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Mineral Resource Assessment of the Chugach National Forest Special Study Area in northern Prince William Sound, Alaska

by

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SUMMARY

Geologic and geochemical investigations by the U.S. Geological Survey and surveys of known prospects and mineral occurrences by the U.S. Bureau of Mines have been conducted to evaluate the mineral resource potential of a special study area in northern Prince William Sound. Polymetallic vein deposits within the study area contain metallic resources of Cu, Pb, Zn, and Ag. These veins are not recognized elsewhere in geologically similar regions of southern Alaska. Prospecting in the study area was active in the early 1900's and a few of the prospects had underground workings. No developed prospect has had any recorded production between the early 1900's and the present time. There are not active mining claims in the study area.

Most of the study area is permissive for the discovery of additional polymetallic veins and most lithologic units in this region are favorable hosts for the veins. Areas specifically considered as favorable or probable for additional vein discoveries are located in the north-central part of the special study area. The polymetallic vein occurrences are uneconomic and will not likely attract interest from industry without a drastic increase in metal prices.

INTRODUCTION

Purpose of work

In 1990 both the U.S. Geological Survey and the U.S. Bureau of Mines were contacted by staff of the Chugach National Forest (CNF) for the purpose of providing mineral resource information for the CNF Master Plan during the planning period FY91-FY96. New information was needed to address the terms and requirements of the 1986 Settlement Agreement (see Minerals Area Management section below) and to provide mineral information to the CNF for aiding in land use decisions.

Three special study areas needing additional mineral study were recommended by a group consisting of members of both the U.S. Geological Survey and the U.S. Bureau of Mines to the CNF in 1990. The first priority area needing study is in northern Prince William Sound. The other two lower priorities areas are Kayak Island and the mountains south of the Tasnuna River. These two areas were not funded for study. Known mineral occurrences in the high priority area include low tonnage, polymetallic veins containing copper, lead, zinc sulfides, and a little silver. These veins do not occur elsewhere in the over 2,000-km-long region of similar geology in southern Alaska (Mackevett and others, 1978; Nelson and others, 1984). Geologic descriptions and tonnage and grade data are absent for these occurrences.

In early 1992 the Interagency Agreement between the U.S. Geological Survey, the U.S. Bureau of Mines, and the CNF was signed. The U.S.G.S. is to provide estimates of the undiscovered mineral endowments of the special study area as well as to identify the potential areas for future mineral discovery. The U.S. Bureau of Mines is to update the discovered mineral endowment of identified occurrences in the special study area.

Location and geographic setting

The CNF, located in the Kenai-Chugach Mountains physiographic province of Alaska (Wahraftig, 1965) is the second largest national forest in the United States and is about 23,000 km^2. This area encompasses scenic Prince William Sound, the largest embayment along the southcentral coast of Alaska.

The special study area is in the northern part of Prince William Sound (fig.1). The special study area of 1000 km^2 is bounded by Unakwik Inlet on the west and Columbia Glacier and Columbia Bay on the east. The southern part of the area includes Glacier Island and the northern boundary is approximately latitude 61° 07'N. The coastline of the special study area is indented by fjords that were produced by south-flowing glaciers. The lower slopes are densely vegetated with stands of spruce and hemlock, alder, and devils club. Timber line elevation is at about 460 m. Relief in the area ranges from sea level to 1,600 m.

The area was extensively glaciated during the Pleistocene and several large glaciers persist today. The most spectacular glacier is Columbia Glacier which has retreated 5 km in the period 1983-1991 (Krimmel, 1992). This retreat has freed the glacier from grounding on its terminal moraine and resulted in numerous icebergs being released in the area (Krimmel, 1992). In contrast, Mears Glacier, another tidewater glacier located 8 km to the north of the study area at the head of Unakwik Inlet, is advancing.

The retreat of Columbia Glacier resulted in the draining of Terentiev Lake. During the 1992 field season the lake level was approximately 100 m lower than it was during the RARE II studies in the early 1980s. The lower lake level has exposed a much larger outcrop of the Terentiev Lake pluton as well as at least two drowned forest horizons.

History of mineral activity

Mineral prospecting in the study area was active in the early parts of the 1900s. Grant and Higgins (1910) reported that there was prospecting activity in the Miners Bay area for nickel. Minor underground workings were developed and by 1905 "encouraging results" were reported (Grant and Higgins, 1910). Seven copper prospects also reported by them to be active on Glacier Island and on the mainland to the north. In 1913 Johnson (1916) reported that only six properties were active--only two were previously discussed by Grant and Higgins (1910). By 1917 there was little if any work being done on the prospects.

Moffit and Fellows (1950) reported considerable development work in the Cedar Bay area in the early 1940's, primarily at the Blackjack and Glendenning prospects. These prospects were of interest as a source for zinc. However, Moffit and Fellows (1950) doubted that zinc grades were sufficient to justify working the properties for only zinc. Moffit and Fellows (1950) also mention that many mineralized areas between Long Bay, in the study area, and Port Wells, 45 km west, were being actively explored. None had production because of low grades and inaccessibility.

Previous resource assessments

Two mineral resource assessments of the CNF are completed. The aim of these two assessments was to provide mineral information useful for land planning to the CNF. The first resource assessment (Nelson and others, 1984; Jansons and others, 1984) completed was conducted under the provisions of the Wilderness Act (RARE II) and related acts. The entire 6 million acres of the CNF was studied and 25 potential resource areas were defined. Each of the resource areas was evaluated as to its favorability for the occurrence of mineral deposits. This favorability was restricted to those commodities and deposits types (lode gold, placer gold, and lode copper) that had a history of production in the CNF. Favorability ranking (low, moderate, or high) of each area was based on several criteria that included the presence of mines, prospects, and occurrences, favorable lithologies, and stream-sediment geochemical anomalies. These rankings were determined to aid the land planners in deciding about where mineral activity might take place. The special study area was identified as a potential resource area. However, there was no favorability ranking for the occurrences because they had not produced ore.

The later resource assessment (Bliss, 1989) presents the quantitative estimate of undiscovered mineral deposits in the CNF. The objective was to forecast the amount of various metals in undiscovered deposits likely present in the CNF. Only the part of the assessment concerned with polymetallic veins is considered in this study. In the report (Bliss, 1989) all deposit types permissive in the forest are evaluated following the three-part method of assessment developed by Singer (1993). Application of the three-part method allows metal endowment of undiscovered deposits to be estimated using a Monte Carlo simulation. The steps in the method are as follows:

1. Delineate areas using geology that are permissible for each deposit type. The resource areas defined by Nelson and others (1984) were used as a guide.

2. Estimate the amount of metal and some ore characteristics by means of grade-tonnage models. For this step grade-tonnage models were based either on grades and tonnages from the local deposits or standard models in Cox and Singer (1986).

   For the polymetallic veins found in the study area the grade-tonnage model was based on 75 deposits of which 60 percent are from the Slocan Mining District, British Columbia, Canada (Cairnes, 1934).

3. Estimate the number of undiscovered deposits of each type within each permissive area. For this step subjective estimates of the number of undiscovered deposits were made in August 1988 by a group comprised of two geologists from the U.S.G.S., four from

the U.S.B.M., and one from the U.S.F.S. The number of deposits estimated at the 90 percent, 50 percent, and 10 percent confidence levels is 1, 3, and 5 respectively for the polymetallic vein deposit type occurring in the special study area (Bliss, 1989).

GEOLOGIC SETTING

Regional Geology

The geology of the CNF is dominated by two major lithologic units, the Late Cretaceous Valdez Group and the Paleocene and Eocene Orca Group (Shrader, 1900). Both groups consist largely of graywacke, siltstone and shale; the finer-grained rocks commonly display a slaty fabric. Petrographic study of the graywackes suggests that the sediments represent the progressive unroofing of a volcanic arc to its plutonic core (Dumoulin, 1987). Isotopic study of the sedimentary rocks from the two groups indicates that their source was likely the Coast Mountains of western British Columbia (Farmer and others, 1993).

Both groups also contain thick sections of mafic volcanic rocks (Nelson and others, 1985). In the Orca Group, the mafic rocks comprise an ophiolite section that contains, from base to top, ultramafic rocks, gabbro, sheeted dikes, and pillow basalt (Nelson and others, 1985; Crowe and other, 1992; and Nelson and Nelson, 1993). The volcanic sections in the Valdez Group also contain thick pillow basalt, lesser sheeted dikes, gabbro, and ultramafic rocks. These units are only spatially associated with each other. Both volcanic sections are hosts to massive sulfide deposits that were worked primarily for copper (Crowe and others, 1992).

The contact between the Orca and Valdez Groups is the Contact fault (Winkler and Plafker, 1981). In eastern Prince William Sound, the location of the Contact fault is based on a change in structural trend. Between the Copper River and Port Fidalgo, the regional strike of the Orca Group is northeast. The Valdez Group in this area exhibits an east-west regional strike. In western Prince William Sound the regional strike of the two groups is parallel. This, coupled with the close lithologic similarities of the two groups, makes location of the fault problematic in western Prince William Sound (Bol and Gibbons, 1992).

Plutonic rocks in the CNF were emplaced during two main intrusive episodes. The earliest intrusive episode has been dated by potassium-argon methods as 50 to 53 Ma (Plafker and Lanphere, 1974; Nelson and others, 1984). Igneous rocks of this age are found throughout south-central Alaska. These plutons are formed largely from melting of the graywacke host (Barker and others, 1992), and have been termed the Sanak-Baranof plutonic belt (Hudson and others, 1979). The younger plutonic episode has been dated by both potassium-argon and argon-argon methods (Lanphere, 1966; Nelson and others, 1984) to yield ages of about 30 to 36 Ma. Plutons of this episode are more localized than those of the Sanak-Baranof belt, being found only in northern and western Prince William Sound.

Geology of the Study Area

Rocks of both the Orca and Valdez Groups are found in the special study area. Rocks of the Valdez Group are low grade-metamorphosed turbidites found north of the Contact fault. Rocks of the Orca Group are found to the south of the Contact fault and consist of both turbidites and mafic volcanic rocks.

Geologic mapping at 1:63,350-scale of both groups has focused on the identification of the depositional facies (Mutti and Ricci Lucchi, 1978) in turbidites (Nelson and others, unpub. mapping, 1994) both for structural interpretation and controls for mineralization (Haeussler and Nelson, 1993). Facies of the Valdez Group suggest deposition as deep-sea fans. In contrast, the Orca Group turbidites were deposited on the continental slope as well as deep-sea fans. In addition, structural studies were conducted to determine some aspects of polymetallic vein formation (Haeussler and Nelson, 1993).

Two ages of volcanic rocks are found in the study area. The youngest, are assigned to the Orca Group, are found on Glacier Island and consist of pillow basalt and sheeted dikes. The Glacier Island ophiolite is part of a 100 km-long belt of ophiolite that extends from Elrington Island in the south, north through Glacier Island and east to Ellamar (Crowe and others, 1992).

The older package of volcanic rocks consists of volcaniclastic rocks and limestone. These rocks are found in two fault-bounded areas within the Orca Group (Nelson and others, unpub. mapping, 1994). Volcanic mudstone with broken pillow breccia. purple or green calcareous shale, and thin beds of gray, green, and purple limestone characterizes the unit. Microfossils from the interbedded limestone have been identified as Cenomanian, Turonian, and Coniacian in age (R. Rosen, written comm., 1993). These rocks are correlated with similar rocks at Cape Current on Shuyak Island, 430 km to the southwest (Connelly, 1978).

Structure in the special study area is complicated. The area is at the hinge of the orocline of southern Alaska (Grantz, 1966) where the regional strike of bedding changes by 90 degrees. It has produced a number of local structural domains with up to a 90 degree difference in strike of bedding and in trend of fold axes (Haeussler and Nelson, 1993).

Plutonic rocks in the study area have eluded radiometric dating and have been correlated with either the 50 Ma suite or the 34 Ma suite based on petrographic and lithologic features (Tysdal and Case, 1979; Nelson and others, 1985). The Miners Bay pluton has been dated and is about 35 Ma (Nelson and others, 1985) and lithologically is similar to other 34 Ma plutons in Prince William Sound that contain both gabbro and granite compositions (Nelson and others, 1985).

The Terentiev Lake, Granite Cove and Cedar Bay plutons have identical chemistry and petrography. However, their modal compositions overlap the modal compositions of the two dated regional suites. Their chemistry is distinctly more enriched in alkalis and silica than any of the dated plutons. A preliminary $^{40}Ar/^{39}Ar$ date on potassium feldspar from the Granite Cove pluton yielded a 30 Ma age. This should be considered a minimum age due to the low blocking temperature of potassium feldspar to argon loss. Possibilities for age of these three plutons include, (1) they are part of the 34 Ma suite, or (2) they are a third younger suite of plutons. Additional radiometric dating is in progress to resolve these possibilities.

MINERAL DEPOSIT TYPES

Regional distribution of deposits

Earlier workers suggested that certain deposit types were restricted to either the Orca or Valdez Groups (Tysdal and Case. 1982). The Valdez Group is largely characterized by quartz vein deposits that have been worked for gold and the Orca Group by volcanogenic massive sulfide deposits that have been worked for copper. However, both types of deposits are found in both groups (Nelson and others, 1985; Goldfarb and others, 1986). These are the only two lode deposit types in the CNF with past production.

Copper deposits in the CNF are products of submarine volcanism. These massive sulfide deposits are found in or near mafic volcanic rocks in both the Valdez and Orca Groups (Crowe and others, 1992). Gold-bearing quartz veins are most abundant in the Valdez Group rocks and are less abundant in rocks of the Orca Group. Veins appear spatially related to rocks metamorphosed to greenschist facies and Eocene intrusive rocks.

Mineralization in the special study area

There are five possible mineral deposit types in the special study area. These include low-sulfide gold-bearing quartz veins largely associated with rocks of the Valdez Group, related placer gold, magmatic nickel accumulations associated with the Miners Bay pluton, volcanogenic massive sulfides associated with the Glacier Island ophiolite, and polymetallic veins. The classification of deposit types is based on Cox and Singer (1986). None of the known occurrences of these deposit types had any history of production from the study area. The polymetallic veins are the only abundant deposit type in the area and the only type to have undergone significant prospecting. Hence they are the main focus of this assessment.

There are 26 polymetallic vein occurrences recognized from the special study area (Roe and Balen, 19__). Only a few have had any development work and most are classified as occurrences. Many of the occurrences were discovered during the RARE II and present special study area fieldwork. The veins contain variable amounts of zinc-, lead-, iron-, and copper-bearing sulfide mineralogy. All contain anomalous amounts of silver.

The veins have a relatively consistent north-south orientation and vary in width from a few cm to up to as much as 2 m. Veins cut all rock types in the study area. The footwall contacts are sharp and the hanging wall contacts are gradational with the enclosing host rocks. There is no shearing along the veins (Haeussler and Nelson, 1993).

Mineralization is spotty along the veins. Even though some veins can be traced for several kilometers along strike the mineralization does not have the same lateral continuity. Many veins contain angular fragments of the country rock and in some cases several generations of quartz are evident. Vuggy quartz-filled openings were seen in some veins and one vein contains fluorite. Common sulfide minerals include pyrite, pyrrhotite, sphalerite, chalcopyrite, and galena.

The vertical distribution of mineralized veins ranges from sea level to about 3500 ft elevation. None of the veins are known to be continuous throughout the vertical range. Cu, Pb, Zn, and Ag grades are found in variable amounts independent of elevation. The same relationship has been documented for similar veins from British Columbia (Cairnes, 1934). The greatest number of known occurrences are found above timberline and the second greatest number are found at sea level. This suggests that there may be a significant number of unknown occurrences at elevations in heavily vegetated areas above sea level and below timberline.

GEOCHEMICAL STUDIES

Isotope studies

Stable isotope investigations of the polymetallic veins have provided data for estimating the temperatures of vein formation and the source of ore fluids (Goldfarb and others, in press). Oxygen isotope geothermometry from two occurrences indicates formation temperatures of 174°C and 190°C, and sulfur isotope geothermometry from one of these suggests a 144°C temperature for sulfide deposition. The lack of high- to moderate-temperature wall rock alteration phases adjacent to the veins and the extremely small vapor:liquid ratios in fluid inclusions within mineralized quartz also agree with vein formation temperatures of <200°C.

Oxygen isotope composition of the hydrothermal fluid that deposited the mineralized quartz in the veins is estimated to be between -4.2 per mil and +2.8 per mil. This is significantly lighter than values estimated for the gold-bearing quartz veins that occur throughout much of the CNF and are hypothesized to have formed from waters of metamorphic origin (Goldfarb and others, 1986). These data indicate that the more localized polymetallic veins in the special study area formed from a different fluid type that was largely meteoric in origin. Hydrogen isotope compositions of fluid inclusion waters for quartz from three occurrences, ranging between -88 per mil and -100 per mil, further support a meteoric origin for the ore fluids. An anomalously light hydrogen value of -139 per mil for inclusion waters from quartz for the Blackjack prospect is best interpreted as reflecting an input of organic hydrogen into the circulating meteoric waters.

Sulfur isotope data for sulfide minerals range between 0 per mil to -6 per mil for occurrences hosted by sedimentary rocks and +4 per mil to +10 per mil for those hosted by igneous rocks. These data are interpreted to reflect two distinct sources of sulfur in the veins such that the circulating meteoric waters locally leached the sulfur from both rock types. Lead isotope compositions of sulfide minerals from the Blackjack(1) (numbers in parens refers to location in fig. 2) and Miners River #2(2) prospects (Gray and others, 1986) indicate base metals were leached from a crustal source, most likely from the sedimentary rocks but also possibly from the granites. Metals could not have been derived from buried mafic volcanic rocks within the accreted pile.

The spatial association of the polymetallic veins and the felsic intrusive rocks suggests that the meteoric water circulation was driven by pluton emplacement. The reason for restriction of this mineral deposit type to this one part of the CNF is uncertain, especially given the fact that Tertiary intrusive bodies are widespread throughout rocks of the Valdez and Orca Groups yet lack associated polymetallic veins. Possible explanations might be the development of favorable conduits and ore host structures in the vicinity of the oroclinal bend (see Haeussler and Nelson, 1993) and (or) a local relatively shallow depth of emplacement of plutons that enhanced interaction with meteoric waters.

Geochemical exploration summary

A detailed geochemical survey of the special study area was conducted to identify drainage basins likely to contain undiscovered polymetallic veins. A total of 167 minus-80-mesh stream sediments and 162 heavy mineral-concentrate samples were collected from the area as part of the Seward quadrangle AMRAP study in the late 1970's, the CNF RARE II survey of the early 1980's, the Anchorage quadrangle AMRAP study of the mid 1980's, and the present more-detailed survey of the special study area. The combined sites resulted in sample coverage at a density of about one site/6.5 km^2. In addition to these samples, mineralized rock samples were collected from most of the occurrences to better define geochemical signatures of hydrothermal mineralization. Such information is essential for adequate interpretation of the stream sediment data.

The predominance of pyrite, pyrrhotite, sphalerite, and chalcopyrite in the majority of the mineral occurrences is reflected in the analyses of the rock samples. Selected high-grade mineralized samples contain 10-20 percent Fe, 0.5 to >2 percent Cu, and 0.5 to >1 percent Zn. Silver values generally range between 30-100 ppm, but mineralized veins from the Wells Bay Copper(3) and Columbia Red Metals(4) prospects contain 500-1,000 ppm Ag. Lead concentrations are generally anomalous but below 0.5 percent; galena-rich samples, however, from the Miners River #2(2) and Long Bay #1(5) prospects contain 3-6 percent Pb. Arsenic, Bi, Cd, and Sb are also consistently detected at anomalous levels and the vein at Wells Bay #1(6) contains about 15 percent F. About half of the occurrences contain elevated gold and mercury concentrations ranging between 50-650 ppb Au and 0.4-2.7 ppm Hg. The Byers(7) occurrence is notably enriched in the two metals, with as much as 4.4 ppm Au and 62 ppm Hg in selected samples.

Watersheds favorable for the upstream occurrence of polymetallic occurrences are best identified by concentrate samples containing at least 5 ppm Ag, 2,000 ppm As, 20 ppm Bi, 50 ppm Cd, 500 ppm Cu, 500 ppm Pb, and (or) 700 ppm Zn. These watersheds delineate most of the special study area, and are found east and northeast of Wells Bay and are underlain by sedimentary rocks of the Orca Group (fig. 2). This anomalous suite does not characterize samples collected from the Valdez Group north of the Contact fault, from mafic volcanic rocks of Glacier Island, or from the interior regions of exposed granitic rocks. Most of the anomalous concentrate samples also contain at least 5,000 ppm Ba, indicative of significant barite. However, the distribution of concentrate samples with anomalous barite is somewhat broader than that for samples with anomalous base metals suggesting that the barite reflects erosion of detrital grains from Orca Group sedimentary rocks. Generally background amounts of barium in most of the mineralized rock samples supports this hypothesis.

Stream sediment samples are not as diagnostic as the concentrate samples for indicating geochemically favorable areas for polymetallic occurrences. Many sediments derived from Orca Group sedimentary rocks to the east of Wells Bay have silver concentrations between 0.15-1.3 ppm and antimony values between 2-6 ppm. However, there are numerous sediment samples with background concentrations of these two metals despite highly anomalous metal concentrations in corresponding concentrate samples. In addition, As, Cu, Pb, and Zn anomalies in stream sediments are very inconsistent, even in the vicinity of some of the known mineral occurrences. This reflects the generally small volume of mineralized rock that characterizes the mineral deposit type and emphasizes the need of collecting concentrate samples for anomaly enhancement in the exploration for these polymetallic occurrences.

A different geochemical signature characterizes many of the concentrate samples collected north of the Contact fault. These samples often contain 70-700 ppm Ag, 700-20,000 ppm As, 100-1,000 ppm Au, and 200-1,500 ppm W, as well as background concentrations of Cu, Pb, and Zn. This is consistent with the presence of mesothermal gold-bearing quartz veins within rocks of the Valdez Group and the lack of polymetallic occurrences. The distinct difference in mineral deposit types across the fault zone (Nelson and others, 1984 and this study), despite no obvious petrographic or metamorphic distinctions, is difficult to explain. It may suggest that in the early Eocene when the gold veins formed, and perhaps during hypothesized early Oligocene formation of the polymetallic deposits, the Orca Group rocks that underlie the special study area had not yet reached their present location.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Discovered mineral endowment

The discovered or known mineral endowment was evaluated by the U.S. Bureau of Mines (Roe and Balen.19__). The Bureau visited 26 sites in the study area: 14 are known prospects, seven occurrences, and five sample sites. Four of the occurrences visited were new discoveries (Roe and Balen, 19__).

Assessment of the known deposits determined that the estimated gross metal value per tonne of ore does no meet the break-even (zero percent return) scenario from a mining feasibility modeling. None of the occurrences or prospects with tonnage and grade estimates contain sufficient grade or tonnage to be economically feasible at present metal values. Therefore the polymetallic veins in the study area are considered uneconomic (Roe and Balen, 19__).

Undiscovered mineral endowment

Bliss (1989) reports the potential for 1, 3, and 5 undiscovered (polymetallic vein type) deposits at the 90 percent, 50 percent, and 10 percent confidence levels for this area. Since none of the deposits in the study area had production, tonnage and grade curves for polymetallic veins from producing mines (Cox and Singer, 1986) were applied to estimate the undiscovered metal endowment. This process resulted in a total metal endowment shown in Table 1.

Table 1. Estimated undiscovered metal endowment for polymetallic vein deposit type from the special study area (after Bliss, 1989)

Confidence level	90 percent	50 percent	10 percent
Commodity			
Ag	1.1 million g	47 million g	500 million g
Cu	-	12,000 mt	500,000 mt
Pb	130,000 mt	6.7 million mt	62 million mt
Zn	2,900 mt	2.2 million mt	51 million mt

After consideration of the limited economic potential of these deposits and the low silver grades it was decided that application of tonnage and grade values from previously producing mining districts to the unproductive veins in the study area results in an overestimate of the metal endowment. In addition we realize that there is potential for additional occurrences of this deposit type in the study area especially in the probable and favorable areas shown on figure 2. However there is no indication that any new occurrences would contain grades or tonnages significantly greater than those estimated from the known prospects and occurrences.

Potential resource areas

Three classifications of resource potential were determined in the special study area (fig. 2). These are permissive, probable, and favorable. The probable area is defined on the basis of anomalous element concentrations in stream sediment and heavy-mineral-concentrate samples and the presence of numerous occurrences and prospects. Favorable areas contain fewer geochemical anomalies and a lessor concentration of prospects and occurrences. Areas considered permissive for additional undiscovered polymetallic veins contain few prospects or occurrences and rare geochemical anomalies.

VII. MINERALS AREA MANAGEMENT

Four issues need to be addressed for mineral resource planning in the national forest. We address these issues below.

1. Current and projected future location and level of development of active mining claims, patented or unpatented.

At the time of this study there were no active mining claims and only one inactive patented mining claim in the study area. The likely areas for future mining claims are those classified as favorable or probable (fig. 2). Known prospects and occurrences shown by Roe and Balen (19__) are most likely to attract future interest but the present economic situation makes any future development unlikely without a drastic increase in metal values.

2. Location of probable occurrences of substantial deposits of locatable, leasable, and common variety minerals.

There is a low probability for the development of locatable, leasable, and common variety minerals in the special study area. More accessible and economic deposits are found elsewhere in the CNF.

3. Current and projected future access needs for exploration and development of active mining claims and areas of probable mineral occurrence.

There are no active mining claims in the special study area. Access to any claims or areas needing future exploration or development would be by boat and/or aircraft. Access to the higher elevation would probably be by helicopter. These access methods are presently used for both recreational and commercial activities in Prince William Sound because there are no roads.

4. Potential environmental effects of current and projected future exploration and development.

Current and future environmental effects, assuming some exploration, would be helicopter and boat access to the area and sample collection. The environmental effects of any additional deposit development cannot be made at this time without study of the impact of the existing prospects and occurrences on the environment. Without a drastic change in the economic situation it seems unlikely that this issue will be of concern in the near future.

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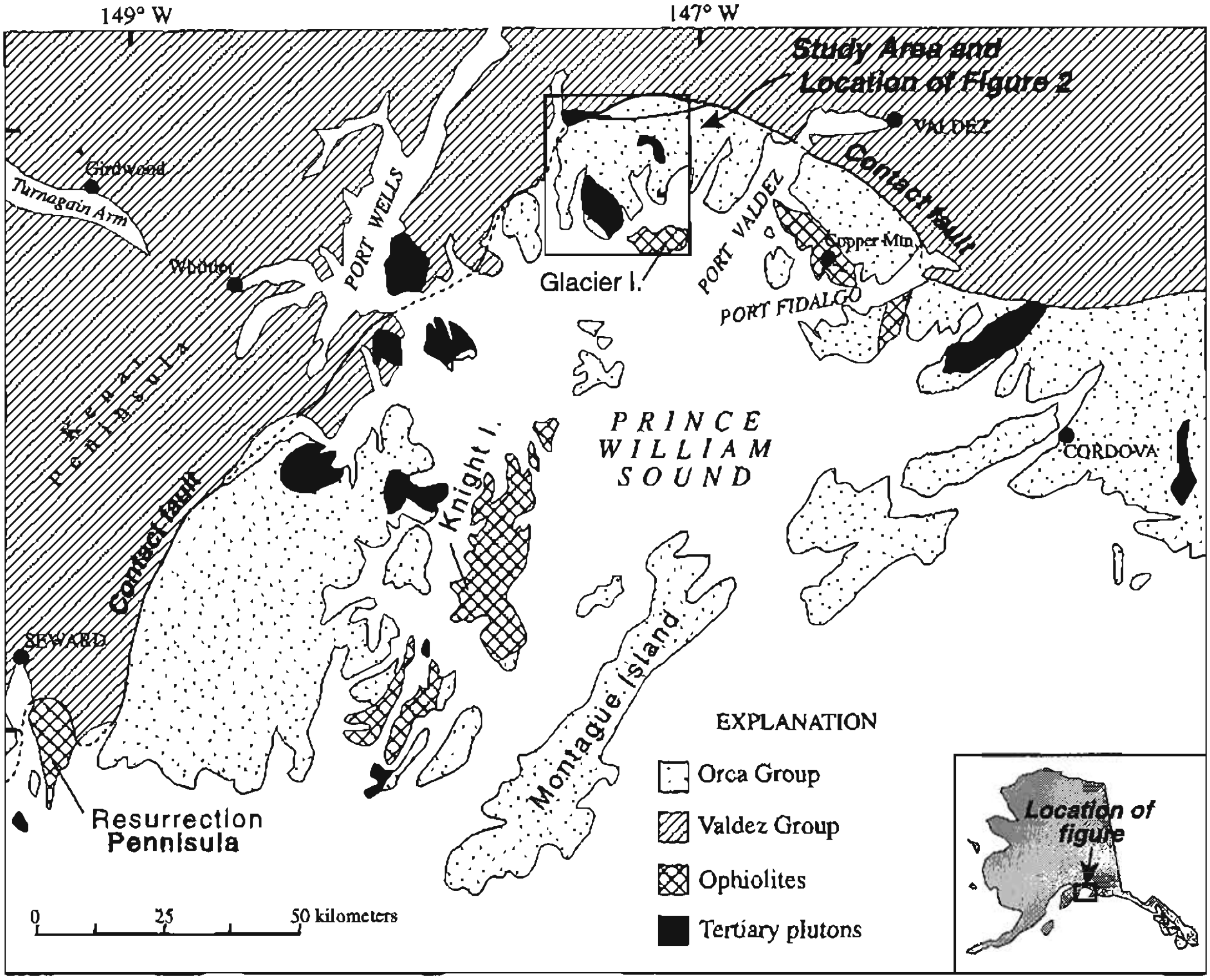

Figure 1. Location of the Special Study area in the Chugach National Forest, northern Prince William Sound and general geology of the region.

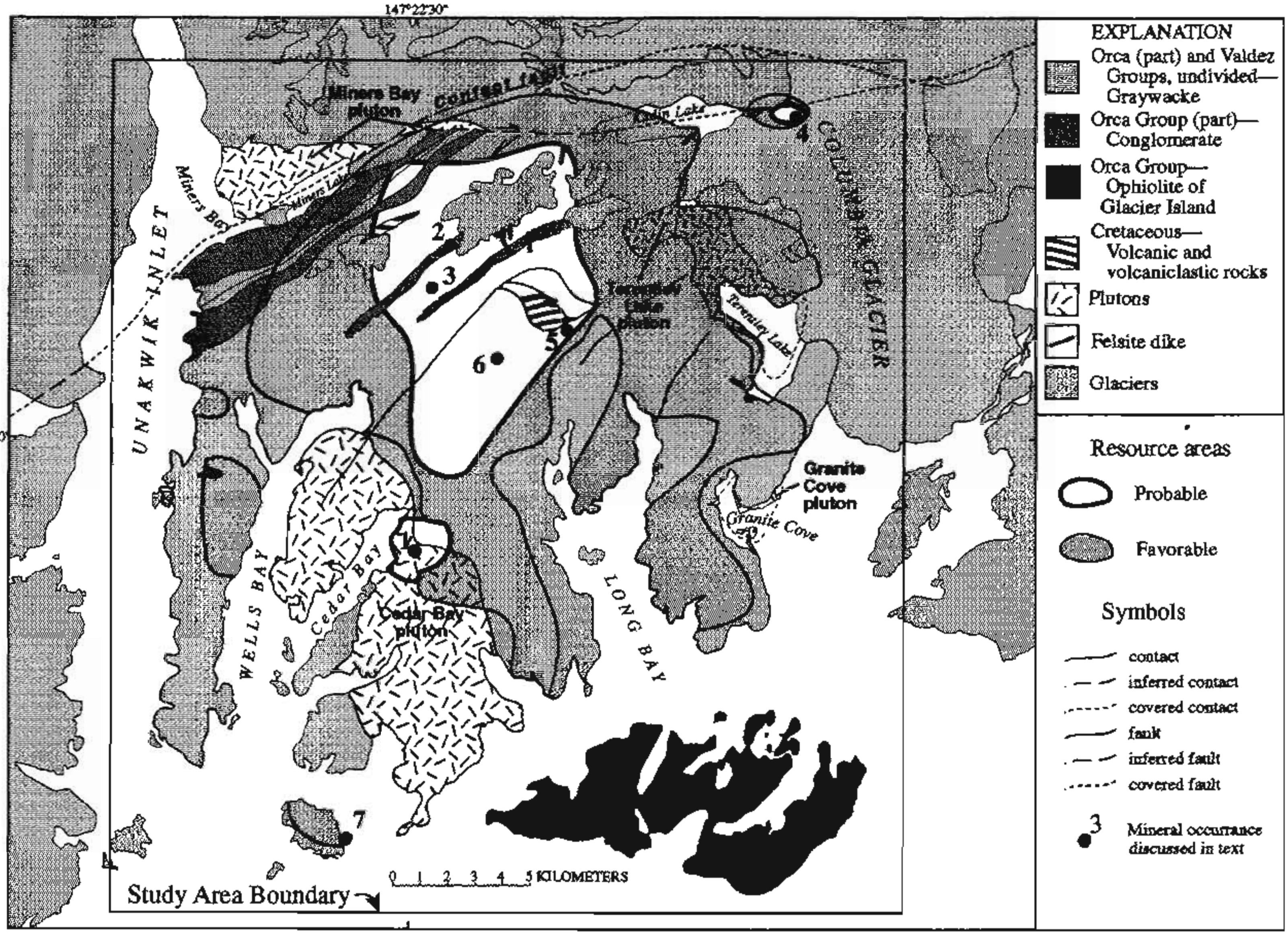

Figure 2. Resource areas in the Special Study area, northern Chugach National Forest classified as probable and favorable. Unassigned areas south of the Contact fault and excluding Glacier Island are considered permissive.