned to recumbent, locally refolded, isoclines. Regionally, the terrane may be a giant melange or megabreccia, consisting of dismembered blocks of relatively competent rocks surrounded by pelitic and tuffaceous phyllite and semischist. The terrane is bounded on the southwest by the northeast-dipping thrusts and blastomylonite zones. In the Ketchikan-Prince Rupert study area, the northeast boundary of the Taku terrane is a line connecting the western contacts of a north- to northwest-trending series of elongate stocks of foliated quartz diorite (tonalite). Beyond the limits of the study area these stocks apparently coalesce into a persistent sill that marks the southwest boundary of the Coast Plutonic Complex (Brew and Ford, 1980), and which probably was emplaced along a Mesozoic suture that corresponds to the contact between the Taku and Tracy Arm terranes (Berg, Jones, and Coney, 1978; Brew and Morrell, 1979). This boundary also is spatially related to the Coast Range Megalineament (Brew and Ford, 1978), an enigmatic topographic, structural, and geophysical feature that locally coincides with the southwestern edge of the Coast Plutonic Complex.

Tracy Arm terrane:

The Tracy Arm terrane is the belt of high (sillimanite)-grade regionally metamorphosed bedded rocks that form roof pendants, screens, and xenoliths within the Coast Plutonic Complex. Correlative rocks in neighboring parts of British Columbia are termed the "Central Gneiss Complex" (Hutchison, 1970). In and near the Ketchikan-Prince Rupert study area, the terrane consists of sequences of pelitic and semipelitic paragneiss and schist, minor marble and amphibolite, and very sparse ultramafic rocks. These rocks are much less abundant than the massive to gneissic plutons of the Coast Plutonic Complex. Radiometric dating of rocks in the study area gives Late Jurassic, Eocene, and Oligocene to Miocene emplacement ages for the plutons, and Eocene metamorphic ages for the metapelite and amphibolite, but the premetamorphic ages of the stratified rocks in the Tracy Arm terrane are unknown. Radiometric dating of possibly correlative rocks in the Central Gneiss Complex near Prince Rupert in British Columbia suggests that at least some of them have premetamorphic ages of late Paleozoic (Armstrong and Runkle, 1979) and early Paleozoic or Precambrian (Wanless and others, 1975).

In the Ketchikan-Prince Rupert study area, the southwest limit of the Tracy Arm terrane and of the Coast Plutonic Complex intrusives that generally envelop it is the western contact of the series of elongate foliated quartz diorite (tonalite) plutons discussed in the foregoing description of the Taku terrane.

The northeastern limit of the terrane is inferred to be a northeast-dipping thrust zone that has been intruded and largely obliterated by Eocene plutons (Berg, Elliott, and others, 1977, p. 29).

Stikine terrane:

Rocks assigned to the Stikine terrane crop out only in a 30 km^2 (20 mi^2) area in the northeast corner of the study area. They consist of Upper Triassic or Lower Jurassic andesitic tuff and agglomerate, volcanic graywacke and argillite, and granodiorite that have been regionally metamorphosed to greenschist facies and then intruded and thermally metamorphosed by Eocene quartz monzonite and granodiorite. The Mesozoic rocks are the southwesternmost fringe of an upper Paleozoic and younger assemblage of marine and nonmarine volcanic, intrusive, and sedimentary rocks that crops out almost entirely in British Columbia and Yukon Territory (Monger, 1977; Monger and Price, 1979). The Stikine terrane probably originated as an upper Paleozoic volcanic arc; its key stratigraphic sequence (in British Columbia) is a thick pile of Lower and Middle Jurassic andesitic volcanic rocks that are unknown in any of the terranes to the west. In the Ketchikan-Prince Rupert study area, we interpret the southwest boundary of the Stikine terrane as a northeast-dipping thrust zone that has been mostly obliterated by the Eocene plutons.

Mines, prospects, and mineral occurrences
(Open-file report 78-73B)

This map and accompanying table briefly and objectively describe 174 metalliferous mines, prospects, and mineral (including barite) occurrences, and 9 occurrences of nonmetallic minerals, publicly known in the Ketchikan-Prince Rupert study area at the time the report was published early in 1978. Since then, several private companies have conducted extensive mineral exploration in the area, but except for the porphyry molybdenum deposit at Quartz Hill (Randolf, 1979), results of this exploration have not been made public.

Our own investigations consisted of examining as many of the known mineral deposits as possible, to determine their age, origin, classification, geologic setting, and extent, and of collecting and analyzing representative samples of ore minerals and hostrocks. We did not enter or remap any abandoned underground mine workings because all of them are caved, flooded, or otherwise inaccessible or hazardous. There are no active mines in the study area.

Our report shows the locations of the known deposits plotted on a combined topographic and generalized geologic map, alphabetically lists the commodities contained in them, classifies them by form and amount of development, and briefly describes each with appropriate references. Their geologic settings and our interpretations of their age, origin, history, and resources are summarized in our report describing the mineral resources of the study area (Berg, Elliott, and Koch, 1978).

Metalliferous deposits

Between the turn of the century and the early 1950's, the study area was the hub of what were formerly known as the Ketchikan and Hyder mining districts (Brooks, 1902; Wright and Wright, 1908; Berg and Cobb, 1967), with numerous active small lode mines that shipped ores containing gold, silver, copper, lead, zinc, and tungsten (Cobb, 1972a,b; Byers and Sainsbury, 1956). The gold and (byproduct) silver mines were mainly on Gravina Island, at Helm Bay on Cleveland Peninsula, along Tongass Narrows and at Thorne Arm on Revillagigedo Island, and near Hyder, where some of the lodes were worked mainly for silver. In addition to gold and silver, the mines on Gravina Island also shipped small amounts of copper ore, and those near Hyder shipped or stockpiled a few hundred tons of ore or concentrates containing tungsten, copper, lead, and zinc. Mines that produced small amounts of zinc concentrates containing subordinate copper and lead were worked at George Inlet and Moth Bay (Robinson and Twenhofel, 1953)

In addition to the productive mines, several metalliferous deposits were more or less extensively explored by drilling or underground workings, but there is no record of any production from them (Berg and Cobb, 1967). These include deposits prospected for gold and silver on Annette Island; copper at Walker Cove and near Smeaton Bay and Humpback Lake; gold, silver, tungsten, and molybdenum near Hyder; titaniferous magnetite on and near Duke Island; and antimony near Caamano Point on Cleveland Peninsula. Extensive drilling and other exploration currently (1980) is underway by private interests at a prospect locally known as Quartz Hill, about 65 km east of Ketchikan, where several hundred million tons of low-grade molybdenum ore reportedly have been blocked out (Randolph, 1979).

In addition to the mines and prospects, the study area contains hundreds of occurrences of metalliferous minerals that have at most been only cursorily prospected. Our report includes only occurrences that we could confirm from published reports, from U.S. Bureau of Mines claim maps, or by our own field studies. We did not include unconfirmed reports of metallic minerals, nor did we consider anomalous amounts of metals in our rock or mineral geochemical samples as "mineral occurrences," unless subsequent followup revealed metalliferous minerals at the geochemical anomaly site.

Numerous such mineral occurrences containing traces to potentially significant amounts of gold, silver, copper, lead, zinc, and barite occur on Annette (Berg, 1972a; Hawley, 1975), Gravina, and southwestern Revillagigedo Islands; gold, silver, copper, and molybdenum on Portland Peninsula; gold, silver, tungsten, and molybdenum near Hyder; and traces of an unidentified radioactive mineral on southern Gravina Island (Williams, 1956).

Nonmetallic minerals

Several occurrences of mica, feldspar, and garnet near the southern tip of Portland Peninsula have been prospected for their value as industrial minerals, but none has proved to be of commercial size or grade (Sainsbury, 1957b).

A small amount of short-fiber chrysotile(?) asbestos occurs at Yellow Hill, south of Metlakatla on Annette Island.

Geochemistry

(Open-file reports 78-73C-J and 78-156A-C)

We conducted systematic geochemical investigations in the Ketchikan-Prince Rupert study area to identify areas of anomalous concentrations of metallic elements. We collected and analyzed two relatively easily obtained types of geochemical samples: stream sediments and rocks. Our reports describe the results of these geochemical investigations in three ways: (1) sample locality maps and accompanying tables list complete analytical data for all samples (Koch and Elliott, 1978a,b,c); (2) the analytical data for all of the U.S. Geological Survey geochemical samples collected for resource assessment in the study area also are available on magnetic computer tape (Koch, VanTrump, and McDanal, 1978); and (3) a set of 8 maps shows the distribution of stream-sediment samples containing anomalous amounts of 9 metals (Koch, Elliott, and Diggles, 1978a-h). We selected these particular metals because the existing information on mineral deposits in the study area indicated that they would be useful as pathfinders either to additional mineral deposits, or to geological tracts with potential for mineral resources.

Analyses were performed by the Branch of Exploration Research of the U.S. Geological Survey for up to 30 elements by the six-step semiquantitative emission spectrographic method (Grimes and Marranzino, 1968), and for gold, copper, lead and zinc by atomic absorption spectrophotometry (Ward and others, 1969). Samples collected in 1972 and 1973 were analyzed for mercury by a flameless atomic absorption mercury-vapor detection technique (Vaughn and McCarthy, 1964). Some analyses were not performed on all samples.

Stream-sediment geochemical investigations

We collected most of the 2,602 stream-sediment samples used in our resource assessment from 1975 through 1977, but the total also includes samples collected during other U.S.G.S. geological mapping and mineral resource investigations in the study area between 1968 and 1977 (for example: Berg, 1972a and 1973; Berg and others, 1977; Smith, 1977; Elliott and others, 1976). The total includes only "normal" samples collected specifically for resource assessment and does not include certain samples collected for quality control, or samples collected for special studies of sample site density and for geochemical tests of different sample size fractions (A. L. Clark, unpublished data, 1972-4).

Sampling and sample preparation: We followed standard procedures in collecting and preparing the stream-sediment samples. We generally collected samples from the finest, most organic-free sediment in the active stream channel. In rare instances where this was not possible, we took them from bank or terrace deposits adjacent to the channel. At sites between sealevel and timber line, it was not always possible to collect a sample completely free of organic material, and a small number of samples have low to occasionally high organic content.

We obtained stream-sediment samples at shoreline sites above highest tide level wherever possible. Most of the study area is steep and sediment in the resulting swift streams is almost all detritus resulting from mechanical, not chemical weathering. The bulk of most stream-sediment samples comprises material ranging in size from very fine sand to pebbles. Samples with a large amount of silt- and clay-sized material are rare and are generally from areas of low elevation and gentle gradient. Samples were dried and sieved; the -80 mesh (-0.2 mm) fraction was pulverized and a split analyzed.

Geochemical data and interpretation

Data from our stream-sediment geochemical program are contained in two reports (Koch and Elliott, 1978b,c) that consist of sample locations plotted on 1:125,000-scale topographic maps, accompanied by tables of all analytical values, statistical summaries, and brief discussions of analytical precision and of bias and variability affecting interpretation. A second set of reports (Koch, Elliott, and Diggles, 1978a-h) graphically presents data for selected elements to aid in mineral resource assessment. They consist of eight 1:250,000-scale combined topographic and generalized geologic maps showing the distribution of gold, silver, copper, lead, zinc, molybdenum, chromium, cobalt, and nickel in stream-sediment samples in the study area. Because geochemical background levels vary for different lithologies and different areas, and because of other variants inherent in geochemical sampling practice and conditions, each map other than the one for gold and silver suggests background, threshhold, and anomalous levels for a particular element by grouping its analytical values into 4 ranges, each represented by a different symbol on the map. Higher values may indicate a greater likelihood of bedrock mineralization in the relevant drainage basin, but confidence levels are low for single-element "anomalies" and for high values that are not supported by neighboring values. Because only 2.2% of the stream-sediment samples analyzed for silver, and only 0.8% of those analyzed for gold returned determinable values, all such samples and their values are plotted on the map showing the distribution of gold and silver.

Rock geochemical investigations

To complement our regional reconnaissance of stream-sediment geochemistry, we collected representative "grab" samples of the main geologic units in most of the study area and analyzed them for the same metals as the stream-sediment samples. We also collected and analyzed "grab" samples of rocks containing visible metallic minerals (most commonly pyrite, magnetite, and hematite), and of hydrothermally altered rocks (mainly from bleached or iron-stained zones). The objectives of these investigations were:

(1) to establish background levels of approximately two dozen "ore" and pathfinder metals in the main geologic units to help interpret data from stream-sediment samples collected from streams draining those units;
(2) to determine whether parts of any rock units have intrinsic value as potentially economic mineral resources;
(3) to detect potentially valuable metals not visible in hand specimens; and
(4) to provide rough assays of samples containing visible metallic minerals.

Whenever possible, we revisited sites from which we collected rock geochemical samples containing very high values of potentially economic metals, to evaluate them as mineral occurrences (see foregoing description of "Mines, prospects, and mineral occurrences").

We collected a total of 1,708 samples, the great majority (about 85%) of which were apparently barren background samples of rock units. The total comprises all of the normal rock geochemical samples collected during U.S.G.S. geologic mapping and mineral resource investigations in the study area from 1968 through 1977. Rock geochemical data from these investigations are contained in two reports (Koch and Elliott, 1978a,b) that consist of sample locations plotted on 1:125,000-scale topographic maps, accompanied by tables of all analytical values, sample descriptions, and statistical summaries; descriptions of sampling procedures, sample preparation, and methods of analysis; and brief discussions of analytical precision and of bias and variability affecting interpretation. Analytical data for rock and ore samples collected in the study area by U.S. Bureau of Mines engineers for mineral appraisal of the Granite Fiords wilderness study area (Berg and others, 1977) are published in a separate similar report (Koch and others, 1976).

Interpretation of Landsat imagery

(Open-file report 78-73K, 2 sheets)

To aid in the mineral resource assessment of the Ketchikan and Prince Rupert quadrangles, we analyzed Landsat images of the study area for color anomalies, for lineaments, circular and arcuate features, and for regional fracture patterns that might be related to known mineral occurrences (Elliott and others, 1978), or to areas of mineral resource potential (Berg, Elliott, and Koch, 1978). To complement this comparison of Landsat data with the distribution of known or potential mineral resources, we also correlated features identified on Landsat imagery with faults, contacts, foliation, and lithologic trends identified during geologic mapping (Berg, Elliott, Smith, and Koch, 1978a); with trends or deflections of aeromagnetic contours (U.S. Geological Survey, 1977), and with interpreted aeromagnetic anaomalies (Griscom, 1978); and with rock geochemical anomalies (Koch and Elliott, 1978a, b).

Our report consists of two 1:250,000-scale combined topographic and generalized geologic maps overprinted with our interpreted Landsat data. One map highlights linear, arcuate, and circular features, and iron-oxide colored areas. It is accompanied by histograms of trends, cumulative lengths, and relative intensities of lineaments. The other map relates the Landsat data to geology, geophysics, and rock geochemistry, and is accompanied by indexes of the Landsat imagery used in our analyses of the Ketchikan and Prince Rupert quadrangles.

Aeromagnetic interpretation

(Open-file reports 77-359 and *78-73L [2 sheets])

The 1:250,000-scale aeromagnetic contour map used for our resource assessment of the Ketchikan-Prince Rupert study area was compiled from aeromagnetic surveys flown in 1972 (U.S. Geological Survey, 1976; Berg and others, 1977) and 1976 (U.S. Geological Survey, 1979), and released by the U.S.G.S. in 1977 as an open-file map (U.S. Geological Survey, 1977). This aeromagnetic contour map was republished as sheet 1 of open-file report 78-73L (Griscom, 1978). The variations in the magnetic field on maps such as these provide valuable information concerning the lateral and vertical extent of rock units containing various amounts of magnetic minerals, usually magnetite. Aeromagnetic maps thus are a most useful adjunct to geologic mapping as well as for mineral resource assessment.

An interpretive map (Griscom, 1978, sheet 2), drawn on a 1:250,000-scale combined topographic and generalized geologic basemap, identifies various rock units in the Ketchikan-Prince Rupert study area that possess characteristic magnetic intensities, and enables the interpreter to extrapolate geologic information from known areas into covered or inaccessible regions.

The interpretive map of the Ketchikan-Prince Rupert study area features prominent magnetic anomalies related to several zoned ultramafic complexes, as well as less prominent anomalies related to other mafic and ultramafic plutons and to several volcanic and metamorphic units. It also shows several major magnetic boundaries marked by differences in the magnetic properties of the rocks on either side. The most prominent such boundaries coincide with mapped or inferred major faults that separate tectonostratigraphic terranes in the study area (Berg, Jones, and Coney, 1978; and figure 5 in this report). The boundaries lie along the Clarence Strait fault, which

*This report will be published in 1980.

separates the Craig and Annette subterranes of the Alexander terrane; along and near an inferred northwest-trending thrust zone that separates the Gravina-Nutzotin belt from the Taku terrane; and along (east) Behm Canal, which coincides approximately with the contact between the Taku and Tracy Arm terranes. The magnetic boundary along (east) Behm Canal is the most prominent feature on the magnetic map. It represents the western limit of exposed magnetic rocks of the Coast Plutonic Complex, which are much more strongly magnetic than rocks of the terrane west of them, and also coincides with a major north-trending lineament that has been traced for the length of southeastern Alaska (Griscom, in Berg and others, 1977; Brew and Ford, 1978).

Mineral resource assessment

(Open-file report 78-73M)

Open-file report 78-73M describes the metallic mineral potential of the Ketchikan-Prince Rupert study area. It consists of a 1:250,000-scale combined topographic and generalized geologic map that shows 16 areas favorable for metal resources in eight specific types of mineral deposits and the commodities likely to be contained in them. It also shows the locations of mines, prospects, and mineral occurrences known in the study area and lists the commodities at each locality. We determined the mineral deposit types and identified the favorable areas mainly from the type and distribution of the known deposits, and from geological, geochemical, and geophysical evidence that favors the occurrence of mineral deposits.

The map is accompanied by a 48-page pamphlet that describes the favorable areas shown on the map, lists the criteria that we used to select each area, and, when data permit, predicts at 3 confidence levels numbers of undiscovered deposits of the specific types and the mineral resources contained in them.

The pamphlet also describes the method that we used for our resource assessment, and includes 3 tables that essentially constitute the assessment. One table describes the known and inferred types of deposits in each area; summarizes the available data on geology, geochemistry, and geophysics, and on production, resources, and status of geologic knowledge; and provides the numerical resource estimates. A second table summarizes the criteria that we used to define the areas of metalliferous mineral resource potential. The third table shows the statistical grade and tonnage models that we used to estimate the resources contained in 4 of the 8 types of mineral deposits in the study area.

Mineral deposit types, mineral resource areas, and metallogenesis

The 8 types of mineral deposits that we identified or inferred in the study area occur in 16 partly overlapping areas characterized by several rock units containing potentially valuable metallic mineral resources. These units in turn impart metallogenic significance to their respective tectonostratigraphic terranes (Berg, Jones, and Coney, 1978), which then provide the framework for interpreting regional metallogenesis, and for resource appraisal and mineral exploration (Berg, 1979, 1980). The 8 types of mineral deposits are:

(1) Porphyry molybdenum deposits in Oligocene and possibly Miocene granite porphyry stocks and peripheral swarms of quartz porphyry dikes in the Tracy Arm and Taku terranes (2 areas);

(2) Porphyry copper deposits in the Triassic or Jurassic Texas Creek Granodiorite in the Stikine terrane (1 area);

(3) Stratabound massive and disseminated volcanogenic base- and precious-metal deposits (8 areas):

   (a) in Paleozoic or Mesozoic paragneiss in the Tracy Arm terrane;

   (b) in upper(?) Paleozoic or Mesozoic metamorphosed sedimentary and volcanic rocks in the Taku terrane;

   (c) in Upper Jurassic or Lower Cretaceous metamorphosed andesitic volcanic and volcaniclastic rocks in the Gravina-Nutzotin belt;

   (d) with barite in Upper Triassic felsic metavolcanic rocks in the Annette subterrane; and

   (e) possibly in Jurassic or older Hazelton(?) Group andesitic metavolcanic rocks in the Stikine terrane;

(4) Stratiform titaniferous iron deposits (with traces of platinum-group metals) in Upper Jurassic or Lower Cretaceous zoned ultramafic complexes that intrude the Annette subterrane, Taku terrane, and possibly Gravina-Nutzotin belt (4 areas);

(5) Disseminated lode gold deposits in pyrite- and arsenopyrite-bearing upper(?) Paleozoic or Mesozoic greenschist and phyllite in the Taku(?) terrane and(or) Gravina-Nutzotin belt (1 area);

(6) Copper- and iron-bearing skarn deposits in Paleozoic or Mesozoic metacarbonate near the contacts of Cretaceous or Tertiary granodiorite and quartz diorite plutons in the Tracy Arm terrane; and tungsten skarns in Hazelton(?) Group **strata** near the contacts of the Texas Creek Granodiorite and possibly of Eocene granodiorite and quartz monzcnite plutons in the Stikine terrane;

(7) A stibnite-bearing epithermal replacement vein in upper Paleozoic or Mesozoic metacarbonate and phyllite in the Taku(?) terrane (1 area); and

(8) Auriferous and polymetallic quartz fissure veins, stockworks, and breccias that occur in diverse hostrocks throughout all of the tectonostratigraphic terranes.

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