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OPHIOLITIC AND OTHER MAFIC-ULTRAMAFIC METALLOGENIC PROVINCES IN ALASKA (WEST OF THE 141st MERIDIAN)

By

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UNIT OF MEASURE ABBREVIATIONS

cm	centimeters	mt	metric tons
g	grams	oz	troy ounces
g/m^3	grams per cubic meter	oz/st	troy ounces per short ton
kg	kilograms	oz/yd^3	troy ounces per cubic yard
km	kilometers	pct	percent
km^2	square kilometers	ppb	parts per billion
m	meters	ppm	parts per million
m^3	cubic meters		

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ABSTRACT

Mafic and ultramafic rocks associated with ophiolitic terranes and other petrologic suites in Alaska contain a variety of metallic and nonmetallic minerals that are of past and potentially future economic significance. Metallic minerals that are reported, or have been produced from these associations in Alaska, contain the precious metals, gold, silver, and platinum-group elements (PGE), ferrous metals, including chromium, manganese, and titanium, and base metals, including cobalt, copper, and nickel. All these and numerous other metallic commodities, including arsenic, barium, bismuth, cadmium, lead, mercury, molybdenum, niobium (columbium), rare-earth elements, thorium, tin, tungsten, uranium, zinc, and zirconium are variably present in placer and lode deposits in geologic terranes that contain ophiolites and other mafic and ultramafic rocks. Nonmetallic minerals including asbestos, jade, and soapstone (massive talc) are variably present in serpentinized ultramafic lithologies associated with ophiolites and other mafic-ultramafic complexes.

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INTRODUCTION

Mineral data contained in this report were largely generated during site-specific investigations that were conducted as part of the U.S. Bureau of Mines Strategic and Critical (S&C) Minerals studies in Alaska. These studies began in 1981 and were conducted by the Bureau's Alaska Field Operations Center (AFOC), with analytical, mineral characterization, beneficiation, and mineral processing support by the Bureau's Research Centers in Albany (OR), Salt Lake City (UT), and Reno (NV). The S&C studies initially concentrated on chromium and platinum-group elements (PGE) and were focused on mafic and ultramafic rocks, including those in ophiolite complexes. Additional mineral data were generated during Bureau of Mines Mineral Land Assessment (MLA) studies, which are area-wide studies that have focused on specific mining districts and various federally-owned lands in Alaska.

In addition to data generated during the Bureau studies, reports by other agencies and individuals that pertain to the mineral occurrences and deposits described in this report are cited in the list of references at the end of this report. Typically a brief synopsis of the published information is contained in the individual site descriptions. The interested reader is encouraged to refer to the cited references for more detailed and more complete historical and geologic information.

This report was compiled in collaboration with W.W. Patton, Jr., J.M. Murphy, S.W. Nelson, and S.E. Box, all of the Geological Survey, and L.E. Burns, Alaska Division of Geological and Geophysical Surveys. The USGS Open-File Report authored by these workers and entitled Geologic Map of Ophiolitic and Associated Volcanic Arc and Metamorphic Terranes of Alaska (west of the 141st meridian) (Patton and others, 1992) provides a geologic framework for the metallogenic data and the geologic map contained in that report has been adopted as the base map for this report. On their map, Patton and others (1992) have divided ophiolitic terranes in Alaska into five major geographic areas: (1) the northern and western Alaska (**onw** on figure 1), (2) the Yukon-Tanana Uplands (**oyt**), (3) the southwestern Alaska (**osw**), and in south-central Alaska, (4) the Border Ranges (**obr**) and (5) Gulf of Alaska (**oga**) ophiolitic terranes. They also include two distinct groups or belts of intrusive mafic and ultramafic rocks of uncertain affinity (**mum**): one located between the Yukon River and Fairbanks, and the other along the Denali-Farewll-Togiak fault system in the Alaska Range. Mafic-ultramafic complexes in southeastern Alaska, most of which are of the Ural-Alaskan type, are not discussed in the report by Patton and others (1992) or in this report.

The report by Patton and others (1992) provides a provisional definition of ophiolites that addresses the importance of understanding ophiolites in Alaska and appropriately addresses the conflicts that have arisen over the evolving definition and various connotations of the term.

As used in this report and in the report by Patton and others (1992), "*ophiolite*...refers to an association of mafic and ultramafic rocks that in a complete sequence is characterized, from bottom to top, by tectonized ultramafic rock, a transition zone of interlayered ultramafic and mafic cumulates, layered gabbro, massive gabbro, a mafic sheeted dike complex, and pillow basalt. Most workers now regard ophiolite assemblages as allochthonous fragments of ancient oceanic crust and upper mantle that formed along ocean ridges, in small spreading basins, or as basement to island arcs. None of the ophiolite sequences in Alaska is complete and typically one or more of the characteristic components are missing."

Based on available geologic maps, field observations, geochemical data, and mineral chemistry, some of the mafic and ultramafic rocks described in this report can be related to tectonic environments or distinct petrologic suites. The western Brooks Range ophiolite appears to be intermediate to arc- and mid-ocean ridge basalt (MORB)-type ophiolites (oral commun., R.A. Harris, West Virginia University, Morgantown, 1991). Ophiolite complexes along the southeastern margin of the Yukon-Koyukuk Basin and along the Ruby Geanticline have similar ages and are petrologically similar to the western Brooks Range ophiolites (Patton and others, 1977 and 1989). Serpentinites and associated gabbroic rocks of unknown origin are present in the Livengood-Tofty region (Foster, 1979).

Both ophiolitic complexes and intrusive mafic and ultramafic plutons of unknown origin are present in east-central Alaska (Keith and Foster, 1973, and Foster and Keith, 1974). An intrusive biotite-rich clinopyroxenite body near Butte Creek, on the North Fork of the Fortymile River is interpreted as an "Alaska-type" zoned ultramafic complex (Keith and others, 1987). Compared to the other ophiolites in Alaska, those in the Gulf of Alaska region most resemble MORB-type ophiolites (oral commun., S.W. Nelson, U.S. Geological Survey, Anchorage, Alaska, 1991). Conversely, in south-central Alaska, the Border Ranges ophiolite complex is interpreted as having volcanic arc affinities (Burns, 1983 and 1985). Intrusive composite igneous plutons comprising alkaline and lamprophyric mafic and ultramafic rocks, south of the Denali fault, in the Yentna River area, central Alaska Range, have affinities with deep crustal- or upper mantle-derived igneous rocks, located north of the Denali fault system, in the Mt. Hayes quadrangle, eastern Alaska Range, that are described by Foley (1982, 1984, and 1985). Another suite of deep-seated ultramafic through mafic and intermediate intrusive igneous plutons extends for over 190 km along the south side of the Denali fault and Broxson Gulch fault systems in the eastern and east-central Alaska Range. In southwestern Alaska, incompletely studied ophiolite complexes and Ural-Alaskan type complexes are both present (Patton and others, 1989, Southworth, 1984b and 1986, and Southworth and Foley, 1986).

In this report, sites are variously described as mineral occurrences or mineral deposits. As used in this report, mineral occurrences refer to sites where minerals containing a given commodity simply have been identified. Mineral deposits refer to sites where valuable minerals are concentrated to the extent that they may invite development for extraction and recovery of the commodity.

METALLOGENIC PROVINCES

Based on the distribution of mineral occurrences and deposits associated with ophiolites and the other mafic and ultramafic complexes described in this report series, eleven metallogenic provinces are delineated on figure 1. The metallogenic provinces, as they relate to the regions containing ophiolites, are:

Northern and western Alaska

Western Brooks Range metallogenic province (onw, on fig.1)

Seward Peninsula and western Yukon-Koyukuk Basin margin metallogenic province (onw)

Northern Yukon-Koyukuk Basin margin metallogenic province (onw)

Southeastern Yukon-Koyukuk Basin margin and Ruby Geanticline metallogenic province (onw)

Yukon-Tanana Uplands

Livengood-Tofty metallogenic province (mum)

Salcha-Seventymile River metallogenic province (oyt)

Alaska Range

Eastern Alaska Range metallogenic province (mum)

Central Alaska Range metallogenic province (mum)

Southwestern Alaska

Southwestern Alaska metallogenic province (osw)

South-Central Alaska

Border Ranges metallogenic province (obr)

Gulf of Alaska metallogenic province (oga)

Northern and western Alaska

The northern and western Alaska region contains four metallogenic provinces that are associated with ophiolitic and other mafic-ultramafic rocks in the western Brooks Range or are marginal to the Cretaceous Yukon-Koyukuk Basin.

Western Brooks Range metallogenic province

Mineral deposits and occurrences of chromium, copper, nickel, and PGE are reported in cumulate mafic and ultramafic rocks of the western Brooks Range ophiolite (map nos. 1-6, fig. 1). Based on surface measurements, mineral characterization tests, and beneficiation studies by the Bureau of Mines, the western Brooks Range ophiolite belt is estimated to contain between 725,000 and 2.3 million mt chromic oxide (Cr_2O_3) in 70 deposits of high-chromium chromite at Iyikrok Mountain (map no. 1), Avan Hills (map no. 4), and Misheguk Mountain (map no. 5). Platinum-group elements are associated with chromitites in dunite and peridotite and with iron- and iron-copper-nickel-sulfide minerals in gabbros and troctolites. Chromite, PGE, and gold have been identified in extensive alluvial deposits eroded from the western Brooks Range ophiolite complexes. More recent cooperative studies by the Bureau and the Geological Survey indicate that chromite deposits of similar size and character as those at the other three locations, as well as anomalous gold, silver, PGE, and barium are also present at Siniktanneyak Mountain (map no. 6). High concentrations of gold and PGE are also reported in sulfide-bearing gabbro at Rabbit Creek (map no. 2), located west of the Noatak River. Two unmeasured chromite occurrences are present at Asik Mountain (map no. 3) in the southern part of the province.

Seward Peninsula and western Yukon-Koyukuk Basin margin metallogenic province

Platinum-group elements occurring as native platinum, iron-platinum alloy, and osmiridium are present in gold placers and are apparently derived from intrusive subalkaline, alkaline, and associated ultramafic igneous rocks at Granite Mountain (map no. 8) and Dime Creek (map no. 9) on the eastern Seward Peninsula, at the western margin of the Yukon-Koyukuk Basin. Small ophiolite bodies in the vicinity of Dime Creek and the Granite Mountain intrusive complex, which also contains ultramafic rock, may be the source of the PGE. Chromite, magnetite, rutile, and ilmenite are particularly abundant in placer concentrates at these locations.

Along the Bluestone River and its tributaries, Alder Creek and Gold Run Creek (map no. 7), and outside the metallogenic province delineated on figure 1, minor amounts of platinum are reported in placer gold concentrates. Traces of palladium and platinum are detected in numerous small greenstone stocks in this area.

Northern Yukon-Koyukuk Basin margin metallogenic province

This province (map nos. 10-17 and 19-21) is the source of most of the jade and asbestos produced in Alaska. Placer gold was produced from 1898 until as recently as 1968 in the Dahl Creek (map no. 15) area where chromite is reported in placer concentrates. Chromite is reported in dunite and minor amounts of PGE are reported in pyroxenite, peridotite, dunite, and gabbro samples from the Christian complex (map no. 20). Manganese minerals are reported in mafic volcanic rocks at an unnamed site (map no. 19). Gold and manganese are also reported in sedimentary rocks near Lois Dome (map no. 21). Additionally, there are reports of copper, nickel, and silver in the province. To the south of the delineated province, and in the north-central Yukon-Koyukuk Basin, platinum and cassiterite are reported in placer gold concentrates at Bear Creek (map no. 18).

Southeastern Yukon-Koyukuk Basin margin and Ruby Geanticline metallogenic province

This province (map nos. 22-36) contains between 31,000 and 62,000 mt Cr_2O_3 in 13 exposed podiform chromite deposits and chromite lenses in the Caribou Mountain, Kanuti River, Holonada Creek, and Kaiyuh Hills ophiolite masses. Platinum-group elements are detected in placer samples from the Yuki River Valley (map no. 29), which drains the Kaiyuh Hills, and minor amounts of platinum were recovered as a byproduct during placer gold mining on Granite Creek (map no. 28), 55 km east of the Yuki River. Minor chromite is reported in dunite at Mount Hurst (map no. 31), and gold and PGE have been produced from placers on Boob Creek (map no. 30) and other creeks in the area that drain the Mount Hurst ophiolite mass.

Manganese occurrences and deposits of several types are present within this province. In the Ray Mountains (map no. 32), a manganese lense crops out in chert horizons within an andesite sequence. An unmapped ultramafic mass of possible ophiolitic affinity and containing mostly peridotite underlies the area immediately to the east and north of this occurrence. Epithermal manganese occurrences are present at several sites in the province, including the Avnet (Map no. 33) and Baldry Mountain (map no. 34) prospects and on Little Minook Creek (map no. 35).

Also present in the Province are asbestos, copper, and cobalt occurrences. Gold and cassiterite from unknown sources are present in placer concentrates throughout the province. Placer gold operations on Little Minook Creek (map no. 35) produced over 2,021,000 g (65,000 oz) Au. Placer concentrates there contain argentite, chromite, cinnabar (?), native copper, barite, galena, ilmenite, scheelite, tetradymite, and zircon.

Yukon-Tanana-Uplands

Livengood-Tofty metallogenic province

Chromium, nickel, and PGE have been geochemically detected in all the ultramafic bodies (mum) along the Livengood-Beaver Creek serpentinite belt (map nos. 37-43). Asbestos, accessory chromite, and clots of massive chromite are locally present, as are iron-nickel sulfide minerals. Platinum-group elements are present in placer gold concentrates and in gold bullion from a lode gold prospect in the Livengood area (map no. 41). Other minerals reported in placer concentrates include silver, mercury, scheelite, and cassiterite. Placer gold production in the Tolovana Mining District, which came primarily from the Livengood vicinity, totals more than 12,441,000 g (400,000 oz).

Near Tofty (map no. 43), chromite that is apparently derived from the American Creek serpentinite body is present in placer gold-cassiterite concentrates from many of the creeks in the area. Placer production for the area, which is in the Rampart Mining District, includes over 14,000,000 g

(450,000 oz) Au and 183,000 kg Sn. Other minerals in the Tofty placers include barite, columbite, monazite, xenotime, and zircon. Identified niobium (columbium) resources in the Tofty area include 155,000 kg Nb in dolomitic marble regolith and 45,000 kg Nb_2O_5 in placers.

Salcha-Seventymile River metallogenic province

Variably serpentinized and silica-carbonate-altered ultramafic rocks of several types, including allochthonous (oyt) masses are present along the Seventymile and Salcha Rivers (map nos. 44-57) and elsewhere in the Eagle quadrangle. In addition to these are small lenses and sills of intrusive clinopyroxene- and hornblende-rich rocks of uncertain origin. Gold and PGE minerals have been identified in the latter and copper, nickel, gold and PGE have been detected geochemically in silica-carbonate-altered mafic and ultramafic rocks in the Salcha-Seventymile metallogenic province. Platinum-group elements, occurring as natural alloys and native metal, plus chromite, silver, tin, and tungsten minerals are locally present in gold placers.

Fifty-four million tons (mt) averaging greater than 5 pct asbestos are delineated in three deposits in serpentinized ophiolitic rocks by diamond-drilling in the Slate Creek area (map no. 54). Several other asbestos deposits in the area have not yet been delineated by drilling.

Alaska Range

Eastern Alaska Range metallogenic province

Chromite- bearing serpentinized peridotite and serpentinite underly several areas (mum) in the eastern part of this metallogenic province. These sites include Mirror Lake (map no. 58), Carden Hills (map no. 59), and Gillett Pass (map no. 66). Platinum-group elements are detected in chromitite samples from the Carden Hills and sulfide-bearing mafic-ultramafic rocks near VABM Mineral (map no. 61). Asbestos and jade are locally present in this province.

Platinum is reported in heavy mineral and placer concentrates from numerous sites throughout this province including Platinum Creek (map no. 60) and several placer gold-producing areas in the Chistochina Mining District. More than 5,536,000 g (178,000 oz) Au and minor amounts of PGE were produced in this district, most of it from the Slate Creek area (map no. 70).

The Slate Creek area is at the eastern end of an arcuate belt of fault-bounded intrusive igneous rocks (mum) that extends for at least 190 km to the southwest (map nos. 70-81). This belt of igneous rocks parallels the Denali-Farewell-Togiak fault system and other faults, including the Broxson Gulch thrust and Talkeetna faults. Associated with these igneous rocks that range in composition from cumulate dunite and peridotite through gabbro and hypabyssal syenodiorite to silicified and carbonate-altered equivalents, are numerous lode copper-cobalt-gold-nickel-PGE occurrences. Locally associated with these are appreciable chromium, silver, and mercury. Within this belt, the valuable metals occur in a variety of petrologic and mineralogical associations in the fault-bounded intrusive rocks.

Central Alaska Range metallogenic province

Farther to the west, in intrusive ultramafic rocks (mum) in the Yentna-Chulitna mineral belt are small banded and podiform chromite deposits, and cobalt, copper, gold, nickel, silver, and titanium lode occurrences (map nos. 82-92). Ultramafic rocks, including dunite and peridotite are locally replaced by silica and carbonate minerals. Also in this region are Cretaceous composite plutons comprising various combinations of peridotite, lamprophyric and alkaline mafic and ultramafic rocks, monzonite, syenite, quartz syenite, and granitic rocks. The Cretaceous composite plutons occur within a distinct belt that extends southwest from the upper Yentna River area to Mount Estelle. Associated with the composite plutons are gold and PGE anomalies. Pan concentrate samples collected in the vicinity of the composite plutons and placer gold concentrates produced downstream from them contain and could have been the source of platinum recovered since the early 1900's. Lode iron-copper-nickel sulfide occurrences are reported in the mafic and ultramafic igneous rocks and in volcanic rocks at several sites in the province. This province overlaps a trend of tin occurrences and deposits in the Alaska Range that are associated with Cretaceous and Tertiary intrusive rocks extending southwest from near Healy to Lake Clark (Warner, 1985). Cassiterite is widespread in placer deposits throughout this region.

Southwestern Alaska metallogenic province

In Southwestern Alaska (map no. 94-103), about 20,217,000 g (650,000 oz) PGE and about 311,000 g (10,000 oz) Au were produced from the Salmon River placers, which, were eroded from the Goodnews Bay Ural-Alaskan type ultramafic complex (map no. 101). The Goodnews Bay complex contains minor chromite, iron-copper-, and iron-nickel-sulfide minerals. Offshore marine placers and beach placers, on the west side of the Goodnews Bay complex, contain gold, PGE, and chromite. Ophiolitic mafic and ultramafic rocks (osw) in the Cape Newenham-Chagvan Mountain area (map no. 102), and in the Arolik River area (map no. 97 and 98) contain gold, chromium, PGE, copper, and nickel occurrences. Minor amounts of PGE have been identified in heavy mineral concentrates or recovered from gold placers in the Cape Newenham and Arolik River areas. Cross-fiber chrysotile asbestos occurs in serpentinized peridotites near Cape Newenham. Platinum is also reported in placer gold concentrates from Disappointment, Willow, and Wilson Creeks (map no. 93), in the Yukon River Valley and to the northwest of the metallogenic province. To the east of the province, and buried beneath unconsolidated sediments and glacial till is the Kemuk Mountain Ural-Alaskan type complex (map No. 104), which hosts a titaniferous magnetite deposit.

South-Central Alaska

Border Ranges metallogenic province

Within this metallogenic province (map nos. 105-129), chromite deposits in dunitic portions of ophiolites (obr) at Bernard Mountain (map no. 123), Sheep Hill (map no. 124), Eklutna (map no. 116), Red Mountain (map no. 114), Windy River (map no. 115), Claim Point (map no. 112), and near Halibut Bay (map no. 105) contain a minimum of 2.5 million mt Cr_2O_3. Minor chromite was produced from deposits at Claim Point during the first World War and at Red Mountain during the second World War and the Korean conflict. Additional unmeasured deposits of high-chromium and high-iron chromite have been identified at all theses sites plus Dust Mountain (map no. 125), the Wolverine complex (map no. 118), and at the other sites on Kodiak Island (map nos. 108-111). Associated with some of the chromite deposits are PGE and minor gold. Other deposits and occurrences in this belt contain cobalt, copper, gold, nickel, silver, manganese, and soapstone.

Gulf of Alaska metallogenic province

Numerous copper prospects were developed in small ophiolite complexes (oga)(Nelson and others, 1987, and Nelson and Koski, 1987). The largest producing mines, however, are hosted in turbidite sequences spatially related to the ophiolites. Lode gold in this metallogenic province was primarily recovered as a byproduct during copper production from the larger copper mines. Manganese deposits associated with pillow basalts and altered volcanic rocks have been described on Chenega and Hinchenbrook Islands, in Prince William Sound (map nos. 130-137)(Kurtak, 1982, and Goodfellow and others, 1984). Lode gold and copper deposits with associated lead, nickel, silver, tungsten, zinc, and cadmium have been mined and prospected by open-pit and underground workings (Jansons and others, 1984).

EXPLANATION OF TABLE 1 AND FIGURE 1

Information listed in table 1 includes map numbers that correspond to numbered locations on the map shown in figure 1, summaries of available published and unpublished information regarding the metallogeny, geology, mineralogy, geochemistry, and history of each site or area, and citations of published and unpublished references. Commodities of past or potential future economic interest are also listed. Commodities for which evidence supports a genetic association with ophiolitic or other mafic and ultramafic rocks are listed first. Commodities that are not considered to be of ophiolitic origin or are not generally associated with mafic and ultramafic rocks are listed in parentheses.

Table 1. - Mineral Deposits and Occurrences Associated with Ophiolitic Terranes in Alaska

Northern and western Alaska - Western Brooks Range metallogenic province

<u>No.</u> <u>Location</u> <u>Commodities</u>

1. **Iyikrok Mountain** — **Cr**

Based on surficial measurements, 131,000-347,000 mt Cr_2O_3 are present in two low-grade deposits with about 4 pct chromite in a dismembered ophiolite mass comprising variably serpentinized dunite with associated peridotite, pyroxenite, and gabbro. Twenty other unmeasured lode occurrences are present and minor placer potential exists.

References: Patton and others, 1977 and 1989; Roeder and Mull, 1978; Mayfield and others, 1983b; and Foley and others, 1985 and 1986.

2. **Rabbit Creek** — **Au, Cu, Ni, PGE**

Based on fire-assay, optical-emission spectrography or neutron activation for palladium and platinum, and X-ray emission or atomic absorption spectrometry for gold, copper, nickel, and cobalt, eight sulfide-bearing gabbro and troctolite float samples contain: 209-316 ppb (0.006-0.009 oz/st) Au; 343-1,090 ppb (0.010-0.032 oz/st) Pd; 412-1,810 ppb (0.012-0.053 oz/st) Pt; 1,000-4,200 ppm Cu; 40-350 ppm Ni; and 10-90 ppm Co. Principle sulfide minerals include pyrrhotite and chalcopyrite, with lesser bornite, covellite, and pyrite.

References: Mowatt and Jansons, 1985; and Mowatt, 1989 and 1991.

3. **Asik Mountain** — **Cr**

Two banded chromite occurrences with 2- to 5-cm-wide chromite-rich bands in "dark-colored, basic, igneous rock" (dunite ?) at one site and a similar occurrence less than 1 km to the southwest on the same ridge. Based on fire-assay, optical-emission spectrography or neutron activation for palladium and platinum, and X-ray emission or atomic absorption spectrometry for gold, copper, nickel, and cobalt, six sulfide-bearing troctolitic(?) gabbro samples contain: 80-220 ppb (0.002-0.006 oz/st) Au; 480-1,112 ppb (0.014-0.032 oz/st) Pd; 510-1,605 ppb (0.15-0.047 oz/st) Pt; 1,100-3,600 ppm Cu; 110-655 ppm Ni; and 80-125 ppm Co. Principle sulfide minerals include pyrrhotite and chalcopyrite, with lesser bornite, covellite, pyrite, and pentlandite(?).

References: Saunders, 1955; Patton and others, 1977 and 1989; Roeder and Mull, 1978; Mayfield and others, 1983b; Mowatt and Jansons, 1985; and Mowatt, 1989 and 1991.

4. Avan Hills **Cr, PGE, (Au)**

Based on surficial measurements, 424,000-1,573,000 mt Cr_2O_3 are present in 26 deposits in dismembered ophiolite comprising variably serpentinized dunite with associated peridotite (primarily wehrlite with lesser lherzolite and harzburgite), pyroxenite, and gabbro. At least 50 other unmeasured occurrences with potential for large low-grade placer chromite deposits with byproduct gold and PGE are reported. Depending on grade, which may be as much as 10 pct chromite, and actual size, the largest of the chromite deposits may contain more than 900,000 mt Cr_2O_3. As much as 549 ppb (0.016 oz/st) Pd and 480 ppb (0.014 oz/st) Pt were detected by fire-assay, atomic absorption procedures in two chromite samples. Based on fire-assay, optical-emission spectrography or neutron activation for palladium and platinum, and X-ray emission or atomic absorption spectrometry for gold, copper, nickel, and cobalt, eight sulfide-bearing troctolite and gabbro samples contain: 110-360 ppb (0.003-0.015 oz/st) Au; 412-990 ppb (0.012-0.029 oz/st) Pd; 606-1,502 ppb (0.018-0.044 oz/st) Pt; 1,100-3,500 ppm Cu; 60-410 ppm Ni; and 19-61 ppm Co. Principle sulfide minerals include pyrrhotite and chalcopyrite, with lesser pyrite, bornite, covellite, and pentlandite(?). Subeconomic PGE concentrations are reported in placer samples.

References: Patton and others, 1977 and 1989; Roeder and Mull, 1978; Jansons and Baggs, 1980; Mayfield and others, 1983a and 1983b; Curtis and others, 1984; Foley and others, 1985, 1986, and 1989; Mowatt and Jansons, 1985; Mowatt, 1989 and 1991; and unpublished Bureau of Mines data.

5. Misheguk Mountain **Cr, PGE, (Au)**

Based on surficial measurements, 106,000-317,000 mt Cr_2O_3 are present in 9 low-grade banded zones in a dismembered ophiolite mass comprising variably serpentinized dunite with associated peridotite (primarily wehrlite with lesser lherzolite and harzburgite), pyroxenite, and gabbro. The largest of the identified chromite deposits contains between 71,000 and 234,000 mt Cr_2O_3. At least 30 additional unmeasured chromite occurrences with potential for large low-grade placer chromite deposits with byproduct gold and PGE are reported.

Fire-assay, neutron-activation analyses detected as much as 4,700 ppb (0.137 oz/st) Pd, 4,200 ppb (0.122 oz/st) Pt, 140 ppb (0.004 oz/st) Ir, 45 ppb (0.0013 oz/st) Os, 360 ppb (0.0105 oz/st) Rh, 98 ppb (0.0029 oz/st) Ru, and 14 ppb (0.0004 oz/st) Au in iron-rich chromitite samples from a clinopyroxene-rich zone in dunite and peridotite; 137 ppb (0.004 oz/st) Pd and 171 ppb (0.005 oz/st) Pt in plagioclase peridotite with accessory pyrrhotite; and 22 ppb (0.0006 oz/st) Pd, and 42 ppb (0.0012 oz/st) Pt in dunite. Inductively-coupled plasma, mass spectrometry analyses detected 96 ppb (0.0028 oz/st) Pd, 150 ppb (0.004 oz/st) Pt in wehrlite, 230 ppb (0.007 oz/st) Pd and 150 ppb (0.004 oz/st) Pt in dunite with accessory chromite; 210 ppb (0.006 oz/st) Pd and 130 ppb (0.004 oz/st) Pt in altered gabbro; and 140 ppb (0.004 oz/st) Pd and 82 ppb (0.0024 oz/st) Pt in an altered gabbro, all from Misheguk Mountain. Based on fire-assay, optical-emission spectrography or neutron activation for palladium and platinum, and X-ray emission or atomic absorption spectrometry for gold, copper, nickel, and cobalt, six troctolitic(?) gabbro samples contain: 100-250 ppb (0.003-0.007 oz/st) Au, 402-985 ppb (0.012-0.029 oz/st) Pd; 512-1,826 (0.015-0.053 oz/st) Pt; 1,500-4,000 ppm Cu; 115-808 ppm Ni; and 30-82 ppm Co.

Ore microscope and scanning-electron microscope examination show that sperrylite ($PtAs_2$) inclusions, as much as 10 microns across, are associated with argentite in high-iron chromian spinel segregations in clinopyroxene-rich portions of the Misheguk Mountain ophiolite mass. Based on X-ray microanalyses, chromium to iron (Cr:Fe) ratios of this chromian spinel are about 1.3, much lower than the Cr:Fe ratios of more typical chromites at Misheguk Mountain and elsewhere in the western Brooks Range ophiolite that are not associated with clinopyroxene-rich rocks. The principle sulfide minerals in the sulfide-bearing gabbros and troctolites are pyrrhotite and chalcopyrite, with lesser pyrite, bornite, covellite, and pentlandite(?).

References: Patton and others, 1977 and 1989; Degenhart and others, 1978; Roeder and Mull, 1978; Jansons and Baggs, 1980; Mayfield and others, 1983b; Curtis and others, 1984; Ellersieck and others, 1984; Foley and others, 1985, 1986, and 1989; Harris, 1987, 1988, and 1989; Mowatt and Jansons, 1985; Mowatt, 1989 and 1991; and unpublished Bureau of Mines data.

6. Siniktanneyak Mountain — **Ag, Au, Cr, Cu, Ni, PGE**

Widespread accessory disseminated and banded chromite occur in serpentinite and dunite with associated pyroxenite, olivine pyroxenite, peridotite (primarily wehrlite with lesser lherzolite and harzburgite), cumulate gabbro, and hornblende pyroxene gabbro. Several large low-grade chromite concentrations similar to those at the other western Brooks Range ophiolite masses and containing from 3-5 pct chromite with numerous smaller concentrations containing from 10-15 pct chromite were identified in 1991. Samples from high-grade chromite segregations within these zones contained as much as 28 pct Cr. A copper prospect, for which no description is available, was located in the 1970's.

Based on fire-assay, directly-coupled plasma analyses for gold, palladium, and platinum and inductively-coupled plasma analyses for silver, copper, and nickel, the following anomalous metal concentrations were detected. Samples of very coarse-grained chromite associated with pegmatitic clinopyroxene veins in dunite and lherzolite contain as much as 110 ppb (0.0032 oz/st) Pd and 618 ppb (0.0180 oz/st) Pt. Samples from several sulfide-bearing zones in gabbro contained as much as 1,928 ppm Cu and 1,725 ppm Ni. A pyritic diorite dike sample contained 166 ppb (0.0048 oz/st) Pd and 56 ppb (0.0016 oz/st) Pt. A pyritic felsite, collected up slope and along strike with the previous sample contained 13.4 ppm (0.39 oz/st) Ag and 77 ppb (0.0022 oz/st) Au. A rhyolite(?) sample from a basaltic outcrop at the faulted margin of the complex contained 280 ppb (0.0082 oz/st) Pd and 65 ppb (0.0019 oz/st) Pt. A gabbro sample contained 184 ppb (0.0054 oz/st) Au. Fire-assay, emission spectrography analyses of a clinopyroxenite sample collected near the previous sample location detected 100 ppb (0.0029 oz/st) Pd and 70 ppb (0.0020 oz/st) Pt. Emission spectrographic analysis of a sample from the pyritic felsite described above detected 3,000 ppm Ba. Based on fire-assay, optical-emission spectrography or neutron activation for palladium and platinum, and X-ray emission or atomic absorption spectrometry for gold, copper, nickel, and cobalt, six troctolitic gabbro samples contain: 150-240 ppb (0.004-0.007 oz/st) Au; 511-1,426 ppb (0.015-0.042 oz/st) Pd; 483-1,215 ppb (0.014-0.035 oz/st) Pt; 1,000-2,600 ppm Cu; 230-910 ppm Ni; and 56-115 ppm Co. Principle sulfide minerals include bornite, chalcopyrite, and pentlandite(?), with lesser bornite, pyrite, and covellite.

References: Patton and others, 1977 and 1989; Jansons and Baggs, 1980; AEIDC, 1982; Nelson and Nelson, 1982; Foley and others, 1985 and 1986; Mowatt, 1989 and 1991; and unpublished Bureau of Mines data.

Northern and western Alaska - Seward Peninsula and western Yukon-Koyukuk Basin margin metallogenic province

7. Gold Run and Bluestone River — **PGE, (Au)**

Minor amounts of platinum reported in placer gold concentrates may be derived from widespread gabbro bodies in the surrounding area.

References: Cobb, 1975; and Sainsbury and others, 1969, p. 15.

8. Granite Mountain — **Cr, PGE, (Ag, As, Au, Bi, Cu, Mo, Pb, Tl, U, Zn)**

Gold and minor amounts of platinum were recovered during placer mining on creeks draining Middle Jurassic to Early Cretaceous andesitic volcanic and volcaniclastic rocks where they are intruded by the Cretaceous alkaline to subalkaline Granite Mountain igneous complex. The Granite Mountain complex comprises a hornblende-pyroxene syenite core surrounded by quartz monzonite and monzonite with a border of pseudoleucite syenite, biotite pyroxenite, and various types of garnet-bearing nepheline syenite. Unpublished aeromagnetic data indicate that an intrusive ultramafic complex, much larger than the exposed 80-km^2 Granite Mountain complex, lies beneath the surface (oral commun., Mark M. McDermott, formerly with Anaconda Minerals Company, Anchorage, Alaska, 1985). Gold and PGE-bearing streams in the area include Bear Creek (Bear Gulch), Sweepstakes Creek, Peace River, their tributaries, and Quartz Creek.

Bedrock metallic mineral occurrences in the Granite Mountain area include bismuth, copper, gold, lead, molybdenum, silver, zinc, and uranium showings in altered rhyolite, quartz monzonite, syenite, and andesite. Ten or more small open cuts exist on the north side of Split Creek, a tributary of Bear Creek, where chalcopyrite and copper carbonate are reported. Bismuth, molybdenum, and silver are reported in altered syenite and quartz veins in the upper Peace River where anomalous lead, zinc, copper, and uranium have been reported in panned concentrates. Numerous occurrences of argentiferous galena and sphalerite, with associated pyrite and arsenopyrite, are reported in altered andesitic rocks in the Quartz Creek and Kiwalik River areas, west of Granite Mountain.

Mining activity in the area includes sporadic placer gold, with byproduct platinum production, since the early 1900's and as recently as 1986. Based on scanning-electron microscope analysis, the composition of 40 iron-platinum alloy grains picked from a placer sample from Quartz Creek in 1984 averaged 80 pct Pt and 20 pct Fe. A minus 20-mesh concentrate produced from a 100-m^3 sample collected on Sweepstakes Creek contains 1,700 ppm (49.6 oz/st) Pt and 12 ppm (0.350 oz/st) Pd.

Other heavy minerals reported in the placer concentrates include magnetite, ilmenite, hematite, pyrite, olivine, chromite, rutile, zircon, uranothorianite, and garnet.

References: Harrington, 1919b; Gault and others, 1953, p. 4; Miller and Elliott, 1969; Miller, 1970 and 1972; Cobb, 1973, p. 62 and 73; Cobb, 1975; Foley and others, 1989; and unpublished Bureau of Mines data.

9. Dime Creek — **Cr, PGE, (Au, Tl)**

Gold, minor amounts of platinum, and lesser osmiridium were recovered during placer mining on Dime Creek, which drains Middle Jurassic to Early Cretaceous andesitic volcanic and volcaniclastic rocks with associated diabases and peridotites. PGE and chromite are possibly derived from a peridotite body at the head of Dime Creek. Aeromagnetic data indicate that an elongate, north-south-trending ultramafic body underlies much of Dime Creek and the Sweepstakes Creek area, a few kilometers to the north (oral commun., Mark M. McDermott, formerly with Anaconda Minerals Company, Anchorage, Alaska, 1985).

Other heavy minerals reported in the placer concentrates include olivine, pyroxene, magnetite, hematite, limonite, chromite, rutile, and garnet.

Gold was discovered in 1915. About 1,089 g (35 oz) Pt were recovered in 1917. The platinum to gold ratios in placer concentrates range from about 1:250 on lower Dime Creek to 1:100 on the upper reaches of the creek. Platinum from upper Dime Creek includes angular and shot-like grains.

References: Harrington, 1919b; Cobb, 1973, p. 60 and 82; Cobb, 1975; and Foley and others, 1989.

Northern and western Alaska - northern Yukon-Koyukuk Basin margin metallogenic province

10. Hunt River — **Asbestos**

Strong, flexible, amphibole asbestos with fibers as much as 5 cm long from a 1-cm seam were reported by an Eskimo hunter at the extreme head of Hunt River. The location is uncertain.

References: Anderson, 1947.

11. Jade Mountain — **Asbestos, jade, Ni**

Cross- and slip-fiber chrysotile seams as much as 1.5 cm wide and averaging 0.6 cm wide are exposed in numerous outcrops in a 90- by 180-m area and in a short tunnel at the head of Jade Creek. Cross- and slip-fiber tremolite, low-quality nephrite, and garnierite are also reported. Gem-quality nephrite is reported from nearby Jade Creek.

References: Anderson, 1945 and 1947; and Heide and others, 1949.

12. Shungnak River — **Asbestos, jade**

Cross- and slip-fiber chrysotile and other asbestiform minerals make up several percent of fractured serpentinite bedrock in a 24-m-wide by 100-m-long zone at Bismark Mountain. Asbestos is variably present in a larger serpentinite zone that is exposed for over 3 km. Slip-fiber veins are from 1 to 5 cm wide with fibers mostly less than 2.5 cm long, but reaching a maximum length of about 5 cm. Associated minerals include magnesite, antigorite, magnetite, and nemalite, a fibrous form of brucite. Gem-quality nephrite is reported in float from Shungnak River.

Four bulldozer trenches were excavated by the Bureau of Mines in 1944. A 1-mt sample from these trenches was shipped to the Bureau's Research Center in Rolla, Missouri for beneficiation tests. Although the fiber produced by these tests was of good length and moderate tensile strength, unfavorable characteristics including brittleness and the presence of iron oxide made the product of inferior quality.

References: Anderson, 1945 and 1947; and Heide and others, 1949.

13. Cosmos Creek — **Asbestos, jade**

Cross-fiber chrysotile veins from 1 to 10 cm wide form extensive networks in a 400-m-long portion of 38-m-thick serpentinite mass. Associated with the cross-fiber asbestos is slip-fiber chrysotile with 5- to 10-cm-long fibers. Nephrite boulders were recovered from Cosmos Creek.

Minor development took place prior to 1945. In 1945 and 1946, the Bureau of Mines excavated six bulldozer trenches and collected two large samples, both weighing about 3 mt, for beneficiation and grade testing by Johns-Manville Company, Asbestos, Quebec. Compared to Canadian fibers that Johns-Manville normally processed, the Cosmos Creek asbestos had a high dust and fines content, looser density, shorter staple length, and lacked the silky character of the typical Canadian fiber. Fiber recoveries by conventional processes were marginal.

References: Anderson, 1945 and 1947; and Heide and others, 1949.

14. Wesley **Asbestos, jade**

Asbestiform tremolite and gem-quality nephrite occur near the head of Wesley Creek.

References: Anderson, 1945.

15. Dahl Creek **Asbestos, jade, Cr, (Au, Cu)**

Tremolite and high-quality cross- and slip-fiber chrysotile in serpentinized nephritic and peridotite bedrock with tremolite fibers as much as 0.3 and 0.6 m long occur at two locations, with associated nephrite, talc, magnesite, magnetite, and antigorite. Tremolite lenses as much as 2 m thick occur in serpentinized zone as much as a 100 m long. Forty-three tons (43 mt) of asbestiform tremolite were produced from four trenches and a 70-m adit in 1944 and 1945 by Arctic Circle Mining Company, Candle, Alaska. Nearly 1 mt of chrysotile and 5 mt of jade boulders were produced in 1945. Remaining reserve estimates include at least 40 mt of tremolite and several tons of chrysotile. Nephrite boulders are reported in Dahl Creek.

The deposits were discovered in 1932 and 1933. Development by the Arctic Circle Mining Company began in 1943. Additional development work by the Bureau of Mines consisted of cleaning out the earlier workings in 1946 and collection of 3 mt for beneficiation and grade tests by Johns-Manville Company. The beneficiation products consisted of long dark grey and brown fibers with high dust and fines content and loose density. These fibers were considered unsuitable for textile manufacturing, but might have uses in shingles and other construction materials.

Placer gold was discovered on Dahl Creek in 1898 and on nearby streams in the succeeding years. Production continued until as recently as 1968. Chromite is reported in the placer concentrates.

References: Anderson, 1945 and 1947; Heide and others, 1949; and Cobb, 1973, p. 56 and 59.

16. Kogoluktuk River **Asbestos, (Au)**

Asbestiform amphibole and cross-fiber chrysotile occur in placer workings and in float on south side of lower California Creek, tributary to Koguluktuk River. Fibers as much as 8 cm long are reported.

References: Anderson, 1945 and 1947; and Heide and others, 1949.

17. **Herbert, Ivan, and Stewart** **Jade**

Minor jade production was reported.

References: Unpublished Bureau of Mines data.

18. **Bear Creek** **PGE, (Au, Sn)**

"Platinum-group metals" and cassiterite were identified in placer samples collected in the 1920's. More recently, placer gold was recovered by a dredge operated on Bear Creek.

References: Cobb, 1973, p. 138 and 144-145; and Cobb, 1975.

19. **Unnamed** **Mn**

Rhodochrosite, manganite, and pyrolusite are reported in altered mafic volcanic rocks and phyllite.

References: Patton and Miller, 1966.

20. **Christian River** **Cr, PGE**

Seven percent chromite was estimated in a dunite sample from Levi Creek and 6.6 pct Cr_2O_3 was detected by atomic absorption in dunite sample near Christian River, at head of Timber and Marten Creeks. Fire-assay, atomic absorption analyses detected 20 ppb (0.0006 oz/st) Pd and 103 ppb (0.003 oz/st) Pt in Cr-bearing magnetite from Levi Creek and traces of PGE in pyroxenite, peridotite, dunite, and gabbro from the Christian River complex.

References: Hawley and Garcia, 1976; Enns and Findlay, 1977; Patton and others, 1977 and 1989; and Foley and others, 1989.

21. **Lois Dome** **(Au, Mn)**

A 2.5-cm-wide psilomelane vein occurs in red ferruginous argillite and a gold-bearing manganiferous pebble was found in the same area. Mineral deposits in the region possibly include sedimentary and volcanic types.

References: Brosge' and Reiser, 1968; and Barker, 1981.

Northern and western Alaska - southeastern Yukon-Koyukuk Basin margin metallogenic province

22. **Upper Kanuti River** **Cr**

Numerous small occurrences of disseminated and massive chromite are reported in dunite and peridotite bedrock and rubble.

References: Patton and Miller, 1970; Patton and others, 1977 and 1989; Foley and McDermott, 1983; Foley and others, 1985; and Loney and Himmelberg, 1985.

23. Caribou Mountain Cr, PGE

Based on surficial measurements, 1,800-2,200 mt Cr_2O_3 are present in three deposits containing high-chromium chromite and magnesian chromohercynite in banded intervals as much as 3 m thick and exposed for as much as 15 m along strike. Seven additional unmeasured or minor occurrences of banded and disseminated chromian spinel are reported. One high-grade chromite sample contained 377 ppb (0.011 oz/st) Pd and 1,337 ppb (0.039 oz/st Pt).

Ultramafic and mafic rocks at Caribou mountain include tectonized harzburgite, dunite, and pyroxenite, and cumulate wehrlite, olivine clinopyroxenite, and gabbro.

References: Patton and Miller, 1970; Clautice, 1978; Dahlin and others, 1983; Foley and McDermott, 1983; Foley and others, 1985, 1986, and 1989; and Loney and Himmelberg, 1985.

24. Lower Kanuti River **Cr, PGE**

Six hundred to seven hundred tons (600-700 mt) Cr_2O_3 are present in banded and disseminated high-chromium chromite in a 1.5-m-thick by 24-m-long exposure. Thirteen additional unmeasured or minor occurrences are reported. A tabled chromite concentrate from one sample contained 340 ppb (0.010 oz/st) Pt.

Ultramafic and mafic rocks at Caribou mountain include tectonized harzburgite, dunite, and pyroxenite, and cumulate wehrlite, olivine clinopyroxenite, and gabbro.

References: Patton and Miller, 1970; Patton and others, 1977 and 1989; Clautice, 1978; Dahlin and others, 1983; Foley and McDermott, 1983; and Foley and others, 1985, 1986, and 1989; and Loney and Himmelberg, 1985.

25. Sithylemenkat Lake **Cr, Co, Cu**

Accessory chromite occurs in a small serpentinized dunite, serpentinized peridotite, and gabbro body. A frost boil sample containing serpentine fragments is reported to contain 700 ppm Co, 3,000 ppm Cr, and 500 ppm Cu.

References: Herreid, 1969, p. 18-19; Patton and Miller, 1970; Patton and others, 1977 and 1989; Foley and others, 1985, 1986, and 1989; and Loney and Himmelberg, 1985.

26. Kilolitna River **Cr**

Numerous small occurrences of disseminated and massive high-chromium chromite are reported in dunite bedrock and rubble.

Ultramafic and mafic rocks at Kilolitna River include tectonized harzburgite, dunite, and pyroxenite, and cumulate wehrlite, olivine clinopyroxenite, and gabbro.

References: Patton and Miller, 1970; Patton and others, 1977 and 1989; Foley and others, 1985 and 1989; and Loney and Himmelberg, 1985.

27. Holonada Creek **Cr**

13,000-25,500 mt Cr_2O_3 are estimated in a 120-m-long, 1.5- to 4.5-m-wide deposit with 20 pct high-chromium chromite and four other low-grade deposits with less than 1,000 mt Cr_2O_3 in each.

Ultramafic and mafic rocks at Caribou mountain include tectonized harzburgite, dunite, and pyroxenite, and cumulate wehrlite, olivine clinopyroxenite, and gabbro.

References: Patton and Miller, 1970; Patton and others, 1977 and 1989; Foley and others, 1985 and 1986; Loney and Himmelberg, 1985; and unpublished Bureau of Mines data.

28. Granite Creek **PGE, (Au)**

Minor amounts of platinum were produced as a byproduct during placer gold mining.

References: Cobb, 1973, p. 170.

29. Kaiyuh Hills and Yuki River **Cr, PGE**

Based on surface measurements, 15,000-34,000 mt Cr_2O_3 are estimated in four high-chromium chromite deposits in dunite. The largest deposit contains a 1-m-wide by 100-m-long massive chromite layer and the other three are low-grade banded and disseminated zones with 5 pct or less chromite. Fourteen additional minor or unmeasured occurrences plus placer potential are reported. PGE have been detected in placer samples from the Yuki River Valley and potential exists for recoverable PGE in placer deposits (oral commun., Toni Hinderman, Alaska Earth Sciences, Anchorage, Alaska, 1987).

Dismembered ophiolite in the Kaiyuh Hills comprises tectonized harzburgite and dunite; cumulate dunite, wehrlite, and olivine clinopyroxenite; and gabbro.

References: Foley and others, 1984, 1985, 1986, and 1989; and Loney and Himmelberg, 1984.

30. Boob Creek **Cr, PGE, (Au)**

During placer gold mining in 1917, 933 g (30 oz) PGE were produced. PGE and chromite were eroded from nearby Mount Hurst dunite and peridotite. Iron-platinum alloy containing 90-92 pct Pt, about 5 pct Fe, and as much as 2 pct Rh, and osmiridium with minor ruthenium were identified by microprobe analysis in a placer concentrate from a recently excavated prospect pit.

References: Harrington, 1919a, p. 349-350; Roberts, 1984b; Foley and others, 1985, and 1989; and unpublished Bureau of Mines data.

31. Mount Hurst **Cr, PGE**

Chromite is reported in seven dunite bedrock and nine dunite float occurrences. The largest bedrock occurrence contains from 35 to 80 pct ferroan picrochromite, is exposed for 8 m along strike, and ranges from 15 to 80 cm wide. As much as 890 ppb (0.026 oz/st) Pt were detected in chromitite sample.

Dismembered ophiolite at Mount Hurst comprises tectonized harzburgite and dunite; cumulate dunite, wehrlite, and olivine clinopyroxenite; and gabbro.

References: Loney and Himmelberg, 1984; Roberts, 1984a and 1984b; and Foley and others, 1985 and 1989.

32. Ray Mountains **Asbestos, Au, Mn, PGE**

As much as 25 pct Mn is reported in samples from a 1-m-thick bed in a chert horizon within a thicker andesite sequence. A Mn-rich cherty interval is exposed for 60 m along strike. Hausmanite and braunite (manganese-oxides) were identified by X-ray analyses. Other occurrences in the area consist of manganese-rich float and rubble. Chrysotile fibers are reported in talus on nearby Dreamland Creek. Several thousand meters to the north and east of the manganese occurrence is a small body of peridotite, plagioclase peridotite, and gabbro that does not appear on published geologic maps of the area. Peridotite samples from this body contain as much as 25 ppb (0.0007 oz/st), 45 ppb (0.0013 oz/st) Pd, and 40 ppb (0.0012 oz/st) Pt.

References: Bureau of Mines, 1963, p. 29 and 44; and Barker, 1980, p. 20.

33. Baldry Mountain **(Mn)**

A psilomelane-bearing manganese deposit is reported on the west slope of Baldry Mountain.

References: Killeen and Mertie, 1951; and Burand and Saunders, 1966.

34. Avnet prospect **(Ag, Mn)**

Abundant psilomelane and minor pyrolusite occur in quartzite and vein quartz float, talus, and rubble scattered over a 180-m- by 900-m-area along flat-topped ridge. Manganese minerals occur primarily as lattice works and stockworks in hydrothermal vein quartz in quartzite and phyllite country rock. Samples contain from 0.59 to 34.4 pct Mn and as much as 9.6 ppm (0.28 oz/st) Ag. Although no ultramafic rocks occur in the immediate vicinity of the Avnet prospect, other manganese occurrences in the region are spatially related to mafic and ultramafic rocks.

References: Thomas, 1965; and unpublished Bureau of Mines data.

35. Little Minook Creek **Cr, (Ag, Au, Bi, Cu, Hg?, Mn, Pb, Ti, W)**

Rhodochrosite or rhodonite are reported in outcrops on Little Minook Creek. Diabase dikes cut slate, sandstone and greenstone(?) bedrock, which is jointed and sheared and contains pyrite, chalcopyrite, and auriferous quartz-calcite veins. Placer concentrates contain gold, chromite, picotite, native copper, native silver, hematite, barite, pyrite, galena, ilmenite, magnetite, argentite, tetradymite, scheelite, cinnabar(?), garnet, zircon, and sphene.

Gold was discovered on Little Minook Creek in 1893 and up until 1977, total production is estimated at 1,555,000-2,022,000 g (50,000-65,000 oz).

References: Mertie, 1934, p. 181-183; Burand and Saunders, 1966; Cobb, 1973, p. 165-167; and Cobb, 1977, p.55-57.

36. **Lost Creek** **Asbestos, Mn**

Cross-fiber chrysotile asbestos is reported "in float rock", manganite is disseminated in chert breccia with clay-altered clasts, and botryoidal psilomelane occurs in vein quartz rubble over 100-m-wide area at ridgecrest.

References: Barker, 1980, p. 20.

East-central Alaska - Livengood-Tofty metallogenic province

37. **Big Creek** **Asbestos**

Asbestiform amphibole occurs along fractures in serpentinized ultramafic outcrop.

References: Barker, 1980

38. **Beaver Creek** **Asbestos, Cr, Ni, PGE**

As much as 0.51 pct Ni and trace platinum, palladium, and rhodium were detected in serpentinite bedrock samples. PGE reported in Livengood Creek placer concentrates are probably derived from these rocks. Thin chrysotile veinlets occur in serpentinite bedrock and chromite occurs in serpentinite scree.

References: Overbeck, 1918; Foster, 1969; Chapman and others, 1971; and Cathrall and others, 1987.

39. **Parker prospect** **Ni**

Nickel is distributed among silicates, spinel-group minerals, alloys, and sulfides in serpentinite. As much as 0.4 pct Ni was detected in rock samples.

References: Foster and Chapman, 1967.

40. **Griffin prospect** **Cr, Ni, (As, Au)**

As much as 3.9 ppm (0.11 oz/st) Au, 1 pct As, 5,000 ppm Cr, and 1,000 ppm Ni were detected in sulfide-bearing, green-stained, silica-carbonate-talc-altered serpentinite.

References: Foster and Chapman, 1967; and Foster, 1968a and 1968b.

41. **Livengood Creek** **Cr, Ni, PGE, (Ag, Au, Hg, Sb, Sn, W)**

Accessory chromite and anomalous nickel concentrations occur in serpentinite bedrock and abundant chromite occurs in placer gold concentrates from Livengood Creek and nearby streams, all in the Tolovana Mining District. Associated with the serpentinite in the Livengood area are gabbro and diorite dikes and plutons. Gold, silver, arsenic, antimony, and mercury are reported in quartz-calcite veinlets proximal to small rhyolite bodies, and granitic rocks in the vicinity of upper Ruth, Lillian, and Olive Creeks. Heavy minerals in placer gold concentrates include magnetite, hematite, chromian spinel, cinnabar, stibnite, other sulfide minerals, scheelite, cassiterite, monazite, and a niobium-titanium-uranium- rare earth mineral. PGE have been detected during fire-assay analysis of placer concentrates from Livengood Creek, and in gold bullion from local placer mines and one lode prospect. Traces of platinum and palladium were detected in serpentinite bedrock samples. Lizardite and clinochrysotile, but no asbestiform aggregates of serpentine minerals are reported.

Workable placer gold deposits were discovered in the Livengood Creek area in 1914. Through 1960, at least 11,819,000 g (380,000 oz) Au had been produced by drifting, dredging, and non-float operations. Most of the production came from the large bench deposit on the northwest side of the Livengood Creek Valley. Non-float placer operations continue to operate on Livengood Creek, some of its tributaries, and nearby Olive Creek, a tributary of the Tolovana River.

References: Overbeck, 1918, p. 183-184; Joesting, 1942, p. 17-20; Berg and Cobb, 1967, p. 239-240 and 1973, p. 174-176; Foster and Chapman, 1967; Foster, 1968a, 1968b, and 1969; Cathrall and others, 1987; Loney and Himmelberg, 1988; Foley and others, 1989; Patton and others, 1989, p.12-13; and unpublished Bureau of Mines data.

42. Barrett prospect **(Ag, Au, Co, Cu, Mn, Pb)**

At least six mineralized shear zones occur in metamorphosed sedimentary rocks near a biotite granite contact. The shear zones were explored by 3 shafts, 1 adit, and 975 m of diamond drilling in 8 holes. Erythrite occurs with galena, chalcopyrite, pyrrhotite, pyrite, siderite, cerussite, limonite, goethite, hematite, quartz, calcite, malachite, and azurite. Gold (1.7-3.4 ppm) and silver (171-274 ppm) are reported. 3.9 pct Mn was detected in a sample collected by the Bureau of Mines.

References: Wedow and others, 1952; Wayland, 1961; Maloney, 1971; and Cobb, 1977, p. 43.

43. Tofty **Cr, (Au, Nb, REE, Sn, Ti, Zr)**

Abundant chromite and picotite are reported in placer gold concentrates from American Creek, Colorado Creek, Boulder Creek, Cache Creek, Deep Creek, Sullivan Creek, and Tofty Gulch. Other heavy minerals identified in placer concentrates include abundant cassiterite and lesser amounts of pyrite, magnetite, ilmenite, barite, hematite, zircon, columbite, aeschynite, monazite, and xenotime.

Chromite in the placer concentrates is apparently derived from small, northeast-striking serpentinite bodies along Serpentine Ridge, between Fish Lake and Roughtop Mountain. Antigorite is the primary serpentine mineral, however, asbestiform aggregates are not reported. Unpublished Bureau of Mines data include reports of as much as 50 pct chromite in select serpentinite samples. This narrow serpentinite belt lies immediately north of and parallels the Tofty gold-tin placer belt.

Gold was discovered in the Tofty area in the winter of 1906-7 and by 1961, 14,000,000 g (450,000 oz) Au were produced. Between 1906 and 1982, placers in the area produced 183,000 kg Sn. Placer gold mining continued intermittently beyond 1961, but no accurate gold production figures are available for that period. Mining operations included hand-mining, ground sluicing, drift mining, bucket-line dredging, and mechanized non-float operations.

Identified niobium resources in the Tofty area include 155,000 kg in dolomitic marble regolith and 45,000 kg Nb_2O_5 in placers.

References: Mertie, 1934, p. 205-214; Waters, 1934, p. 238-246; Thorne and Wright, 1948; Thomas, 1957; Wayland, 1961; Cobb, 1973, p. 137-142; Cobb, 1977; Southworth, 1984a; Warner, 1985; Warner and others, 1986; and unpublished Bureau of Mines data.

East-Central Alaska - Salcha-Seventymile River metallogenic province

44. Caribou Creek **PGE, (Au, Sn, W)**

Platinum, cassiterite, and scheelite are reported in placer gold dredge concentrates. Fire-assay analysis by the Bureau of Mines detected 243 ppm (7.1 oz/st) and 3.4 ppm (0.1 oz/st) Pt in two dredge concentrate samples. Platinum is probably derived from serpentinized ultramafic and associated rocks similar to those in the vicinity of VABM Nail, near the Salcha River. Cassiterite and scheelite are present in many creeks in the region with no known lode deposits.

References: Cobb, 1973, p. 126 and 129; Southworth 1984b and 1985; Foley and others, 1989; and unpublished Bureau of Mines data.

45. Nail Ridge and Salcha River **Cu, Cr, Ni, PGE**

Traces of platinum are reported in peridotite and serpentinite in the Salcha River region and 0.6 pct Ni and traces of platinum were detected in serpentinite at the head of Nickel Creek. High-aluminum high-magnesium chromite is disseminated throughout serpentinized and carbonate-silica-altered peridotite masses. Pyrrhotite and chalcopyrite occur as accessory minerals and are concentrated in an iron-stained zone where 120 ppm (3.5 oz/st) Pd were detected in a rock sample by fire-assay, atomic absorption analyses.

References: Joesting, 1942, p. 17-20; Eberlein and others, 1977; Menzie and Foster, 1978; Weber and others, 1978; Foster and others, 1979; Southworth, 1984b and 1985; Foley and others, 1989; and unpublished Bureau of Mines data.

46. Woodchopper Creek **PGE, (Au, Sn, W)**

Traces of platinum (0.42 pct of specimen) and iridium were reported to be alloyed with placer gold recovered in early placer gold dredging operations. Platinum was claimed as seigniorage by the U.S. Mint during refining of the gold recovered in 1938. Subsequent efforts were successful in separating small amounts of platinum prior to refining by the U.S. Mint. Scheelite, wolframite, and cassiterite were identified in Bureau of Mines pan concentrate samples.

Several bedrock sources have been proposed for the placer gold in the region; the platinum and associated PGE are probably derived from the fairly extensive ultramafic rocks at the heads of

Woodchopper Creek and other north-flowing tributaries of the Yukon River in the Circle Mining District.

Recorded production for Woodchopper Creek, prior to 1963, is 3,660,000 g (117,654 oz) Au and 304,280 g (9,783 oz) Ag. Most of this was produced by a bucket-line dredge that began operating in 1937.

References: Mertie, 1942, p. 257-259, and 1969, p. 90-91; Cobb, 1973, p. 116, 119, and 122, and Cobb, 1975; Barker, 1986, p. 10 and 17; and Foley and others, 1989.

47. Boulder Creek — **Cr, PGE, (Au, Ag)**

Gold, an "osmiridium" grain, and chromite were identified in a pan concentrate sample. Scanning-electron microscope analysis of the PGE grain indicate it has an Os:Ir ratio of about 5:1; therefore it corresponds to the composition of iridosmine.

Recorded production includes 10,400 g (334 oz) Au and 1,300 g (42 oz) Ag recovered prior to 1951. Mining methods included open-cut and drift mining. Open-cut operations, but no recorded production, were reported in 1976 and 1977.

References: Cobb, 1973, p. 116 and 120; Barker, 1986, p. 10 and 17; and Foley and others, 1989.

48. Washington Creek — **PGE, (Au)**

An iron-platinum alloy grain was identified by electron microprobe examination and 103 ppb (0.003 oz/st) Pt was detected, by fire-assay emission spectrography, in a pan concentrate sample with visible gold.

References: Mertie, 1942, p. 257-259, and 1969, p. 90; Barker, 1986, p. 17; Foley and others, 1989; and unpublished Bureau of Mines data.

49. Fourth of July Creek — **PGE, (Au)**

Traces of platinum (0.28 pct of analyzed specimen), iridium (0.05 pct), and palladium ("trace") were reported to be alloyed with placer gold recovered in early mining operations.

References: Mertie, 1942, p. 257-259, and 1969, p. 90; Cobb, 1973, and 1975; Foley and others, 1989; and Barker, 1986.

50. Seventymile River — **PGE, (Au)**

Discrete platinum grains were identified in placer concentrates from Lucky Gulch and platinum (0.20 pct) and iridium (0.02 pct) are alloyed with placer gold from Broken Neck Creek. The PGE and some of the gold are probably derived from the widespread ultramafic rocks that occur along a splay of the Tintina fault in the Seventymile River valley.

References: Joesting, 1942, p. 20; Mertie, 1942, p. 257-259, and 1969, p.90; Cobb, 1973, p. 116, 122, and 125, and 1975; Keith and Foster, 1973; Foster and Keith, 1974; and Foley and others, 1989.

51. Eagle Bluff and Greenstone Point — Ag, Au, Co, Cu, Ni, (Pb, Zn)

Erythrite and annabergite are reported in iron-copper-nickel sulfide veins in greenstone. Traces of gold are reported and as much as 1.5 ppm (0.04 oz/st) Ag, 2,000 ppm Co, 1 pct Cu, 1,500 ppm Pb, and 1,500 ppm Zn were detected by emission spectrography.

References: Wedow, 1954; Bureau of Mines, 1963; Saunders, 1967; and Clark and Foster, 1971, p. 14.

52. Wolf Creek — Cr, (Au)

Chromite is reported in placer gold concentrates.

References: Cobb, 1973, p. 126.

53. Butte Creek — Au, PGE

Gold and PGE are concentrated in small biotite clinopyroxenite sills and lenses, with associated felsic dikes and granodiorite near Butte Creek. These metals were detected in heavy mineral concentrates from alluvium and colluvium proximal to the igneous bodies. Based on fire-assay, emission spectrography, as much as 3 ppm (0.087 oz/st) Pt and 1.5 ppm (0.044 oz/st) Pd, and based on fire-assay, atomic absorption as much as 80 ppb (0.002 oz/st) Au and 36 ppb (0.001 oz/st) Rh were detected in biotite clinopyroxenite. Sperrylite and stibiopalladinite were identified by scanning-electron microscopic examination of select biotite clinopyroxenite samples. SEM examination also identified sperrylite and iron-platinum alloy in heavy mineral concentrates produced by panning and sluicing alluvium and colluvium from gullies that drain these bodies. Based on fire-assay, inductively-coupled plasma procedures, as much as 70.4 ppm (2.054 oz/st) Au, 16.8 ppm (0.49 oz/st) Pd, and 29.3 ppm (0.85 oz/st) Pt were detected in the heavy mineral concentrates.

References: Keith and Foster, 1973; Foster and Keith, 1974; Keith and others, 1987; and unpublished Bureau of Mines data.

54. Slate Creek — Asbestos

Fifty-four million tons (mt) averaging greater than 5 pct asbestos were delineated by 12,200 m of diamond-drilling in the Cache Creek, Core Shack Ridge, and Pump Creek deposits. Asbestos at these deposits is mostly cross-fiber chrysotile suitable for use in concrete. Four additional deposits were tested by drilling and five others remain untested.

References: Noyes, 1986.

55. Alder Creek — Au, Cu:

Traces of gold were detected by inductively-coupled plasma analyses of red-iron-stained and altered, pyrite- and chalcopyrite-bearing, fine-grained basaltic rock from a trench in an exposed dike, west of Alder Creek. Dikes crop out intermittently for several miles to the northwest, and appear to be faulted to the south along northeast-flowing tributaries of the Seventymile River (e.g. Flume Creek, map no.

56). Reports indicate that these dikes have been investigated as lode-gold sources by diamond-drilling within the last three years.

References: Unpublished Bureau of mines data.

56. **Flume Creek** **Au, Co, Cr, Ni**

At lower Flume Creek, a 12-m-wide mass of gold-, pyrite-, and arsenopyrite-bearing quartz-carbonate rock and associated altered diorite (rodingite?) that contains hydrogrossularite, diopside, chlorite, and prehnite cut serpentinite bedrock. Pyrite- and chalcopyrite-bearing basaltic dikes border these altered zones on the south. Emission spectrographic analyses indicate 1,700-6,400 ppm As, as much as 400 ppb (0.012 oz/st) Au, 300 ppm Co, more than 5,000 ppm Cr, and more than 5,000 ppm Ni in rock samples from lower Flume Creek. Fire-assay, inductively-coupled plasma analyses detected 340 ppb (0.01 oz/st) Au and 970 ppm Ni in a pan concentrate sample from upper Flume Creek and as much as 1,370 ppb (0.04 oz/st) Au in altered diorite and other lithologies from the altered zone on lower Flume Creek. A short adit was driven into the altered bedrock and minor placer gold production took place on lower Flume Creek. Accessory chromite in serpentinized peridotite are present on upper Flume Creek.

References: Clark and Foster, 1971; Keith and Foster, 1973; Foster and Keith, 1974; Foley and others, 1985 and 1989; and unpublished Bureau of Mines data.

57. **Mount Sorenson** **Asbestos, Co, Cr, Ni, PGE**

Minor asbestiform minerals, including lizardite and chrysotile (clinochrysotile?), accessory chromite, and traces of PGE (10 ppb Pt) were identified in serpentinized peridotite. Emission spectrographic analyses indicate as much as 300 ppm Co, more than 5,000 ppm Cr, and 5,000 ppm Ni in rock samples. Ultramafic rocks include massive serpentinized harzburgite and dunite with minor cross-cutting veinlets of asbestiform minerals and some slip-fiber asbestos on massive blocks. Alteration minerals also include actinolite (tremolite), talc, brucite, magnetite, and chlorite (penninite). Diabase is reported to occur as tectonic inclusions, and bastite has formed as a result of serpentinization. Quartz-carbonate (magnesite) veins cut altered ultramafic rock.

References: Keith and Foster, 1973; and Foster and Keith, 1974.

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58. Mirror Lake Creek **Cr**

Cobble-size massive chromite float is derived from serpentinized peridotite mass.

References: Richter and others, 1975.

59. Carden Hills **Cr, PGE**

Accessory to 6 pct coarse-grained, disseminated, slightly magnetic chromite occur in dunite layers that are interlayered with gabbro and pyroxenite. The largest exposed chromite-bearing area is greater than ten meters wide and hundreds of meters long. Three chromite-bearing dunite samples contain from 73-344 ppb (0.002-0.01 oz/st) combined Pt (50-300 ppb) and Pd (23-44 ppb) with traces of Ir, Rh, and Ru as determined by fire-assay, inductively-coupled plasma methods.

References: Richter and others, 1975; Foley and others, 1985 and 1989; and unpublished Bureau of Mines data.

60. **Platinum Creek** **PGE:**

Small amounts of platinum are reported from Platinum Creek.

References: Rose, 1965, p. 41; Richter and others, 1975; and Foley and others, 1989.

61. **Mineral** **PGE**

Minor amounts of platinum and palladium were detected by fire-assay, atomic absorption analyses in twenty rock samples from fault-bounded, serpentinized, and silica-carbonate-altered pyroxenite, peridotite, and dunite. Maximum detected PGE is 125 ppb (0.0037 oz/st) each Pd and Pt.

References: Foley and others, 1989; and unpublished Bureau of Mines data.

62. **Mentasta Pass Lodge** **Ag, Au, Cu**

Bornite and trace chalcopyrite occur as vesicle fillings and as irregular segregations in a 120-m-thick section of the upper Slana basalt, 1 km southeast of the Mentasta Pass Lodge. Analysis of a grab sample by atomic absorption yielded 1.1 pct Cu with traces of gold and silver.

References: Richter, 1967, p. 18.

63. **Discovery** **Jade**

Minor nephrite production is reported.

References: Unpublished Bureau of Mines data.

64. **Mentasta Pass** **Jade**

Nephrite was discovered in a prospect pit in serpentinite, near junction of Mentasta Village Road and Tok Highway.

References: Richter, 1967, p. 18; and Richter and others, 1975.

65. **Alteration Creek** **Ag, Au, Cu**

Chalcopyrite and copper oxide minerals are present in limonite- and silica-bearing quartz veins in diorite and altered volcanic rocks of the Slana basalt. Based on atomic absorption analyses, one sample contains 1.5 pct Cu with 18.5 ppm (0.54 oz/st) Ag and 684 ppb (0.02 oz/st) Au.

References: Richter, 1967, p. 16-17.

66. Gillett Pass Asbestos, Cr

Accessory chromite occurs in 3-km-long dunite body and acicular and fibrous antigorite occur in carbonate-altered portions of dunite mass.

References: Richter, 1967, p. 12 and 18.

67. Slana River Ag, Au, Cu, Ni

A piece of massive chalcocite was found in Slana basalt and limestone talus east of the Slana River and a band or pod of pyrrhotite with minor chalcopyrite is reported in Slana basalt, across Slana River, 5 km to northwest. Based on atomic absorption analyses, a pyrrhotite-rich grab sample contains 0.6 pct Cu and 0.04 pct Ni with traces of gold and silver.

References: Richter, 1967, p. 18.

68. Eagle Creek Au, Cu, PGE

Platinum and native copper were reported in placer gold concentrates in 1941 and 1942. Other heavy minerals in the concentrates include magnetite and barite. Rock fragments in the stream gravels include diorite, volcanic rocks, agglomerate, and conglomerate. The presence of native copper and platinum, along with diorite and the other gravel constituents are all similar to features in the platinum-bearing gold placers in the Slate Creek - Miller Gulch area (map no. 70).

References: Moffit, 1944, p. 41; Cobb, 1973, p. 24 and 28; and Cobb, 1975.

69. Middle Fork Chistochina River Ag, Au, Cr, PGE, Cu, (Pb)

Platinum and native copper are reported in placer gold concentrates. Other heavy minerals in the concentrates include silver, magnetite, pyrite, chromite, garnet, galena, and olivine (?). Mining began sometime after 1907 and peaked about 1941. Mining included heavy equipment and hydraulic operations; some of the deposits were tested in the 1940's by drilling. Recent mining has included mechanized, non-float, open-cut operations.

Igneous rocks similar to gold- and platinum-bearing igneous rocks described in the Slate Creek and Miller Gulch area (map no. 70) are described in gravels on the Middle Fork.

References: Moffit, 1944, p. 37.

70. Miller Gulch, Ruby Gulch, and Slate Creek Ag, Au, Co, Cr, Cu, Hg, Ni, PGE, (Pb, Ti)

Iron-platinum alloy and osmiridium are recovered during placer gold mining. Native copper, native mercury, and cinnabar are particularly abundant in placer concentrates. Other heavy minerals in placer concentrates include copper-gold, silver-gold (electrum), lead-gold, and silver-copper-gold alloys, pyrite, pyrrhotite, chalcopyrite, hematite, magnetite, ilmenite, garnet, chromite, cobaltite, apatite, barite, molybdenite, galena, native lead, scheelite, sphene, and zircon.

Most of the 5,540,000 g (178,000 oz) of placer gold and 529,000 g (17,000 oz) of silver production from the Chistochina Mining District came from Miller Gulch and Slate Creek. Placer gold was discovered in the district in 1899 and has been produced by a variety of hand-mining and mechanized operations until present. Platinum was discovered in concentrates from Miller Gulch shortly after production began. Platinum was recently discovered in concentrates from Slate Creek and Ruby Gulch. Total recorded platinum production is 2,582 g (83 oz). Because platinum and alloys of osmium and iridium are so common in concentrates from these three creeks and because complete records of platinum production are unavailable, significantly larger amounts of PGE were probably produced.

Highly-differentiated intrusive igneous rocks in the Slate Creek - Miller Gulch area that contain anomalous concentrations of copper, gold, mercury, and PGE include dunite, pyroxenite, serpentinite, gabbro, hornblende gabbro, hornblendite, syenodiorite and silica-carbonate-altered diorite. These fault-bounded intrusive rocks are part of the 190-km-long belt mentioned under Chistochina Glacier and Big Four Gulch (map no. 71). Anomalous metal concentrations were detected in bedrock samples by a combination of fire-assay, atomic absorption and neutron activation analyses for gold and PGE, atomic absorption for copper, and cold vapor atomic absorption for mercury. Samples from a porphyritic syenodiorite stock on Miller Gulch contain as much as 400 ppb (0.012 oz/st) Pt, 65 ppb (0.0019 oz/st) Pd, 507 ppb (0.015 oz/st) Au, 700 ppb Hg, and 100-300 ppm Cu. After crushing, pulverizing, and panning, a heavy mineral concentrate produced from a rock sample from the same location contained 3,500 ppb (0.10 oz/st) Pt, 35 ppb (0.0012) Pd, 22 ppb (0.0006 oz/st) Rh, and 9 ppb Au. A magnetic hornblende gabbro sample from the west side of Miller Gulch contained 29 ppb (0.0008 oz/st) Pd. A plagioclase hornblendite sample with accessory pyrrhotite and trace chalcopyrite from the same area contained 216 ppb (0.006 oz/st) Pt. A serpentinite sample from Quartz Creek contained 1,200 ppb (0.034 oz/st) Pt.

References: Chapin, 1919, pp. 137-141; Martin, 1919, p. 30-31; Moffit, 1954, p. 193; Rose, 1967; Cobb, 1973, p. 26-28; Foley and others, 1989; Foley and Summers, 1990; and unpublished Bureau of Mines data.

71. Chistochina Glacier and Big Four Gulch — **Ag, Au, Cr, Cu, Hg, Ni, PGE, (Ti)**

Gold and platinum were panned from glacial gravels and traces of platinum, gold, silver, and 0.2 pct Ni were detected by atomic absorption procedures in a dunite boulder from Chistochina Glacier. Iron-platinum alloy with 83 pct Pt and 17 pct Fe were identified by electron-microprobe analysis, and minor chromite identified in placer gold concentrate from Big Four Gulch, which has been mined intermittently by open-cut methods since the early 1950's. Other heavy minerals in placer concentrates include native copper, mercury, chromite, ilmenite, magnetite, hematite, cinnabar, garnet, and zircon.

Big Four Gulch dissects a body of cumulate gabbro and hornblende gabbro that contains anomalous concentrations of copper, gold, mercury, and PGE. This gabbro body is part of an 190-km-long belt of highly-differentiated ultramafic through siliceous, fault-bounded, intrusive igneous rocks in the east-central Alaska Range.

References: Rose, 1967, p. 21-26; Cobb, 1973, p. 26-27; Foley and others, 1989; and Foley and Summers, 1990.

72. Canwell Glacier — Asbestos, Au,

Co, Cu, Ni, PGE

Disseminated copper-nickel sulfide minerals and massive sulfide segregations, with associated cobalt, PGE, and gold, are abundantly present in serpentinite, gabbronorite dikes and sills, and contact-related sulfide segregations near the contacts between the gabbronorite and serpentinite and between the mafic and ultramafic rocks and younger quartz diorite and granodiorite. Fibrous chrysotile is particularly abundant at the west end of the Canwell Glacier mafic-ultramafic body, which comprises serpentinite, dunite, peridotite, plagioclase peridotite, and gabbroic rocks. The Canwell glacier body is part of the highly-differentiated, 190-km-long belt of PGE-gold-copper-nickel-cobalt-bearing igneous rocks in the east-central Alaska Range.

Based on atomic absorption analyses for cobalt, copper, and nickel, fire-assay, inductively-coupled plasma analyses for gold, fire-assay, atomic absorption analyses for palladium and platinum, and fire-assay, emission spectroscopy for iridium, osmium, rhodium, and ruthenium, sulfide-bearing rocks from the Canwell Glacier body are variably enriched in all these metals except iridium. Five gabbronorite samples contained an average of 411 ppb (0.012 oz/st) Pd and 314 ppb (0.009 oz/st) Pt. Two gabbronorite samples yielded 540 and 5,950 ppm Cu, 1,440 and 3,730 ppm Ni, 70 and 137 ppb (0.002 and 0.004 oz/st) Au, 137 and 370 ppb (0.004 and 0.011 oz/st) Pd, and 137 and 200 ppb (0.004 and 0.006 oz/st) Pt. A quartz diorite sample with disseminated sulfides contained 340 ppm Co, 1.55 pct Cu, 2.65 pct Ni, 100 ppb (0.003 oz/st) Os, 600 ppb (0.017 oz/st) Pd, 400 ppb (0.011 oz/st) Pt, 45 ppb (0.0013 oz/st) Rh, and 40 ppb (0.0012 oz/st) Ru. A massive sulfide sample contained 600 ppm Co, 0.96 pct Cu, 3.03 pct Ni, 270 ppb (0.008 oz/st) Au, 1,700 ppb (0.050 oz/st) Pd, and 1,770 ppb (0.0516 oz/st) Pt.

References: Hanson, 1963; Bond, 1976; Barker and others, 1985; Barker, 1988; Foley and others, 1989; and Foley and Summers, 1990.

73. Glacier Lake — Au, Co, Cu, Ni, PGE

At the Glacier Lake prospect, which is within the 190-km-long belt of mineralized mafic, ultramafic, and associated igneous rocks in the east-central Alaska Range, disseminated sulfide minerals occur in granodiorite and quartz diorite dikes.

Based on atomic absorption analyses for cobalt, copper, and nickel, fire-assay, inductively-coupled plasma analyses for gold, fire-assay, atomic absorption analyses for palladium and platinum, and fire-assay, emission spectroscopy for iridium, osmium, rhodium, and ruthenium, sulfide-bearing rocks from the Glacier Lake body are variably enriched all these metals except osmium. As much as 3 pct Ni and 2 pct Cu were detected in samples from a contact-related deposit where granodiorite and quartz diorite intrude serpentinite. Nine mineralized samples averaged 1.46 pct Cu, 2.89 pct Ni, 687 ppm Co, 25 ppb (0.0007 oz/st) Au, 90 ppb (0.0026 oz/st) Ir, 495 ppb (0.012 oz/st) Pd, 410 ppb (0.012 oz/st) Pt, 57 ppb (0.0016 oz/st) Rh, 29 ppb (0.0008 oz/st) Ru, and 25 ppb (0.0007 oz/st) Au.

References: Hanson, 1963; Bond, 1976; Barker and others, 1985; Barker, 1988; Foley and others, 1989; and Foley and Summers, 1990.

74. Emerick prospect — Au, Co, Cu, Ni, PGE

Pyrrhotite, pyrite, pentlandite, chalcopyrite, and trace bornite occur in a gabbronorite dike and enclosing serpentinite at the Emerick prospect, located on Miller Creek. The Miller Creek gabbronorite and serpentinite bodies are part of the 190-km-long belt of mineralized mafic, ultramafic, and associated rocks in the east-central Alaska Range. Based on atomic absorption analyses for cobalt, copper, and nickel, fire-assay, inductively-coupled plasma analyses for gold, fire-assay, atomic absorption analyses for palladium and platinum, and fire-assay, emission spectroscopy for iridium, osmium, rhodium, and ruthenium, sulfide-bearing rocks from the Emerick prospect are variably enriched in cobalt, copper, nickel, gold, palladium, platinum, iridium, osmium, and rhodium. Analyzed rock samples averaged about 1 pct each Cu and Ni, 189 ppm Co, 193 ppb (0.006 oz/st) Au, 977 ppb (0.028 oz/st) Pd, 989 ppb (0.029 oz/st) Pt, 16 ppb (0.0005 oz/st) Ir, 4 ppb (0.0001 oz/st) Os, and 17 ppb (0.0005 oz/st) Rh. PGE minerals identified by scanning-electron microscope examination include merenskyite, palarstanide, and irarsite. These generally occur as minute particles along grain boundaries between sulfide and silicate minerals.

References: Hanson, 1963; Bond, 1976; Barker and others, 1985; Barker, 1988; Foley and others, 1989; and Foley and Summers, 1990.

75. Ann Creek **Au, Co, Cu, Ni, PGE**

Disseminated sulfide minerals in gabbronorite dikes, contact-related deposits where diorite intrudes serpentinite, and massive sulfide deposits are present at several sites on Ann Creek. Based on atomic absorption analyses for cobalt, copper, and nickel, fire-assay, inductively-coupled plasma analyses for gold, fire-assay, atomic absorption analyses for palladium and platinum, and fire-assay, emission spectroscopy for iridium, osmium, rhodium, and ruthenium, sulfide-bearing rocks from the Ann Creek body are variably enriched in cobalt, copper, nickel, palladium, platinum, iridium, and rhodium. Samples from a massive sulfide segregation on upper Ann Creek contain as much as 1.35 pct Ni, 2.65 pct Cu, 730 ppm Co, 450 ppb (0.013 oz/st) Pd, and 130 ppb (0.004 oz/st) Pt. Samples from a massive sulfide lens in the Ann Creek ultramafic body contain 3.5 pct Cu, 1.9 pct Ni, 340 ppm Co, 540 ppb (0.016 oz/st) Pd, 340 ppb (0.010 oz/st) Pt, and traces of iridium and rhodium. Sperrylite was identified in a gabbronorite sample that contained 200 ppm Co, 0.3 pct Cu, 0.44 pct Ni, 340 ppb (0.010 oz/st) Pd, and 273 ppb (0.008 oz/st) Pt.

References: Hanson, 1963; Rose, 1966a; Stout, 1976; Barker and others, 1985; Barker, 1988; Foley and others, 1989; and Foley and Summers, 1990.

76. Rainy Creek **Asbestos, Ag, Au, Co, Cr, Cu, Ni, PGE**

At numerous locations along the two major tributaries of Rainy Creek, located in the 190-km-long belt of mineralized mafic, ultramafic and associated igneous rocks in the east-central Alaska Range, accessory chromite and iron-copper-nickel-sulfide minerals with associated cobalt, PGE, gold, and silver occur in various lithologic associations. Disseminated and massive segregations of sulfide minerals are present in dunite, serpentinite, gabbroic rocks, andesitic and tuffaceous volcanic rocks, and dioritic intrusive rocks. Very fine-grained disseminated blebs of native copper are observed in dunite of the Rainy Creek peridotite and iron-copper-gold skarns are locally present where the igneous and volcanic rocks are in contact with sedimentary carbonate beds. The larger concentrations of sulfide minerals are present along gabbro and diorite contacts and as disseminated and massive sulfide segregations in serpentinite and gabbronorite.

Based on atomic absorption analyses for cobalt, copper, and nickel, fire-assay, inductively-coupled plasma analyses for gold, fire-assay, atomic absorption analyses for palladium and platinum, and fire-assay, emission spectroscopy for iridium, osmium, rhodium, and ruthenium, these metals are variably concentrated in gabbronorite and massive sulfide segregations. A sample of gabbronorite rubble from the North Fork of Rainy Creek contains 235 ppm Co, 2,500 ppm Cu, 9,000 ppm Ni, 1,070 ppb (0.031 oz/st) Pd, 725 ppb (0.021 oz/st) Pt, 300 ppb (0.009 oz/st) Ir, 70 ppb (0.002 oz/st) Rh, and 260 ppb (0.008 oz/st) Ru. Massive sulfide float from the North Fork of Rainy Creek contains 4,100 ppm Cu, 920 ppm Co, 4.5 ppm (0.13 oz/st) Ag, and 65 ppb (0.0019 oz/st) Pd. Disseminated and massive sulfide segregations near contacts between diorite and serpentinite, on the West Fork of Rainy Creek, contain as much as 6.2 ppm (0.18 oz/st) Ag, 9,600 ppm Cu, 520 ppm Co, 415 ppb (0.012 oz/st) Pd, and 100 ppb (0.003 oz/st) Pt.

Throughout the peridotite mass between Ann Creek, to the east, and Rainy Creek, to the west, sulfide- and native copper-bearing clots in dunite contain consistently elevated contents of cobalt, copper, nickel, and PGE. Maximum metal contents in Rainy Creek dunite samples, as determined by neutron-activation for cobalt, copper, and nickel, and fire-assay, atomic absorption for palladium and platinum are 250 ppm Co, 4,600 ppm Cu, 3,500 ppm Ni, 310 ppb (0.009 oz/st) Pd, and 360 ppb (0.010 oz/st) Pt. Microprobe analyses of several Rainy Creek dunite samples show that platinian copper (platinum-copper alloy with 19.5-28.6 pct Pt) occurs as 5- to 20-micron grains associated with chromite, chromian-magnetite, and copper sulfide (chalcocite or digeonite?).

In the Rainy Creek area, skarn and tactite assemblages are present in several areas where sedimentary carbonate beds are intruded by basalt, gabbro, diorite, peridotite, dunite, and associated igneous rocks. Garnet-pyroxene skarn, marble, basalt, diorite, gabbro, and serpentinite contain disseminated and nearly massive pods of pyrite, pyrrhotite, and chalcopyrite. Maximum metal content in these samples, as determined by atomic absorption procedures, are 6.2 ppm (0.18 oz/st) Ag, 85 ppb (0.003 oz/st) Au, 520 ppm Co, 2 pct Cu, and 960 ppm Ni.

Cobalt minerals, including erythrite, cobaltite, and safflorite ($CoAs_2$) were identified in volcanic float and rubble along the North Fork of Rainy Creek.

Cross-fiber chrysotile with as much as 2.5-cm-long fiber is abundant in a 120- by 270-m area at the southeast margin of the Rainy Creek ultramafic body

Small-scale placer gold mining is reported to have taken place intermittently since 1900 on Rainy Creek.

References: Cobb, 1973, p. 116 and 124; Rose, 1965, and 1966a; Stout, 1976; Barker, 1988; Foley and others, 1989; Foley and Summers, 1990; and unpublished Bureau of Mines data.

77. Broxson Gulch

Asbestos, Ag, Au, Co, Cr, Cu, Ni, PGE

Numerous iron-copper-nickel sulfide occurrences crop out in the vicinity of the two major valleys of Broxson Gulch. Mineralized mafic and ultramafic rocks in this area are within the 190-km-long belt of related rocks in the east-central Alaska Range. Occurrences include massive sulfide lenses, veins, pods, and disseminated sulfide minerals near contacts between peridotite or serpentinite and gabbro, similar occurrences in surrounding sedimentary and volcanic rocks, and in tactite occurrences with associated diopside, garnet, epidote, and quartz. Ore minerals include pyrite, pyrrhotite, pentlandite, chalcopyrite, marcasite, malachite, azurite, chromite, and magnetite.

Maximum metal content in massive sulfide samples from the Broxson Gulch area, as determined by atomic absorption procedures, are 13 ppm (0.38 oz/st) Ag, 760 ppm Co, 2.4 pct Cu, and 6,600 ppm Ni. Maximum precious metal content as determined by fire-assay, atomic absorption are 416 ppb (0.012 oz/st) Au, 137 ppb (0.004 oz/st) Pd, and 137 ppb (0.004 oz/st) Pt. A reddish-colored, iron oxide-stained granular dunite sample from the Broxson Gulch area contained 480 ppb (0.014 oz/st) Pd.

Asbestos veinlets are common in serpentinized peridotites in the area.

Small-scale, mechanized placer gold mining is reported on Broxson Gulch. Mineral exploration in the area includes drilling of placer deposits as recently as 1991.

References: Cobb, 1973, p. 116 and 124; Rose, 1965, and 1966a; Stout, 1976; Barker, 1988; Foley and others, 1989; Foley and Summers, 1990; and unpublished Bureau of Mines data.

78. Landslide Creek **Asbestos, Ag, Au, Co, Cr, Cu, Hg, PGE, (Zn)**

Mafic and ultramafic rocks of the 190-km-long east-central Alaska Range belt crop out near Landslide Creek. Landslide deposits on Landslide Creek comprise slump and slide blocks made up solely of magnetite-rich peridotite-cobble conglomerate. Based on neutron-activation analyses for cobalt, chromium, and nickel, atomic absorption analyses for copper, and fire-assay, atomic absorption analyses for gold, palladium, and platinum, elevated concentrations of these metals were detected in rock and placer samples from several areas in the vicinity of Landslide Creek. Asbestos veinlets are common in serpentinized peridotites.

At the head of Landslide Creek, disseminated sulfide minerals are present in several ultramafic lithologies and in skarns of probable ultramafic parentage. Plagioclase peridotite with accessory pyrite, pyrrhotite, and chalcopyrite contain 110 ppb (0.003 oz/st) Au, 185 ppm Co, 4,036 ppm Cr, 1,540 ppm Cu, 3,520 ppm Ni, 300 ppb (0.009 oz/st) Pd, and 380 ppb (0.012 oz/st) Pt. A peridotite sample contains 168 ppm Co, 5,370 ppm Cr, 236 ppm Cu, 2,360 ppm Ni, and 25 ppb (0.0007 oz/st) each, Pd and Pt. Serpentinized peridotite samples with accessory pyrite, pyrrhotite, chalcopyrite, very fine-grained chromite, and rarely, very fine blebs of native copper, contain as much as 214 ppm Co, 4,030 ppm Cr, 360 ppm Cu, 3,260 ppm Ni, 100 ppb (0.0029 oz/st) Pd, and 90 ppb (0.0026 oz/st) Pt. A sample of magnetite-chalcopyrite-epidote-diopside skarn contains 130 ppb (0.004 oz/st) Au and 5,000 ppm Cu.

A prominent hill on the west side of Landslide Creek is capped by conglomerate that is made up almost entirely of peridotite and dunite with minor gabbro. Angular to sub-rounded clasts and pebbles of magnetite, as much as 2 cm across, are particularly abundant in the matrix of the conglomerate. The eastern slope of this hill, to the floor of the Landslide Creek valley, is covered with landslide deposits that were derived from the ultramafic-rich conglomerate. Grab samples of the conglomerate and heavy mineral concentrates produced by panning pulverized conglomerate and regolith overlying the conglomerate were all found to contain traces of gold and platinum; maximum values detected were 102 ppb (0.003 oz/st) Au, 150 ppb (0.0044 oz/st) Pd, and 240 ppb (0.007 oz/st) Pt. Abundant pyrite and cinnabar, with fine gold particles, weighing as much as 4 milligrams were panned from alluvium along Landslide Creek.

South of the conglomerate-capped hill, in a south-facing gully, disseminated pyrite, pyrrhotite, and chalcopyrite were observed in siliceous veins cutting diorite and quartz monzonite. The diorite contains elongated segregations of gabbro and hornblende gabbro. Based on neutron-activation analyses for gold and zinc, diorite from this location contains 310 ppb (0.009 oz/st) Au and 450 ppm Zn. A sample from a gabbro segregation in the diorite contains 270 ppb (0.008 oz/st Au) and 310 ppm Zn.

References: Rose, 1965,and 1966a; Stout, 1976; Foley and others, 1989; Foley and Summers, 1990; and unpublished Bureau of Mines data.

79. Eureka Glacier Ag, Au, Co, Cr, Cu, Ni, PGE

Sill-form masses of mafic and ultramafic rocks of the 190-km-long east-central Alaska Range belt crop out along ridges above the east and west sides of Eureka Glacier and one mile farther to the west, on the next high ridge. Based on inductively-coupled plasma analyses for gold, silver, cobalt, copper, and nickel, and fire-assay, atomic absorption analyses for palladium and platinum, trace to elevated concentrations of these metals were detected in select samples from this area. Serpentinized plagioclase peridotite, peridotite, and gabbro samples with accessory chalcopyrite, pyrrhotite, native copper, chromite, and magnetite contains as much as 4 ppm (0.12 oz/st) Ag, 61 ppb (0.0017 oz/st) Au, 110 ppm Co, 5,260 ppm Cr, 2,700 ppm Ni, 220 ppb (0.006 oz/st) Pd, and 300 ppb (0.009 oz/st) Pt. Neutron-activation analyses for silver, gold, cobalt, chromium, copper, nickel and fire-assay, atomic absorption analyses for palladium and platinum for a similar suite of samples from the same area detected as much as 3.5 ppm (0.10 oz/st) Ag, 80 ppb (0.0018 oz/st) Au, 90 ppm Co, 3,812 ppm Cr, 2,680 ppm Cu, 3,640 ppm Ni, 370 ppb (0.011 oz/st) Pd, and 550 ppb (0.016 oz/st) Pt. The highest palladium and platinum concentrations were detected in a red iron oxide-stained, sulfide-rich olivine gabbro, which upon microprobe examination, was found to contain minute particles of moncheite (Pt,Te) along grain boundaries between chalcopyrite and ferromagnesian silicate minerals.

References: Rose, 1965, and 1966a; Stout, 1976; Foley and others, 1989; Foley and Summers, 1990; Balen, 1990; Foley, 1991; Kurtak and others, 1991; and unpublished Bureau of Mines data.

80. Fish Lake Cu, Ni, PGE

A serpentinized peridotite sample with accessory pyrrhotite, pentlandite, chalcopyrite, and magnetite contains 70 ppb (0.0020 oz/st) Pd and 70 ppb (0.0020 oz/st) Pt.

References: Rose, 1966a; Stout, 1976; and unpublished Bureau of Mines data.

81. Butte Creek **Ag, Au, Co, Cr, Cu, Ni, PGE**

At the southwestern end of the 190-km-long east-central Alaska Range belt of mafic and ultramafic rocks is an elongate, fault-bounded, sill-form mass of serpentinite, peridotite, troctolitic gabbro with accessory copper-colored biotite, and leucocratic intrusive rocks. Sulfide minerals including pyrite, pyrrhotite, pentlandite, and chalcopyrite, disseminated and massive magnetite, and accessory chromite are locally concentrated in these rocks. Neutron-activation analyses for silver, gold, cobalt, chromium, copper, nickel and fire-assay, atomic absorption analyses for palladium and platinum indicate that these rocks contain as much as 300 ppm Co, 1,400 ppm Cu, 3,500 ppm Ni, 28 ppb (0.0008 oz/st) Pd, 140 ppb (0.004 oz/st) Pt, and traces of gold and silver. Gold was identified in placer samples collected downstream from this area.

References: Foley and others, 1989; Foley and Summers, 1990; Balen, 1990; Foley, 1991; Kurtak and others, 1991; and unpublished Bureau of mines data.

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82. Long Creek Ti

Disseminated ilmenite grains are reported in fine-grained gabbro in the Long Creek area.

References: Hawley and Clark, 1973; and Jones and others, 1980.

83. Copeland Creek-Ohio Creek — **Co, Cr, Ni, PGE**

Small chromite pods and accessory chromite with 99 ppb (0.003 oz/st) Pd and 97 ppb (0.003 oz/st) Pt were detected by fire-assay, atomic absorption in samples from a 300-m-wide by 5-km-long fault-bounded serpentinized and silica-carbonate-altered dunite and peridotite mass.

References: Hawley and Clark, 1973, and 1974; Jones and others, 1980; and unpublished Bureau of Mines data.

84. Eldridge Glacier — **Ag, Au, Co, Cu, Ni**

Pyrite- and chalcopyrite-rich quartz rock occur in malachite-stained serpentinite with as much as 7.5 pct Cu, 1.5 pct Ni, 200 ppm Co, 15 ppm (0.44 oz/st) Ag, 100 ppb (0.003 oz/st) Au detected by emission spectrography.

References: Hawley and others, 1969; Hawley and Clark, 1973, and 1974; and Jones and others, 1980.

85. Cache Creek-upper Kahiltna River Valley — **Cr, PGE, (Au, REE, Sn, Th, Ti, U, W)**

Small amounts of platinum were recovered during placer gold mining on Cache Creek, Peters Creek, Poorman Creek, Willow Creek, Ruby Creek and other streams in the upper Kahiltna River Valley. Other heavy minerals in placer concentrates include cassiterite, scheelite, magnetite, monazite, uranothorianite, rutile, and garnet. Chromite and platinum in the concentrates are probably derived from dunite sills and silica-carbonate-altered mafic and lamprophyric ultramafic dikes in the region. Mining operations in the Cache Creek - Peters Creek area have employed bucket-line dredges, hydraulic plants, and most recently, mechanized non-float equipment.

References: Mertie, 1919; Robinson and others, 1955, p. 22; Clark and Hawley, 1968; Cobb, 1973, p. 20-23; Hawley and Clark, 1973 and 1974.

86. Yentna and Lacuna Glaciers — **Cr**

Chromite occurs as disseminated grains, schlieren, and massive lenses in dunite sills at six locations. The largest of these is a 2-m-wide by 20-m-long lens of nearly massive chromite.

References: Hawley and Clark, 1973 and 1974; and Reed and others, 1978.

87. Shellabarger Pass — **Ag, Cu, PGE, (Pb, Zn)**

Massive and disseminated sulfide minerals are concentrated in interbedded sedimentary and volcanic rocks in the lower part of a structural trough. The interbedded lithologies include chert, dolomite, siltstone, shale, volcanic graywacke, basaltic aquagene tuff, sedimentary breccia, and conglomerate. The interbedded rocks are overlain by submarine basaltic pillow flows and subordinate interbedded agglomerate, flow breccia, and tuff.

A composite pluton comprising primarily gabbro, with less abundant mafic and ultramafic rocks including hornblende gabbro, olivine gabbro, magnetite gabbro, biotite dunite, and silica-carbonate rock (listwaenite?) crops out near the above occurrence. A pan concentrate sample from a creek to the west contained 840 ppb (0.025 oz/st) Pt. Mineral deposits in the area consist of as much as 15 pct sulfides, including fine-grained pyrite, marcasite, sphalerite, and galena, in siderite, calcite, quartz, and dolomite. Average grades are estimated at 1-1.5 pct Cu, 0.8-1.7 pct Zn, 0.5 pct Pb, and 30.1-82.3 ppm (0.9-2.4 oz/st) Ag.

References: Reed and Eberlein, 1972; Reed and Nelson, 1980; unpublished U.S. Geological Survey data; and unpublished U.S. Bureau of Mines data.

88. Yentna River — **Ag, Cr, Cu, PGE, (Au)**

Chromite reported in placer gold concentrates at several locations in the upper Yentna River Valley is probably eroded from the serpentinized and silica-carbonate-altered dunite sills and associated ultramafic rocks at the headwaters of the East Fork Yentna River.

Several Cretaceous composite plutons comprising minor peridotite, lamprophyric and alkaline mafic-ultramafic igneous rocks and more abundant monzonite, syenite, quartz syenite, and granitic rocks, all containing biotite, crop out at the headwaters of the West Fork Yentna River and adjacent tributaries. Three separate pan concentrate samples from creeks that drain these plutons contained maxima of 70 ppb (0.002 oz/st) Pd, 300 ppb (0.009 oz/st) Pt, and 840 ppb (0.025 oz/st) Pt.

References: Hawley and Clark, 1973; Reed and Eberlein, 1972; Reed and Nelson, 1980; unpublished U.S. Geological Survey data; and unpublished U.S. Bureau of Mines data.

89. Kichatna River — **PGE, (Au)**

Platinum recovered during placer gold prospecting and mining may be derived from Cretaceous composite plutons in the Kichatna River headwaters like those described in the preceding description of the Yentna River area.

References: Martin, 1919, p. 33; Cobb, 1973, p. 23; Reed and Eberlein, 1972; Reed and Nelson, 1980; unpublished U.S. Geological Survey data; and unpublished U.S. Bureau of Mines data.

90. Lake Creek — **Cr, PGE, (Au, Hg, Tl)**

Minor amounts of platinum are reported in placer gold concentrates. Iron-platinum alloy was identified by microprobe examination. Recent exploration by trenching indicates that gold and PGE in the Lake Creek area are derived from Tertiary conglomerate of the Tyonek Formation. Other heavy minerals in placer concentrates include magnetite, ilmenite (?), chromite, olivine, garnet, and minor mercury. Placer mining is expected to take place in 1991.

References: Martin, 1919, p. 33; Cobb, 1973, p.22; and unpublished Bureau of Mines data.

91. Lower Kahiltna River **PGE, (Au)**

Small amounts of PGE were recovered during small-scale placer gold mining and prospecting at several sites, including Shulin (Sholan) Bar, Red Hill Bar, and Boulder Bench. River bars were prospected for platinum by hand-drilling and power-drilling in 1917.

References: Mertie, 1919, p. 262-263; Robinson and others, 1955, p.22; Cobb, 1973, p.23.

92. Chulitna River: **PGE, (Au)**

Platinum was recovered during placer gold prospecting and mining.

References: Martin, 1919, p. 33.

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93. Disappointment Creek, Willow Creek, and Wilson Creek **PGE, (Au)**

Small amounts of platinum, probably eroded from greenstone in the region, were reported in placer gold concentrates. Mining began on Wilson Creek in 1914 and continued until at least 1965.

References: Harrington, 1918, p. 59; West, 1954, p. 8; Cobb, 1973, p. 107 and 162, and 1975.

94. Ptarmigan Creek **Jade**

A mining claim was located for jade in 1979.

References: Unpublished Bureau of Mines data.

95. Bear Creek **PGE, (Au, Hg)**

Small amounts of platinum are reported in placer gold concentrates. Cinnabar, possibly derived from diabasic dikes and sills in the region, was abundant in the concentrates from Bear Creek, a tributary of Tuluksak River. Mining took place from about 1909 until 1964 when dredges in the area shut down.

References: Mertie, 1969, p. 89-90, Cobb, 1973 and 151, and Cobb, 1975.

96. Tuluksak River **PGE, (Au):**

Small amounts of platinum were recovered with gold in placer concentrates. Mining took place from 1909 until 1964 when placer dredges in the area shut down. More recently, dredging was revived for a short period.

References: Hoare and Coonrad, 1959; Cobb, 1973, p. 42 and 44; and Cobb, 1975.

97. Bear Creek and Slate Creek **PGE, (Au)**

Small amounts of PGE were produced during prospecting by the Goodnews Bay Mining Company and combined with the PGE produced from the Salmon River placers. 6,500 ppb (0.19 oz/st) Pt were detected in a placer sample from Bear Creek and >10,000 ppb (>0.29 oz/st) Pt with 325 ppb (0.009 oz/st) Pd were detected in a placer sample from Danielson Creek, a tributary of Bear Creek.

References: Mertie, 1969, p. 89-90; and Fechner, 1988.

98. Snow Gulch, Butte Creek, and Kowkow Creek **PGE, (Au)**

Small amounts of PGE were produced during prospecting by the Goodnews Bay Mining Company and other operators and combined with the PGE produced from the Salmon River placers. A pan concentrate sample from tailings contains 412 ppb (0.012 oz/st) Pt.

References: Smith, 1930, p. 52-53; Mertie, 1969, p. 89-90; and unpublished Bureau of Mines data.

99. Mitlak Mountain **Cr**

Accessory chromite occurs in serpentinized peridotite.

References: Foley and others, 1985 and 1986; and unpublished Bureau of Mines data.

100. Tatlignagpeke Mountain **Cr, PGE**

Accessory chromite and traces of palladium and platinum occur in dunite and peridotite.

References: Foley and others , 1985 and 1986; and unpublished Bureau of Mines data.

101. Goodnews Bay-Salmon River **Au, Cr, PGE**

More than 20,217,000 g (650,000 oz) PGE and about 311,000 g (10,000 oz) Au were produced from placers by the Goodnews Bay Mining Company and other operators since 1927. The source for the PGE is thought to be the Goodnews Bay Ural-Alaskan type, zoned ultramafic complex at Red and Susie Mountains. No economic lode deposits have been found in the complex, which has been explored as recently as 1987 and 1988 by Ashton Mining Company.

Geochemical data and the common presence of intergrown chromite and magnetite with iron-platinum alloy in placer concentrates indicate that PGE are concentrated with chromite and magnetite in dunitic portions of the Goodnews Bay complex. Anomalous platinum was detected in pan-concentrated soil samples at the summit and south and northeast ends of the complex and anomalous platinum and palladium, in some cases associated with iron-copper-sulfide minerals, were detected in magnetite clinopyroxenite border zones by Ashton and by the Bureau of Mines (oral commun., Toni Hinderman, Alaska Earth Resources, Anchorage, Alaska, 1989).

In the placers near Red Mountain, platinum is the most abundant PGE in concentrates and occurs primarily as iron-platinum alloy of variable composition. Osmiridium and iridosmine are the next most abundant PGE minerals but make up less than 10 pct of the precious metal concentrates. Other PGE minerals include minor sperrylite, hollingworthite, and Ir-Fe, Ir-S-As-Rh-Pt-Fe, Rh-As-Pd-Ni, and Pb-S-Rh-Fe-Ir minerals associated with magnetite. Gold makes up between less than 1 pct and 5 pct of the precious metal concentrates. Remaining resources include an estimated 31 million m^3 of tailings grading between 0.053 g/m^3 (0.0013 oz/yd^3) and 0.68 g/m^3 (0.017 oz/yd^3), and low grade (0.083 g/m^3 = 0.0021 oz/yd^3) unmined, unfrozen, measured and indicated resources in the lower bench paystreak, which is as much as 60 m deep. Additional unmeasured alluvial placer resources are indicated at the northwest side of Red Mountain.

Gold and PGE have been geochemically detected and mineral grains identified in offshore and onshore marine placers from Goodnews Bay to Chagvan Bay, to the north and south of Red Mountain. Identified PGE minerals include isoferroplatinum, osmiridium, platiniridium, sperrylite, and moncheite. Also present in the samples are chromite, magnetite, ilmenite, zircon, cinnabar, and native mercury. Based on bathymetric surveys, magnetometer surveys, seafloor sampling, limited drilling, and scanning-electron microscope studies, several deposit types have been identified or suggested. These include: onshore, swashzone, heavy mineral concentrations and submerged alluvial and marine placers. Magnetometer survey data indicate that the Goodnews Bay complex extends at least 10 km offshore, and reworked residual submarine placers may exist on top of the submerged ultramafic bedrock.

References: Harrington, 1921; Mertie, 1940, 1969, and 1976; Bird and Clark, 1976; Rosenblum and others, 1982 and 1986; Carlson, 1983; Ulrich, 1984; Southworth, 1984c and 1986; Southworth and Foley, 1986; Barker and Lamal, 1988; Fechner, 1988; and Zelenka, 1988.

102. Cape Newenham, Security Cove and Chagvan Mountain — **Asbestos, Au, Cu, Ni, PGE**

Cross-fiber chrysotile occurs in serpentinized peridotite and serpentinized dunite. As much as 2,200 ppm Cu and 1,300 ppm Ni were detected by atomic absorption procedures in serpentinized peridotite and gabbro with accessory pyrite, pyrrhotite, and pentlandite. Traces of gold were detected in sulfide-bearing gabbros. Osmiridium, and iron-platinum alloy grains with osmiridium inclusions were identified in placer concentrates from streams draining till-covered Cape Newenham ophiolite.

References: Fechner, 1988; and unpublished Bureau of Mines data.

103. Hagemeister Straight — **Au, Cu, Cr, (Pb, Mn, Zn)**

Chalcopyrite, pyrite, galena, and sphalerite ocurr in gossans in mafic to intermediate volcanic rocks and diabase along shore. Based on fire-assay, atomic absorption analyses, select samples from a quartz-carbonate-sulfide vein at the margin of a diabase dike contain as much as 762 ppb (0.022 oz/st) Au. Manganese oxide- and ferricrete-cemented gravels were observed in bluffs along the coastline. Trace chromite is reported in beach sand samples.

References: Berryhill, 1963, p. 17; and unpublished Bureau of Mines data.

104. Kemuk Mountain — **Cu, Fe, Ti**

Based on airborne magnetometer surveys in 1957 and diamond-drilling in 1958 and 1959, Humble Oil and Refining Company delineated 2.3 billion mt of magnetite clinopyroxenite ore containing 15-17 pct total Fe in a buried Ural-Alaskan type ultramafic complex. The deposit is buried beneath alluvium and glacial till, in the Nushagak River lowlands, east of Kemuk Mountain. Iron assays indicate that magnetic iron grades in the titaniferous magnetite are between 10.5 and 12 pct. Copper minerals are reported along a faulted portion of the complex.

References: Humble Oil and Refining Company, 1959; and Berg and Cobb, 1967, p. 11.

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105. Halibut Bay and Sturgeon River **Ag, Au, Co, Cr, Cu, Ni, PGE**

Based on surface measurements, 182,000 mt Cr_2O_3 are estimated in seven deposits in dunitic portion of cumulate ultramafic mass with interlayered peridotite and clinopyroxenite. The largest deposit contains 178,000 mt Cr_2O_3 and is a 300-m-long, low-grade banded zone averaging 5 pct chromite. Chromite is abundant in pan-concentrate samples from valleys draining the ultramafic rocks. Minor wispy chromite segregations and schlieren occur throughout dunite in the Halibut Bay and nearby Sturgeon River mass. Stannopalladinite, chalcocite, covellite, cobaltian pentlandite, pyrrhotite, chalcopyrite, uvarovite, and villamanite were identified by scanning-electron and ore microscope examination of a peridotite sample with both orthopyroxene and clinopyroxene. Based on inductively-coupled plasma analyses, a sulfide flotation concentrate produced from this sample contained 0.083 pct Co, 11.8 pct Cu, 1.55 pct Ni, 11,522 ppb (0.336 oz/st) Pd, 5,453 ppb (0.159 oz/st) Pt, 4,561 ppb (0.133 oz/st) Au, and 24 ppm (0.70 oz/st) Ag. Grab samples of peridotite and olivine pyroxenite from this location contain as much as 3,629 ppm Cu, 839 ppm Ni, and 7,700 ppm Cr, 420 ppb (0.012 oz/st) Pt, and 480 ppb (0.014 oz/st) Pd.

References: Beyer, 1980; Dahlin and others, 1985; Foley and Barker, 1985; and Foley and others, 1985, 1986, and 1989; and unpublished Bureau of Mines data.

106. Gurney Bay **Cr**

Minor disseminated and banded chromite occur in dunite.

References: Dahlin and others, 1985; Foley and Barker, 1985; Foley and others, 1985 and 1986.

107. Ayakulik Beach and Canvas Island **Cr, PGE, (Au)**

Minor amounts of platinum and abundant "chromic sands" were identified in heavy mineral concentrates from beach sands and small amount of platinum were recovered during placer gold mining. Analyses indicate platinum, iridium, and osmium are the most abundant PGE present.

References: Maddren, 1919, p. 316-317; and Cobb, 1975.

108. Grant Lagoon **Cr**

Minor disseminated chromite occurs in dunite.

References: Dahlin and others, 1985; Foley and Barker, 1985; and Foley and others, 1985 and 1986.

109. Karluk **Cr**

Accessory chromite occurs in dunite.

References: Beyer, 1980.

110. Saddle Mountain **Cr**

Minor banded and disseminated chromite occur in dunite.

References: Foley and Barker, 1985; Foley and others, 1985 and 1986.

111. Miners Point **Cr**

Minor banded and disseminated chromite occur in dunite.

References: Foley and Barker, 1985; Foley and others, 1985 and 1986.

112. Claim Point **Cr, PGE**

Two thousand metric tons (mt) of chromite ore were produced in 1917 and 1918. Eighty-two thousand tons (82,000 mt) Cr_2O_3 are estimated in 16 deposits of banded chromite in dunite with grades ranging from 5 to 30 pct Cr_2O_3. Eight other deposits with no reserve estimates have been described. A tabled chromite concentrate from one sample at Claim Point contained 1,166 ppb (0.034 oz/st) Pt and 2,469 ppb (0.072 oz/st) Pd. Fourteen grab and chip samples from the same chromite mass contained from less than 15-100 ppb Pt and from 2-30 ppb Pd.

References: Gill, 1922; Guild, 1942; Sanford and Cole, 1949; Burns, 1983 and 1985; Dahlin and others, 1985; Foley and Barker, 1985; Foley and others, 1985 and 1986; and unpublished Bureau of Mines data.

113. Port Graham **Cr**

Chromite-bearing ultramafic rocks were observed over a large area in the Port Graham dunite-peridotite mass.

References: Anaconda Minerals Company, 1981.

114. Red Mountain **Cr, PGE**

About 26,000 mt of ore containing from 38 to 43 pct Cr_2O_3 were produced between 1943 and 1958. Reserve estimates include 1.5 million mt of contained Cr_2O_3 in 33 deposits. About 88,000 mt Cr_2O_3 are contained in 20 relatively high-grade deposits with more than 20 pct chromite. The bulk of the reserves, 1.35 million mt, are in three low-grade deposits with 5 to 6 pct Cr_2O_3. These are the Turner Stringer Zone (1.13 million mt Cr_2O_3), the Star Stringer Zone (189,000 mt Cr_2O_3), and the Horseshoe Stringer Zone (26,000 mt Cr_2O_3). Based on fire-assay, atomic absorption analyses, chip samples across the Turner Stringer Zone contained as much as 485 ppb (0.014 oz/st) Pd and 690 ppb (0.020 oz/st) Pt.

References: Gill, 1922; Guild, 1942; Wells and others, 1957; Anaconda Minerals Company, 1981; Burns, 1983 and 1985; Dahlin and others, 1985; Foley and Barker, 1985; Foley and others, 1985, 1986, and 1989.

115. Windy River **Cr**

Low-grade placer deposits with 1.33 pct Cr_2O_3 and containing 504,000 mt Cr_2O_3 were eroded from Red Mountain.

References: Rutledge, 1946; Dahlin and others, 1985; Foley and Barker, 1985; Foley and others 1985 and 1986.

116. Eklutna **Cr, PGE**

Four chromite deposits as much as 12 m wide and 50 m long contain 1,000 st Cr_2O_3 combined, and two unmeasured occurrences are reported. Based on fire-assay, emission spectrography analyses, ten samples, including gabbro, hornblendite, pyroxenite, peridotite, and dunite contain averages of 46 ppb (0.0013 oz/st) Pt and 40 ppb (0.0012 oz/st) Pd with maxima of 100 ppb (0.0029 oz/st) each Pd and Pt in pyroxenite with associated magnetite. A sample of coarse-grained, cumulate clinopyroxenite with accessory interstitial pyrrhotite was analyzed for gold, palladium, and platinum by fire-assay, directly-coupled plasma techniques and for cobalt, chromium, copper, nickel, and silver by inductively-coupled plasma procedures; the sample contained 55 ppm Co, 1,584 ppm Cr, 221 ppm Cu, 459 ppm Ni, 1.4 ppm (0.041 oz/st) Ag, 32 ppb (0.0009 oz/st) Au, 94 ppb (0.0027 oz/st) Pd, and 91 ppb (0.0027 oz/st) Pt.

References: Gates, 1942; Bjorklund and Wright, 1948; Rose, 1966b; Clark and Greenwood, 1972, p. C159; Burns, 1983 and 1985; Dahlin and others, 1985; Foley and Barker, 1985; Foley and others, 1985, 1986, and 1989; and unpublished Bureau of mines data.

117. Willow Creek **Soapstone, PGE**

An inoperative open-cut soapstone mine was observed at the head of Willow Creek in 1978. Traces of Pd (0-30 ppb) and Pt (0-30 ppb) were detected by fire-assay and as much as 5,000 ppm Cr and 2,000 ppm Ni were detected by emission spectroscopy in serpentinite samples.

References: Csejtey and Evarts, 1979; and unpublished Bureau of Mines data.

118. Wolverine Complex **Cr**

From 9,000 to 25,000 mt Cr_2O_3 are estimated in two zones of banded, nodular, and disseminated chromite in dunite with associated peridotite and pyroxenite. The larger zone contains between 10 and 20 pct chromite and is discontinuously exposed for 600 m.

References: Clark, 1972; Burns, 1983 and 1985; Dahlin and others, 1985; Foley and Barker, 1985; Foley and others, 1985 and 1986; and Newberry, 1986.

119. Metal Creek **PGE, (Au)**

Small amounts of platinum were recovered during intermittent placer gold mining.

References: Cobb, 1973, p. 17; and Cobb, 1975.

120. Alfred Creek **PGE, (Au)**

Small amounts of platinum are reported in gold placers.

References: Brooks, 1925, p. 30; and Cobb, 1975.

121. Albert Creek **PGE, (Au)**

Small amounts of platinum were produced during placer gold mining in 1913.

References: Cobb, 1973, p. 29; and Cobb, 1975.

122. Barnette Creek **Cr**

Accessory disseminated chromite occurs in a small fault-bounded serpentinite mass less than 150 m across in maximum dimension.

References: Foley and Barker, 1985; and Foley and others, 1985 and 1986.

123. Bernard Mountain **Cr, PGE**

Based on surface measurements, inferred reserve estimates include 311,000 mt Cr_2O_3 in seven low-grade zones of banded and disseminated chromite in dunite. Numerous other small and unmeasured occurrences exist. As much as 823 ppb (0.024 oz/st) and 1,749 ppb (0.051 oz/st) Pd were detected by fire-assay, neutron activation analyses in two high-chromium tabled concentrates from a 60-kg, high-chromium chromite sample, but no PGE were detected in replicate samples from that location or other samples from Bernard Mountain.

References: Pittman, 1957; Wells, 1957; Berg and Cobb, 1967, p. 52; Hoffman, 1972; Burns, 1983 and 1985; Dahlin and others, 1985; Foley and Barker, 1985; Foley and others, 1985, 1986, 1988, and 1989; and Newberry, 1986.

124. Sheep Hill **Cr, PGE**

Based on surface measurements, inferred reserve estimates are from 41,000 to 64,000 mt Cr_2O_3 in two low-grade, high-iron chromite deposits with associated PGE. Based on fire-assay, neutron activation analyses, samples from a 60- by 90-m area with 5 pct chromite contained as much as 927 ppb (0.27 oz/st) total PGE. Maximum results for individual elements include 412 ppb (0.012 oz/st) Pd and 515 ppb (0.015 oz/st) Pt with associated Ir (<75 ppb), Os (<27 ppb), Rh (<72 ppb), and Ru (<45 ppb). Pt/Pt+Pd values range from 0.57 to 0.75.

References: Berg and Cobb, 1967, p. 52; Burns, 1983 and 1985; Dahlin and others, 1985; Foley and Barker, 1985; Foley and others 1985, 1986, 1988, and 1989; and Newberry, 1986.

125. Dust Mountain **Cr, PGE**

Based on surface measurements, inferred reserve estimates include from 2.4 million to 4.8 million mt Cr_2O_3 in a 60- by 1,100-m area comprising dunite, clinopyroxenite, clinopyroxene-rich peridotite, and high-iron chromitite, with associated PGE and very fine blebs of native copper. PGE are preferentially associated with high-iron chromitites in clinopyroxene-rich horizons. Based on fire-assay, neutron activation analyses, chromitite samples from this area contain as much as 0.6 oz/st PGE (11,936 ppb Pd, 8,918 ppb Pt, 330 ppb Ir, 87 ppb Os, 550 ppb Rh, and 140 ppb Ru). Pt/Pt+Pd ratios range from 0.44 to 0.87. Identified PGE minerals include PGE-amalgams, arsenides, alloys, and sulfides that are concentrated in fractures and grain boundaries in serpentinized, metasomatically-, and magmatically-altered high-iron chromitites and maximum PGE concentrations were observed in malachite- and native copper-bearing, magnetic chromitites.

References: Pittman, 1957; Wells, 1957; Burns, 1983 and 1985; Dahlin and others, 1985; Foley and Barker, 1985; Foley and others, 1985, 1986, 1988, and 1989; and Newberry, 1986.

126. Liberty Falls **Mn**

Manganite occurs in a 12-m-long, 0.6-m-thick lens in Strelna greenstone outcrop. Several other similar lenses are reported along strike to the south. Select samples contain as much as 58.7 pct Mn.

References: Jasper, 1967, p. 4; and Berg and Cobb, 1967, p. 49.

127. Spirit Mountain **Ag, Au, Co, Cu, Ni, PGE**

Disseminated and massive iron-copper-nickel sulfide minerals occur in sill-form peridotite-pyroxenite intrusions. Reserve estimates include 5,900 mt of material grading from 0.22 pct Ni and 0.12 pct Cu to 7.61 pct Ni and 1.56 pct Cu. Ore minerals include pyrrhotite, pentlandite, bravoite, chalcopyrite, chalcocite (?), and hematite (?). Heads from a metallurgical sample contain 1.16 pct Ni, 0.76 pct Cu, 0.04 pct Co, 0.02 pct Zn, 240 ppb (0.007 oz/st) Au, 2,640 ppb (0.077 oz/st) Ag, 206 ppb (0.006 oz/st) Pt, and 171 ppb (0.005 oz/st) Pd; 92 pct of Cu, 79 pct of Ni, 76 pct of Co, and minor Au, Ag, Pt, and Pd were recovered during flotation tests.

References: Kingston and Miller, 1945; Pierce, 1946; Herreid, 1970; and unpublished Bureau of Mines data.

128. Hanagita River **Cr**

A 5-cm clot of massive chromite was observed in wehrlite and accessory disseminated chromite occurs in dunite.

References: Foley and Barker, 1985; and Foley and others, 1985 and 1986.

129. Chakina River **Cr**

Disseminated chromite occurs in serpentinized peridotite and dunite.

References: Foley and Barker, 1985; and Foley and others, 1985 and 1986.

South-Central Alaska - Gulf of Alaska metallogenic province

130. Resurrection Peninsula — Ag, Au, Cr, Cu, Ni, (As, Cd, Pb, Zn)

Numerous abandoned prospects, and reported mineral occurrences occur in mafic volcanic and mafic and ultramafic plutonic rocks. Volcanic rocks include pillow basalt, diabase, sheeted dikes, and greenstone. Plutonic rocks include gabbro, dunite, and peridotite. Prospects and mineral occurrences include disseminated sulfide minerals, massive sulfide veins and pods, and quartz-calcite veins and stringers in breccia zones and shear zones in the volcanic and plutonic rocks. Mineral occurrences are also reported in metasandstone. Ore minerals include pyrite, pyrrhotite, chalcopyrite, arsenopyrite, sphalerite, galena, hematite, limonite, and magnetite. Underground workings are reported at several sites but no production records are available.

References: Jansons and others, 1984; and Nelson and others, 1987.

131. Latouche Island — Asbestos, Ag, Au, Cu, (Zn)

Numerous abandoned mines, prospects, and reported mineral occurrences exist on Latouche Island and on Elrington Island, across Latouche Passage to the west. Massive sulfide lenses and sulfide stringers cut mostly graywacke, shale, and slate, but are also reported in nearby greenstone bodies. Reported ore minerals include pyrite, pyrrhotite, chalcopyrite, cubanite, galena, sphalerite, and native copper. Combined production, through 1930, from the Beatson Mine, the Duchess claim, the Blackbird Mines, and the Seattle prospect totals 83.2 million kg Cu, 46,700,000 g (1.5 million oz) Ag, and 15,000 g (484 oz) Au. Significant copper reserves remain in the mines that produced and in the Duke Mine which was flooded.

References: Jansons and others, 1984; and Crowe and others, 1988.

132. Chenega Island — Cu, Mn

Between 18,000 and 36,000 mt of Mn are estimated in 104,000-209,000 mt that contain about 17 pct Mn. The manganiferous iron deposit comprises rhodonite, pyroxmangite, and rhodochrosite at the highly altered contact between siliceous greenstone and phyllitic, quartzofeldspathic argillite of the Eocene to Paleocene Orca Group. Pyrite, pyrrhotite, and chalcopyrite are locally abundant in the altered and mineralized zone.

References: Kurtak, 1982; Jansons and others, 1984; and unpublished Bureau of mines data.

133. Knight Island — Ag, Cu, Ni, (Pb, Zn)

Fifty-eight abandoned prospects and reported mineral occurrences exist on Knight Island. Most of these are in greenstone and mafic volcanic rocks or are near contacts between clastic sedimentary rocks and greenstones or mafic volcanic rocks. Ore minerals include chalcopyrite, covellite, bornite, native copper, sphalerite, galena, limonite, malachite, pyrite, and pyrrhotite. Ore minerals are concentrated as disseminated grains and massive segregations in greenstone, along shear zones in greenstone, in quartz veins, and in nearby sedimentary rocks. Sedimentary rocks include graywacke, slate, shale, schist, and chert.

Extensive shallow underground workings, prospect pits, and ore and tailing dumps remain at these sites. Minor copper production is reported for many of the sites and indicated and inferred copper reserves are reported for a few of the larger deposits.

References: Jansons and others, 1984; and Nelson and others, 1987.

134. Port Valdez area **Ag, Au, Cu, Ni, (As, Pb, Zn)**

Numerous abandoned mines, including the Midas, Cliff, and Ramsay-Rutherford mines, prospects, and mineral occurrences are present in the area. High-grade quartz-gold veins, mostly cutting sedimentary rocks but locally in greenstone, accounted for production of about 1,990,000 g (64,000 oz) Au, 1,306,000 g (42,000 oz) Ag, and 1.5 million kg Cu. Gold and sulfide minerals are mostly present in quartz veins, stringers, and ribbon quartz in slate, shale, and graywacke. Minor production is reported from sites where ore minerals are contained in greenstone and basic dikes. Ore minerals include native gold, chalcopyrite, bornite, pyrite, pyrrhotite, galena, sphalerite, and arsenopyrite.

References: Jansons and others, 1984, Nelson and Koski, 1987, and Crowe and others, 1988, p. 153.

135. Port Fidalgo area **Ag, Au, Co, Cu, (Pb, W, Zn)**

Abandoned mines, including the Fidalgo, Schlosser, South Landlocked Bay, Threeman, and Boulder Bay mines, numerous prospects and mineral occurrences are present in the area. Massive sulfide lenses, disseminated sulfide minerals, quartz-sulfide veins and veinlets, and mineralized shear zones occur in slate, greenstone, and along contacts between the two rock types. Ore minerals include chalcopyrite, pyrite, pyrrhotite, arsenopyrite, galena, sphalerite, scheelite, malachite, and azurite. Recorded production includes 2.7 million kg Cu and 208,000 g (6,700 oz) Ag.

References: Jansons and others, 1984: and Crowe and others, 1988.

136. Hinchinbrook Island **Cu, Mn**

As much as 35 pct Mn is estimated in rubblecrop over a 280-m^2 area in metsasediments and pillow basalt of the Eocene to Paleocene Orca Group. Manganese oxide minerals and the manganese silicates rhodonite and tephroite were identified. Native copper is reported as an accessory mineral in greenstone on the island.

References: Goodfellow and others, 1984; and Jansons and others, 1984.

137. Cordova area **Ag, Au, Cu, (Pb, Zn)**

Numerous abandoned mines, prospects, and mineral occurrences are present in shear zones and quartz veins in greenstone and nearby clastic sedimentary rocks. Ore minerals include chalcopyrite, bornite, chalcocite, malachite, pyrite, pyrrhotite, sphalerite, and galena. Minor production is reported.

References: Jansons and others, 1984.

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