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Mineral Occurrence and Development Potential Report

Locatable and Salable Minerals
Bering Sea-Western Interior Resource Management Plan

Joseph Kurtak, John Hoppe, and Robert Ellefson

Alaska

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Bureau of Land Management (BLM) geologist John Hoppe examines rock outcrops in the Terra Cotta Mountains in the southeast portion of the Bering Sea–Western Interior Planning Area.

Authors

Joseph Kurtak is a geologist with the BLM Anchorage Field Office. John Hoppe and Rob Ellefson are geologists with the BLM Alaska State Office, Branch of Energy and Solid Minerals.

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Abstract

The Anchorage Field Office of the Bureau of Land Management (BLM) is preparing the Bering Sea–Western Interior (BSWI) Resource Management Plan (RMP) to provide a comprehensive framework for managing and allocating uses of public lands and resources in the central southwestern portion of the State of Alaska. The BSWI Planning Area encompasses nearly 60 million acres, with 13% of those lands managed by the BLM. An analysis of the locatable and salable mineral potential within the BSWI Planning Area was completed as part of this study. The main objective was to delineate areas with high potential for the development of locatable and salable minerals.

The BSWI Planning Area has a long and colorful mining history, dating back to the late 1830s when Russian traders discovered mercury-bearing minerals along the Kuskokwim River near Aniak. This was the site of one of the last great gold rushes in Alaska when gold was discovered in the Flat area in 1908. Documented mineral production within the planning area totals 3.2 million oz gold, 151,750 oz silver, 2.1 million lbs of copper, and 41,767 flasks of mercury. The Iditarod Mining District, which includes the Flat area, ranks 3rd in placer gold production in Alaska.

The planning area contains 445 documented mineral occurrences. This includes placer gold, gold-bearing quartz veins, copper-gold skarns, and silica-carbonate mercury deposits. The area currently contains a total of 6,618 mining claims with 219 of those under federal management. In 2008 there were nine active placer mines and one active lode mine within the planning area.

There are several sites within the planning area containing mineral resources. At the Donlin felsic-dike-hosted gold deposit, measured/indicated resources total 94.6 million tons at an average grade of 0.06 oz/ton gold. Additional inferred resources place total contained metal at 29.3 million oz gold. At the Nixon copper-gold skarn deposit measured/indicated resources total 164,639 tons at an average grade of 0.70 oz/ton gold along with an undisclosed amount of copper and silver.

The present study focused on locating and evaluating mineral occurrences and all other information that could affect mineral potential within the BSWI Planning Area. Much of the data used was the result of a mineral assessment of the Aniak Mining District made by the BLM from 2003 to 2006. This district makes up the core of the planning area. Additional field investigations were done in 2008 to assess those portions of the planning area not included in the original mineral assessment.

The evaluation of mineral potential focused on individual mineral occurrences and then on data sets that can be used to further indicate future mineral resource development. Each section of land in the Public Land Survey System within the planning area was given a numerical score based on the sum of various attributes associated with mineral development potential. The mineral potential score is composed of the number and quality of mineral occurrences located within the section and the intersection of areas designated as being significant to mineral potential.

As a result of this study, a total of 57 sites within the planning area are considered to have high locatable mineral potential (LMP). There are a number of these high LMP areas that fall within BLM-managed lands and are covered by federal mining claims. These include: 1) Nixon Fork Mine area; 2) Flat-Chicken Mountain area; 3) Ophir Creek drainage (Kilbuck Mountains), and 4) the NYAC (Shamrock Creek) area. Present and future mineral exploration and mining activities in these areas could have impacts on BLM-managed lands extending outside the mining claim boundaries. Though located on Native-patented lands, the access routes to the Donlin deposit will likely cross and have possible impacts on BLM-managed lands.

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ABBREVIATIONS

ADGGS ..... Alaska Division of Geological and Geophysical Surveys
ADNR ..... Alaska Department of Natural Resources
AEIDC ..... Arctic Environmental Information and Data Center
AMIS..... Alaska Minerals Information System
AMRAP ..... Alaska Mineral Resource Assessment Program
ANCSA..... Alaska Native Claims Settlement Act of 1971
ANILCA..... Alaska National Interest Conservation Act of 1980
ARDF..... Alaska Resource Data File
BLM..... Bureau of Land Management
CY..... Cubic Yards
EIRMP ..... Eastern Interior Resource Management Plan
FLPMA ..... Federal Land Policy and Management Act of 1976
KMDA..... Known Mineral Deposit Areas
LMP..... Locatable Mineral Potential
MAS/MILS..... Mineral Availability System/Mineral Industry Location
MODPR ..... Mineral Occurrence and Development Potential Report
Ma..... Mega-annum, millions of year ago
MTA..... Mineral Terranes of Alaska
NEPA..... National Environmental Policy Act of 1969
NGDB..... National Geochemical Database
NURE ..... National Uranium Resource Evaluation
RASS..... Rock Analysis Storage System
RDI ..... Research Data Institute
REE ..... Rare Earth Element
RFD ..... Reasonably Foreseeable Development Scenario Report
RMP..... Resource Management Plan
SEDEX ..... Sedimentary Exhalative lead-zinc deposit
USBM..... U.S. Bureau of Mines
USGS ..... U.S. Geological Survey
VMS..... Volcanogenic Massive Sulfide deposit

Mineral Terranes of Alaska (MTAs) Mineral Terrane Units

IGA	Alkalic granitic rocks
IGF	Felsic granitic rocks
IGI	Intermediate granitic rocks
IGU	Undivided granitic rocks
IMA	Mafic intrusive rocks
IUM	Ultramafic rocks
VFU	Undivided felsic volcanic rocks
VSF	Undivided sedimentary and felsic volcanic rocks
VSM	Undivided sedimentary and mafic volcanic rocks
VOP	Ophiolite terrane
SLS	Limestone and shale
SBS	Black, carbonaceous shale, and limestone

Elemental Abbreviations

Ag = Silver
As = Arsenic
Au = Gold
Co = Cobalt
Cr = Chromium
Cu = Copper
Hg = Mercury
Mo = Molybdenum
Ni = Nickel
Pb = Lead
PGE = Platinum group elements (e.g., platinum, palladium, iridium)
Pt = Platinum
Sn = Tin
REE = Rare earth elements (e.g,, lanthanum, cerium, neodymium)
U = Uranium
W = Tungsten
Zn = Zinc

I. INTRODUCTION

The Anchorage Field Office of the Bureau of Land Management (BLM) is preparing the Bering Sea-Western Interior (BSWI) Resource Management Plan (RMP) to provide a comprehensive framework for managing and allocating uses of public lands and resources in the southwestern portion of the State of Alaska. The planning process will meet the requirements of the National Environmental Policy Act (NEPA) through a detailed description of the management alternatives and environmental consequences resulting from each alternative. The Federal Land Policy and Management Act of 1976 (FLPMA), as amended, provides the authority for BLM land use planning on public lands. In particular, FLMPA Sec. 202(a) requires the Secretary of the Interior, with public involvement, to develop, maintain, and when appropriate, revise land use plans that provide by tracts or areas for the use of the public lands. Implementing regulations which provide procedures and guidance for the planning process are contained in the Code of Federal Regulations 43 CFR 1610, and in BLM Manuals 1601 (Land Use Planning) and H-1601-1 (Land Use Planning Handbook). This Mineral Occurrence and Development Potential Report (MODPR) was prepared following the guidance of BLM Manual Section 3031 (Energy and Mineral Resource Assessment).

Mineral resources on BLM-managed surface and subsurface lands are divided into three categories – locatable, leasable, and salable – based on provisions of various mining laws. In the late 1800s, the U.S. Department of the Interior began to define hardrock minerals as "locatable" if they could be found on public lands in quantity and quality sufficient to make the land more valuable by their existence. The General Mining Law of 1872 established the authority for locatable mineral mining claims, and provided the basis for subsequent mining laws that, over time, substantially reduced the number of minerals considered locatable. Two primary laws, the Mineral Leasing Act of 1920 and the Materials Act of 1947, excluded certain mineral types that could only be acquired through a federal leasing program or disposed of by sale. "Leasable" minerals include oil and gas, coalbed methane, geothermal fluids, and certain solid minerals such as potassium, sodium, phosphate, and oil shale. "Salable" minerals include common varieties of mineral materials such as construction aggregate (sand and gravel), building stone, pumice, clay, and limestone. Mineral types remaining in the locatable category following these modifications include metallic and certain nonmetallic industrial minerals generally found in lode or placer deposits. Under certain circumstances, mineral materials can be considered locatable minerals.

Purpose of this Report

This report was drafted to provide land use planners with the basic locatable and salable minerals information used in developing the various alternatives analyzed in the NEPA documents; and to identify areas of High, Medium, and Low mineral potential.

The goal of the planning process with respect to locatable and salable minerals is to identify areas open or closed to the operation of the mining laws and mineral material disposal; and, in open areas, to identify any area-wide terms, conditions, or other special considerations needed to protect resource values. Leasable minerals and energy resources are beyond the scope of this report.

Lands Involved and Land Status

The Bering Sea-Western Interior (BSWI) Planning Area encompasses approximately 59.9 million acres in southwestern Alaska (**Figure 1 map**). This acreage includes: 1) all lands south of the Central Yukon watershed to the southern boundary of the Kuskokwim River watershed; 2) all lands west of Denali National Park and Preserve and the divide of the western portion of the

Alaska Range south of Denali National Park and Preserve; and 3) Saint Lawrence, Saint Matthew (not depicted), and Nunivak Islands.

A total of 7.9 million acres (13.2%) are public lands managed by the BLM Anchorage Field Office. Additional federal lands include 19.5 million acres of U.S. Fish and Wildlife Service (FWS); 556,000 acres of National Park Service (NPS); and 29,000 acres Department of Defense (military) lands (**Table 1**). Mineral development and surface activities on split estate lands are managed by the appropriate surface agency, but the BLM is responsible for administrative functions for those lands, including mining claim filings, adjudications, and record keeping. Thus, the BSWI RMP will not make decisions regarding management of subsurface estate under NPS, FWS, or military lands.

Table 1. Land Status, Bering Sea-Western Interior Planning Area[1]

	Land Ownership	Acres	Percent
1	BLM	7,915,286	13.2
2	State Conveyed[1]	18,087,118	30.2
3	State-Selected	2,427,974	4.1
4	ANCSA[2] Conveyed	10,710,295	17.9
5	ANCSA-Selected	489,244	0.8
6	Private	204,970	0.3
7	National Wildlife Refuges[†3]	19,474,447	32.5
8	National Parks and Preserves[4]	556,016	0.9
9	Military	29,175	0.1
	Total:	59,894,525	100.0

[1]See **Figure 1**
[2]Alaska Statehood Act, Public Law 85-508, 72 Stat. 339, July 7, 1958
[3]Alaska Native Claims Settlement Act (ANCSA), Public Law 92-203, 43 U.S.C. §1601 et seq., December 18, 1971
[4]Alaska National Interest Lands Conservation Act (ANILCA), Public Law 96-487, 94 Stat. 2371, December 2, 1980
[†]Wildlife refuges take up much of the western portion of the planning area. The refuges include, in order of size, the Yukon Delta, Innoko, and Togiak National Wildlife Refuges, respectively.

The BLM is responsible for administering subsurface minerals on federal split-estate lands in the BSWI Planning Area. A portion of the BLM-managed lands include lands selected by, but not yet conveyed to, the State of Alaska and native Alaskans – referred to as State-selected and Native-selected lands.

State lands in Alaska came about through the Alaska Statehood Act of 1959. This Act gave the new state selection rights to federal land to foster development and state independence, a process that was supposed to end in 1984.

Native lands were designated as a result of the Alaska Native Claims Settlement Act (ANCSA) of 1971, which superseded the Statehood Act and provided for Native claims to traditional lands. ANCSA and the Alaska National Interest Conservation Act (ANILCA) of 1980 froze state selection rights to previously open federal lands. ANILCA granted a 10-year extension to complete the state-selection process by 1994. Due to initial over-selection by the State and Native corporations, management of some of these selected lands will be retained by the BLM and become "unencumbered" BLM lands at the completion of the conveyance process. The Alaska Native corporations and the State of Alaska have finalized their prioritized lists for federal land conveyances. [See **Figure 1 map].**

There are 60 rural communities within the planning area with 26 in the immediate vicinity of the Federal planning blocks. The human population is approximately 25,000. The largest population center is Bethel (population 6,468), located in the southwest portion of the planning area. The economy is mixed, dominated by public sector employment and heavy emphasis on use of subsistence resources. There are very few roads in the area; the longest being a 43-mile gravel road that connects Sterling Landing on the Kuskokwim River with the historic mining community of Ophir on the Innoko River.

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Scope and Objective

This report describes the known, existing mineral resources and current resource management and identifies areas of High, Medium, and Low mineral development potential in the BSWI Planning Area. By incorporating a wide variety of available geologic information, including federal and state reports, this Mineral Occurrence and Development Potential Report will present a summary of occurrence and development potential for the entire BSWI Planning Area, regardless of land status. This assessment provides an intermediate level of detail, as required by Manual Section 3031 for all of the BLM land use plans (BLM 1994).

Information contained in this report will be used to construct a forthcoming Reasonably Foreseeable Development Scenario Report, detailing the type, location, and manner of potential environmental disturbance due to locatable and salable minerals extraction.

Occurrence and Development Potential

Mineral potential assessments require the understanding of two components: (1) the potential for mineral occurrence and (2) the potential for their economic development. The potential for mineral occurrence is a prediction of the likelihood of the presence of economic minerals. Mineral occurrence potential does not necessarily imply that the mineral can be economically exploitable, or that the quality and quantity of the resource is known. Whenever known, however, the current and projected development potential is part of the mineral resource assessment. For the purposes of the BSWI RMP, development potential describes whether or not a mineral occurrence is likely to be explored or developed within the 10- to 15-year lifespan of the RMP under given geologic and non-geologic assumptions and conditions (BLM 1994).

Report Organization

The following section presents the organizational format for this report:

Section I – Introduction: Identifies regulatory justification and guidance for the planning process and presents background information as it relates to locatable and salable minerals.

Section II – Description of Geology: Provides a summary description of planning area geology and an overview of data types and resources used to compile geologic data for this report.

Section III – Description of Mineral Resources: Presents a description of mineral resources; identifies and summarizes minerals information used in the development of potential ratings; and identifies how each information type is applied to the determination of mineral potential.

Section IV – Rationale for the development of Potential Ratings: Provides rationale for generating potential ratings and explains the level of confidence criteria.

Section V – Mineral Occurrence and Development Potential: Provides a summary of mineral occurrence and development potential for the Planning Area.

Section VI – Recommendations.

Section VII – Statement of Qualification.

Section VIII – Current Management and Existing Land Use Plans.

Section IX – Acknowledgements.

▲**Figure 3.** Kuskokwim River Lowlands near Tuluksak. View to the southwest.

II. DESCRIPTION OF GEOLOGY

The following sections summarize the BSWI Planning Area geology and geography, and provides an overview of available geochemical and geophysical data.

Physiography

The BSWI Planning Area contains an extremely diverse group of 11 different physiographic provinces. Wahrhaftig (1965) remains as the definitive reference for descriptions of these provinces. The following descriptions are excerpts from that reference with some additions. [See **Figure 2 map**]

1. Yukon-Kuskokwim Coastal Lowland

The Yukon-Kuskokwim coastal lowland dominates the western portion of the BSWI Planning Area (**Figure 3**). The coastal lowland is a triangular, lake-dotted marshy plain that rises from sea level on its west margin to 100–300 ft at its east end. Many low hills of basalt surmounted by cinder cones, broad shallow volcanic craters, and a few craggy mountains of older rocks 2,300-2,450 ft high, rise from the western part of the plain. Low beach ridges, marked by lines of thaw lakes, lie along part of the west coast. The lowland is crossed by meandering streams of extremely low gradient, many of which are distributaries or former channels of the Yukon River. These streams flow to the Bering Sea. The Yukon River flows along the base of hills on the north side of the lowland and is building a delta into the Ber-

Insert FIGURE 2 MAP here (fold-out)

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ing Sea. On the southeast side, the Kuskokwim River ends in a marine estuary that appears to be a drowned river mouth.

The lowland is dotted with innumerable thaw lakes, many of them 10 or more miles long. Some have scalloped shorelines and probably formed through the coalescence of several smaller lakes. Probably 30%-50% of the lowland is lake surface. Lying underneath the area is discontinuous permafrost.

The lowland is also underlain by Quaternary sediments to unknown depth. Basalt flows and cinder cones are of Tertiary and Quaternary age. Other bedrock hills consist of Cretaceous sedimentary rocks, cut by early Tertiary intrusions, and of crystalline rocks of unknown age. [See **Figure 2 map**].

2. Kuskokwim Mountains

The Kuskokwim Mountains dominate the central portion of the BSWI Planning Area (**Figure 4**). They are a monotonous succession of northeast-trending ridges having rounded to flat summits 1,500–2,000 ft in altitude and broad gentle slopes. Ridge crests north of the Kuskokwim River are accordant at about 2,000 ft and are surmounted at intervals of 10–30 miles by isolated circular groups of rugged glaciated mountains 3,000–4,400 ft in altitude. Valleys have flat floors 1–5 miles wide.

The Kuskokwim Mountains are drained by tributaries of the Yukon and Kuskokwim Rivers. Major streams generally flow northeast to southwest along valleys that are probably controlled by faults; streams are fast and meandering and generally lie near the northwest walls of their valleys. The Kuskokwim River crosses the mountains in a gorge 100-400 ft deep incised in an older valley about 1,000 ft deep and 2–8 miles wide. Lakes are few. There are oxbow and thaw lakes in the valleys and a few cirque lakes in the glaciated mountains. Permafrost underlies most of the section, and periglacial erosional processes predominate.

Most of the Kuskokwim Mountains are made of tightly folded Cretaceous rocks that strike northeast. Graywacke upholds the ridges, and argillite underlies the valleys. The northeastern and northwestern parts are underlain by Paleozoic

◄**Figure 4.** Kuskokwim Mountains near Sleetmute. Chicken Mountain pierces the skyline on photo right. View to northeast.

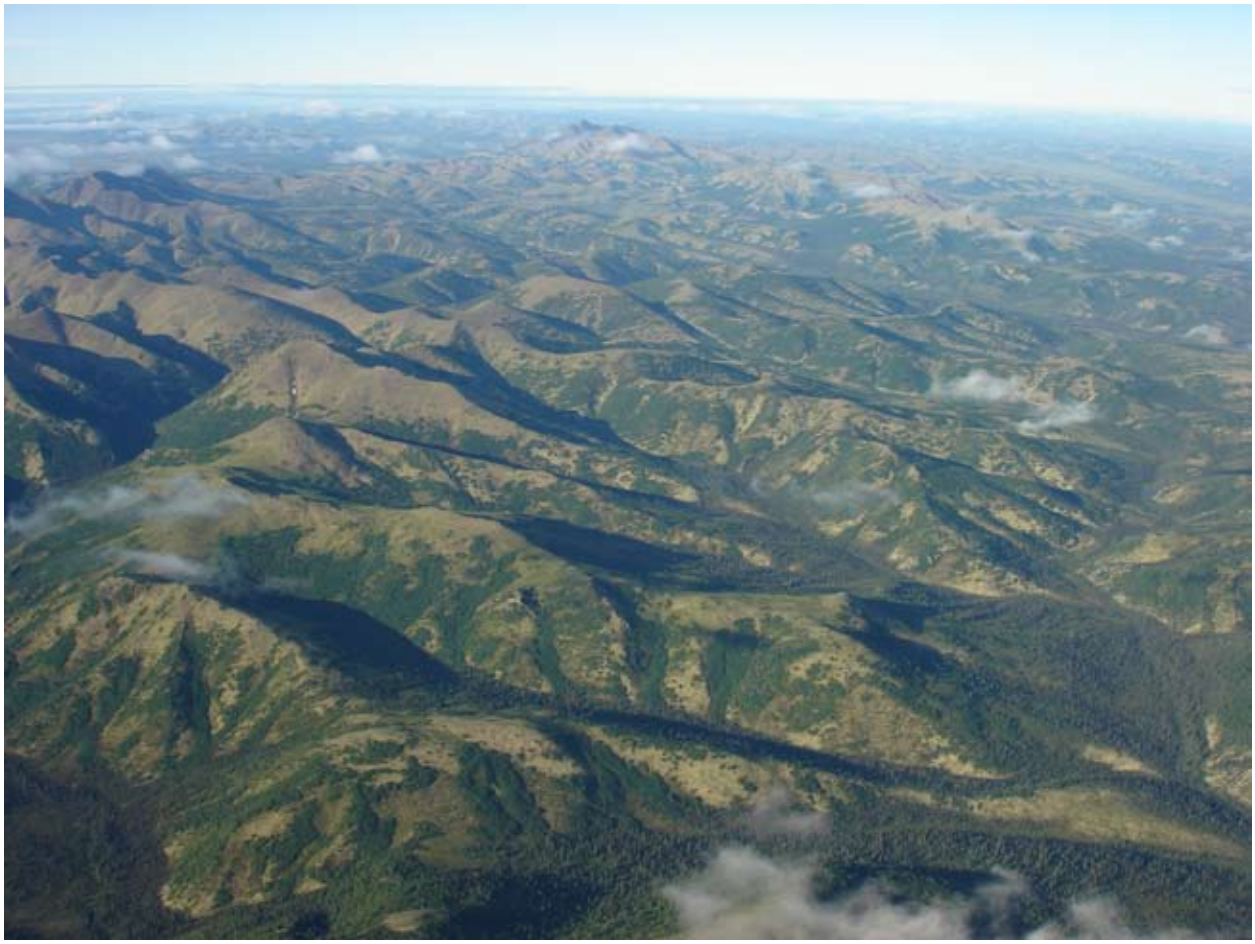
sedimentary rocks and Precambrian schist. The isolated circular groups of high mountains including the Russian, Horn, and Beaver Mountains are underlain by monzonitic intrusions and their surrounding hornfels aureoles. Flat-lying basalt locally caps the remnants of a mid-Tertiary erosion surface. Pleistocene and Recent block faulting has occurred south of the Kuskokwim River.

3. Nulato Hills

The Nulato Hills make up the majority of the northwest portion of the BSWI Planning Area (**Figure 5**). These consist, in general, of northeast-trending even-crested ridges, 1,000-2,000 ft in altitude, having rounded summits and gentle slopes. Valleys are narrow and have flat floors that are generally trenched in their upstream parts to depths of about 30 ft. Local relief is 500–1,500 ft. The topography is relatively fine textured; gullies are spaced 500–1,500 ft apart and second-order tributaries are ½–1 mile apart. Three highland areas of steeper ridges rise to about 4,000 ft in altitude.

Streams on the east side of the section flow to the Yukon River and those on the west side to Norton Sound. Major streams are markedly parallel, flowing either northeast or southwest, and their courses are eroded along northeast-trending fault zones. Valley heads are generally connected by low passes along the faults. There are a few thaw lakes in the valleys. The entire section is probably underlain by permafrost.

Almost all the hills are composed of tightly folded sandstone, conglomerate, and shale of Cretaceous age. The fold axes trend 45 degrees northeast, but



▲**Figure 5.** Nulato Hills near Unalakleet, vew to the south.

bend around to northward in the northern part. The rocks are cut by northeast- and north-trending faults. A few mountains are underlain by post-Cretaceous intrusive and volcanic rocks. Older rocks, chiefly of volcanic origin, make up the hills in the extreme northern part and extreme southern part.

4. Nushagak-Big River Hills

The Nushagak-Big River Hills are largely rounded, flat-topped ridges rising to an altitude of 1,500 ft on the west and 2,500 ft on the east. The hills have broad gentle slopes and broad flat or gently sloping valleys. Local relief is 1,000-2,500 ft. Mountains in the northeastern part rise to an altitude of 4,200 ft. Ridges trend northeastward in the eastern part but have no preferred trend in the southwestern part. The hills drain to the Kuskokwim River via the Big, Stony, Swift, and Holitna Rivers. The rivers rise from glaciers in the Alaska Range and flow across the hills. Some, like the Stony and Swift, are braided muddy streams. Others, like the Holitna, are clear and meandering. Some valleys contain thaw lakes. Ponds are abundant in the moraine-mantled eastern part of the hills. Most of the section is underlain by permafrost, and periglacial erosional processes predominate.

Most of the Nushagak Hills consist of tightly folded Mesozoic graywacke, argillite, conglomerate, and greenstone flows. There is a central northeast-trending belt of Paleozoic rocks, including steep isolated ridges of limestone. Early Tertiary intrusions and their metamorphic aureoles uphold the Taylor Mountains and Shotgun Hills, which are two small circular groups of high mountains in the southwestern part of the province.

5. Southern Alaska Range

The BSWI Planning Area contains that portion of the Southern Alaska Range that drains into the Kuskokwim River basin (**Figure 6**). The Alaska Range consists of many parallel rugged glaciated north-trending ridges 7,000-12,000 ft in altitude; south of Lake Chakachamna the ridges trend

►**Figure 6.** Terra Cotta Mountains in the southern Alaska Range. Peaks range from 7,000 to 12,000 ft in elevation. View to the south.

northeast and are 4,000-6,000 ft in altitude. Between the ridges lie broad glaciated valleys which have floors less than 3,000 ft in altitude. Local relief is between 4,000 and 9,000 ft. Many spire-like mountains rise in the central part of the range.

Large braided glacial streams follow the north- and northeast-trending valleys. They flow north or south to the Kuskokwim River and southwest to the Nushagak or Kvichak Rivers.

Many large lakes occupy glaciated valleys within and on the margins of the range. The largest of these bodies is Lake Clark; 49 miles long and 1-4 miles wide.

Extensive systems of valley glaciers radiate from the higher mountains. The firn line is lower and the glaciers are larger on the southeast side of the range than on the northwest and west sides of the range. The extent of permafrost is unknown.

Most of the Southern Alaska Range is underlain by large granitic batholiths, intrusive into moderately metamorphosed and highly deformed Paleozoic and Mesozoic volcanic and sedimentary rocks, which form scattered areas of lower mountains. Structural trends are generally northerly, but change abruptly to northeasterly and easterly northward across Rainy Pass.

6. Central Alaska Range

The BSWI Planning Area contains that portion of the central part of the Alaska Range consisting of two or three parallel rugged glaciated ridges, 6,000-9,000 ft in altitude, surmounted by groups of extremely rugged snowcapped mountains more than 9,500 ft in altitude. The ridges are broken at intervals of 10-50 miles by cross-drainage or low passes; most of the drainage appears superposed. The range rises abruptly from lower country on either side, and its longitudinal profile, seen from a distance, is irregular. Mount McKinley, 20,269 ft high and the highest mountain in North America, is in the Alaska Range.

The western part of the range drains to the Kuskokwim River. Streams are swift and braided, and most rivers head in glaciers. There are a few rock-basin lakes and many small ponds in areas of ground moraine. Lakes are rare for a glaciated area.

The firn line on the north side of the Alaska Range is 6,000-8,000 ft in altitude; this change reflects the northward decrease in cloudiness and precipitation as one passes from the Gulf of Alaska coast to the interior. The high mountains are sheathed in ice. Short valley glaciers lie in north-facing valleys in the lower parts of the range. Rock glaciers are common. Permafrost is extensive and solifluction features are well developed.

The internal structure of the Alaska Range is a complex synclinorium having Cretaceous rocks in the center and Paleozoic and Precambrian rocks on the flanks. This synclinorium is cut by great longitudinal faults that trend approximately parallel to the length of the range and are marked by lines of valleys and low passes. The synclinorium was probably formed near the close of the Mesozoic Era. Many roughly oval granitic stocks and batholiths support groups of high mountains that have cliffs as high as 5,000 ft. Synclinal areas of Tertiary rocks underlie lowlands that trend parallel to the length of the range. Much of the major topography of the range was probably produced from mid-Tertiary structures by removal of easily eroded Tertiary rocks to form lowlands. Recently formed scarplets as high as 30 ft can be seen on several longitudinal faults. At least four periods of glaciation have been recognized; the earliest is indicated only by scattered giant granite erratics on uplands in the foothills to the north.

7. The Innoko Lowlands

The Innoko Lowlands lie near the center of the BSWI Planning Area and are a group of flat river floodplains, dendritic in pattern, whose bounding slopes are generally steep banks cut into the surrounding hills; in places, however, gentle silt-

covered slopes merge with the surrounding hills. The Yukon River and a large tributary, the Innoko River, cross the lowlands. The main part of the lowlands has a complex intersecting network of meandering sloughs of these two rivers (**Figure 7**).

▲**Figure 7.** Looking north up the Yukon River between Kaltag and Grayling

Oxbow and meander-scroll lakes are abundant in recently abandoned floodplains and partly silted sloughs. Thaw lakes abound in old floodplains and on gentle silt-covered slopes. The lower parts of many tributaries from surrounding hills are dammed by alluvium from the Yukon River and form narrow dendritic lakes. Much of the section is underlain by permafrost.

Bedrock geology in the Innoko Lowlands is probably the same as that of the surrounding hills. The plains are mantled by river-floodplain deposits and by windborne silt, which also extends up the slopes of the surrounding hills.

8. Holitna Lowland

The Holitna Lowland makes up a small area of largely a moraine-covered plain 300-800 ft in altitude and is crossed by several low arcuate hummocky ridges marking the end moraines of glacial advances and by broad outwash and meander plains along rivers. The Lime Hills, conspicuous isolated steep-sided ridges in the southern part of the lowland, rise to an altitude of 1,000-2,300 ft. The Holitna Lowland is drained by the Kuskokwim River and three of its tributaries, the Stony and Swift Rivers, which are glacial streams from the Alaska Range that have braided gravelly courses, and the Holitna River, a clear meandering stream that rises in uplands to the south. There are numerous morainal and thaw lakes throughout the lowland. This section is probably one of discontinuous permafrost.

The bedrock hills in the Holitna Lowland are composed of Mesozoic graywacke, argillite, and conglomerate and early Paleozoic limestone. Most of the lowland is underlain by moraine and outwash together with thick accumulations of windborne silt.

9. The Tanana-Kuskokwim Lowland

A small portion of the western part of the Tanana-Kuskokwim Lowland is located along the east-central boundary of the BSWI Planning Area. It consists of a broad depression bordering the north flank of the Alaska Range with surfaces of diversified origin. Coalescing outwash fans from the Alaska Range slope 20-50 ft per mile northward to floodplains along the axial streams of the lowland. Rivers from the range flow for a few miles at the heads of the fans in broad terraced valleys 50-200 ft deep. Semicircular belts of morainal topography lie on the upper ends of some fans. The floodplain of the Kuskokwim River is incised 50-200 ft below the level of the lowland. Several nearly level projections of the lowland extend into uplands on the north. Large fields of stabilized dunes cover the northern part of the lowland and lower slopes of adjacent hills between Nenana and McGrath.

▲ **Figure 8.** The Ahklun Mountains at Kisaralik Lake. View to the northeast.

The southwestern part of the lowland is drained by the Kuskokwim River. Braided glacial streams rising in the Alaska Range, flow north across the lowland at intervals of 5-20 miles. Outwash has pushed the axial streams of the Kuskokwim River against the base of hills on the north side of the range. Tightly meandering tributaries of low gradient flow into the section from the north. Thaw lakes abound in areas of fine alluvium. Thaw sinks are abundant in areas of thick loess cover. The entire section is an area of permafrost; however porous gravel at the heads of the outwash fans, however, has a deep water table and dry permafrost (ground perennially at temperatures below freezing but having no ice).

The outwash fans grade from coarse gravel near the Alaska Range to sand and silt along the axial streams. Areas north of the axial streams are underlain by thick deposits of "muck," a mixture of frozen organic matter and silt. Parts of the southwestern portion of the lowland have thick loess cover. Scattered low hills of granite, ultramafic rocks, and Precambrian schist rise above the outwash. Tertiary conglomerate in the foothills of the Alaska Range plunges beneath the lowland in a monocline, and the heads of the outwash fans may rest on a pediment cut across this conglomerate.

10. Ahklun Mountains

The northern tip of the Ahklun Mountains province lies within the southwest portion of the BSWI Planning Area. It contains groups of rugged steep-walled mountains that rise abruptly above the lowlands and low hills on the north and east

(**Figure 8**). The peaks have sharp summits 2,000-5,000 ft in altitude, separated by broad flat valleys and lowlands. The Ahklun Mountains are drained on the north by shallow, clear streams that flow directly to the Bering Sea and the Kuskokwim River on the northwest. Most rivers are incised in bedrock gorges 20-50 ft deep in the downstream parts of their valleys. Drainage is roughly radial, and several streams in the northwestern part flow through canyons that cut directly across structurally controlled ridges. This province is outstanding for the number and beauty of its glacial lakes, which are long narrow bodies of water in U-shaped canyons. Kisaralik Lake is an excellent example. Lake depths as great as 900 ft have been reported. A few small cirque glaciers are found in the highest parts of the mountains. Permafrost occurs sporadically.

The mountains are made of strongly deformed sedimentary and volcanic rocks of late Paleozoic and Mesozoic age together with some bodies of older schist. These rocks are cut by great northeast-trending faults along which many of the valleys have been eroded. Structural trends control many ridges. Small granitic masses surrounded by more resistant hornfels have formed many ring-like mountain groups. The entire province was intensely glaciated.

11. Bering Platform

The Bering Platform province includes that portion of the BSWI Planning Area that lies within the Bering Sea. It is a montonously smooth submarine plain 100–500 ft deep bordered on the southwest by a submarine scarp several thousand

▲**Figure 9.** Coastal lowlands of the exposed portion of the Bering Platform near Unalakleet (arrow). View to the north.

feet deep. A coastal lowland at the head of Norton Sound is included in the platform (**Figure 9**). Several islands rise abruptly from the plain. Most of the islands are rolling uplands a few hundred to 1,000 feet high bordered by wave-cut cliffs.

St. Lawrence Island, the largest, is about 100 miles long and 20 miles wide. It is chiefly a lake-dotted bedrock plain less than 100 ft in altitude above which isolated mountain groups, bordered by old sea cliffs, rise to altitudes of 1,000-1,500 ft. A large shield volcano with many vents is on the north coast of St. Lawrence Island. St. Matthew and Nunivak Islands consist largely of undissected volcanic topography. Many small rivers drain St. Lawrence Island and Nunivak Island; most small islands have no permanent streams.

Thaw lakes abound on the lowlands of St. Lawrence Island and the lower parts of Nunivak Island; there are small crater lakes on Nunivak Island. Part of St. Lawrence Island and possibly Nunivak Island may be underlain by permafrost.

St. Matthew Island, Nunivak Island, and north-central St. Lawrence Island are made of Cenozoic basalt flows and pyroclastic debris interbedded with some sediments. St. Lawrence Island is underlain largely by intensely deformed Paleozoic and Mesozoic sedimentary and volcanic rocks and granitic intrusions.

Regional Geology

The following summary description of regional geology and geologic history is taken from the works of Beikman (1980); Decker et al. (1994); Bundtzen and Miller (1997); Miller et al. (2002 and 2005); Goldfarb et al. (2004). Figure 10 presents a generalized geologic map for the BSWI Planning Area after Beikman (1980) and Wilson et al. (1998, 1999). Overlaying the geology is an index for the 1:250,000-scale U.S. Geological Survey (USGS) Quadrangles. **[See Figure 10 map]**

The oldest rocks within the BSWI Planning Area consist of Early Proterozoic metamorphic rocks of the Idono Complex that occur locally within the central Kuskokwim Mountains. Late proterozoic metamorphic rocks occur in the northern Kuskokwim Mountains and form the depositional basement for Paleozoic shelf deposits. Paleozoic continental margin deposits underlie much of the southwestern Alaska Range and northern Kuskokwim Mountains. These include greenschist facies metaigneous and metasedimentary rocks (Decker et al. 1994). Triassic-aged ultramafic rocks in the Mt. Hurst area are believed to be slivers of dismembered ophiolites which host chromite occurrences and PGE-bearing placers. In the southern Alaska Range, Triassic-aged ultramafic rocks host nickel-copper-PGE mineralization.

Unconformably overlying the older rocks is the regionally extensive Upper Cretaceous Kuskokwim Group which is primarily a turbidite sequence composed of detritus derived from the varied pre-Cretaceous terranes. The Kuskokwim Group consists largely of rhythmically interbedded sandstone and shale, but local Late Cretaceous tuff layers record intermittent regional volcanic activity. Erosion of pre-Cretaceous rocks occurring to the north, provided clastic material which began to fill basins which formed in the area during middle to Late Cretaceous time. The Kuskokwim Group basin-fill sequence contains prograding turbidite, shallow-marine, and shoreline facies, which suggest that the basin filled in by early Late Cretaceous time (Bundtzen and Miller 1997) (**Figure 11**).

Late Cretaceous to early Tertiary volcanic-plutonic complexes, plutons, and extensive dike and sill complexes, intrude and overlie the Cretaceous flysch basin fill sediments. Extrusive sections of the complexes consist of basal tuffs overlain by andesite and basaltic andesite flows and lesser volcanic agglomerate. Plutonic rocks associated with the complexes range in composition from alkali gabbro to granite, but monzonite and quartz

Figure 10 fold-in 11x17 MAP GOES HERE.

BACKSIDE Figure 10 fold-in map.

▲**Figure 11.** Exposure of Late Cretaceous Kuskokwim Group interbedded brown-weathering fine-grained sandstone and black argillite near the Red Devil mine.

►**Figure 12.** A volcanic-plutonic complex exposed in the Russian Mountains near Aniak. Volcanic and intrusive rocks make up the mountainous terrain on photo left. A contact aurole along the margins of the complex is defined by a crescent-shaped ridge of resistant hornfels (arrow). View to the east.

syenite are the most common compositions. Hornfels aureoles, up to 1.2 miles wide, surround the larger plutons such as at the Russian, Horn, and Beaver Mountains. (**Figure 12**)

These areas host polymetallic vein-type mineralization. Age data for the plutons indicates a bimodal distribution of ages with one group from 64 to 61 million years and the other 71 to 66 million years. Intrusion of carbonate sequences by plutons, resulted in the formation of gold-bearing copper skarn deposits in the Nixon Fork area (Bundtzen and Miller 1997).

The dike and sill complexes cut the sedimentary rocks and form elongate belts. These appear to be structurally controlled in part by northeast-trending high-angle structures such as the Yankee-Ganes Creek and Iditarod-Nixon Fork faults (**Figure 13**). This includes the Ganes-Yankee Creek and Donlin Creek dike swarms. Locally the dikes have been altered by silicification and contain fine-grained arsenopyrite, pyrite, and stibnite. Late-stage quartz veins and veinlet networks associated with the felsic dikes are the source of the gold at deposits such as the Independence Mine and the Donlin Creek. Peraluminous granite-porphyry dikes, stocks, and sills in the area and of similar age contain gold-copper polymetallic deposits such as at Chicken and Vinasale Mountains (Bundtzen and Miller 1997; Bundtzen et al. 1987).

The intrusive bodies and dikes are probably the source of the placer gold found in such drainages as Ganes and Flat Creeks and at Nyac. Placer gold has concentrated in both bench and modern stream placers. The modern stream placers were probably formed from reworking of the bench deposits during uplift and subsequent downcutting by area streams.

Altered Tertiary-Cretaceous intermediate to mafic dikes, cutting the sedimentary units are associated with epithermal mercury-antimony deposits, concentrated mostly within the Kuksokwim River basin.

▲**Figure 13.** Tan-colored felsic dike cutting Kuskokwim Group rocks in the Buckstock Mountains. View to the north.

Upper Cretaceous nonmarine sedimentary rocks occur within a series of fault-bound basins within the study area. These formations locally contain coal beds which were mined for use by steamboats on the Yukon River. These occur mainly along that stretch of the Yukon River between Anvik and Kaltag. A large portion of the study area is covered by Quaternary surficial deposits consisting of young river, floodplain, glacial, alluvial, and lake deposits. These young continental sediments are concentrated mostly along the drainage basins of the Kuskokwim and Yukon Rivers.

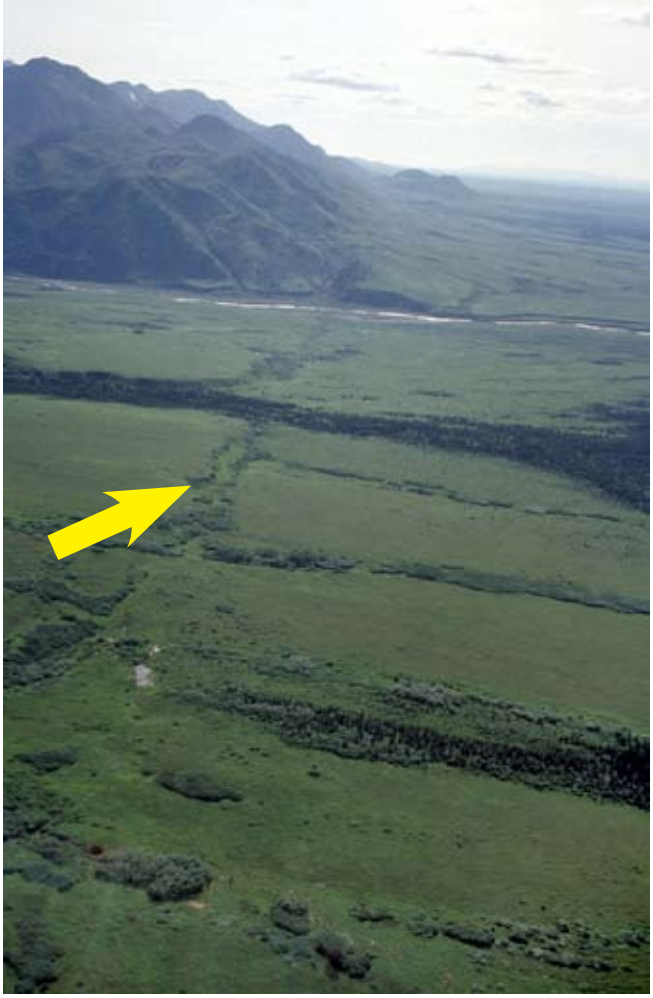
The youngest volcanic activity within the area consists of subaerial basalt flows and cinder cones of Quaternary to Tertiary age on the south side of Norton Sound. Pliestocene glaciation was confined to some of the isolated mountain ranges in the area such as the Horn and Russian Moun-

tains and in the Alaska Range along the southern boundary of the study area. Cirque glaciers exist to the present day in the higher portions of the southern Alaska Range in the southeast corner of the area.

Structural Geology and Tectonics

The structural geology of the study area is dominated by a series of northeast-trending right-lateral strike-slip faults with proposed offsets of up to 90 miles. These are from north to south the Kaltag fault near Unalakleet, the Iditarod-Nixon Fork fault, near McGrath, and the Denali-Farewell fault. Movement along these faults is believed to be dominantly Cenozoic. These faults in part form boundaries between a series of geologic terranes including the Ruby, Nixon Fork, Dillinger, Innoko, Kahiltna, and Farewell terranes. They also cut overlapping younger units such as the Kuskokwim Group. The Farewell terrane makes up the bulk of the rock units within the study area and probably formed a significant part of the North American Continental margin against which the Mesozoic terranes of southern Alaska were accreted (Decker et al. 1994).

Deformation affecting the Kuskokwim Group rocks began in Late Cretaceous time. Rock assemblages were deformed in a right-lateral wrench fault tectonic environment, as characterized by en echelon folds and high-angle faults. One of the major right-lateral structures is the northeast-trending Iditarod-Nixon Fork fault along which there may be as much as 58 miles of right-lateral offset. This fault lies within what is termed the "Kuskokwim Mineral Belt" and is spatially associated with both placer and lode deposits within the study area. The Yankee-Ganes Creek fault parallels this structure and is spatially associated with mineralized small intrusive bodies and dike swarms. To the south lies the parallel Denali-Farewell fault which runs along the Alaska Range front. The fault is estimated to have 80 miles of right-lateral offset. Offset steams and sag ponds along the fault trend are indicative of recent movement (**Figure 14**). The oldest rocks were subjected to multiple fold episodes as characterized by tight isoclinal folds. Late Cretaceous and younger rocks are more broadly folded. This tectonics probably controlled the formation of the Kuskokwim basins and the emplacement of the Late Cretaceous to early Tertiary plutonic and volcanic rocks (Bundtzen and Miller 1997).



▲**Figure 14.** Trace of the Denali-Farewell Fault *(arrow)* cross-cutting Quaternary alluvium on the north side of the Alaska Range near Farewell. View to the west.

Geophysical Data

The following discussion provides an inventory and brief description of the geophysical data readily available for the BSWI Planning Area. These data sets are routinely used in the identification/interpretation of mineral resource and potential.

1. Alaska Division of Geological & Geophysical Surveys (ADGGS)

The ADGGS conducts detailed airborne geophysical surveys in areas of the State that are prospective for mineral deposits and, in many instances, are spatially associated with State and State-selected-Federal lands. Since 1995, the ADGGS has completed four separate surveys that cover lands within the BSWI Planning Area. These include the Nyac area (south of Aniak) Sleetmute, and the Styx River area near the eastern boundary of the RMP. Two of the surveys in the Aniak and Sleetmute areas were funded by the BLM in conjunction with a mineral assessment of the Aniak Mining District (Burns et al. 2000, 2003, 2004, 2008). A number of additional areas within the BSWI Planning Area are presently being considered for future geophysical survey depending on state funding levels. These include the Marshall, Shotgun Hills, Iditarod, Sleetmute, and Farewell areas.

2. U.S. Geological Survey (USGS)

The USGS completed an airborne magnetic survey of the Taylor Mountains Quadrangle and a portion of the Bethel Quadrangle (Saltus and Milicevic 2004, USGS 2006).

Geochemical Data

Both the State and the USGS maintain databases summarizing the geochemical results of various geologic resource studies, and much of this data is readily available through government websites. This publicly available geochemical data consists of rock, soil, stream sediment, and pan concentrate samples, and has been extensively used in mineral resource assessments. Most of the significant results from these geochemical investigations have been evaluated as site specific mineral occurrences in available government resource assessments. It should be noted that more unpublished geochemical data has been generated by private sector exploration, but it is usually proprietary in nature. The following discussion provides a brief description of published geochemical data available for the BSWI Planning Area. These data sets, along with geophysical surveys as noted above, are routinely used in the identification and interpretation of mineral resources; numerous studies are also available documenting the petrology and chemical composition of various rock types in the planning area.

The BLM conducted a mineral assessment of the 27-million-acre Aniak Mining District from 2003 to 2005. During field work 365 mines, prospects, and mineral occurrences were examined and over 1,500 samples collected for geochemical analysis. Due to budget constraints, the final reports for the project were not completed. The results of that work, however, are incorporated into this study.

1. USGS National Geochemical Database

Several online USGS databases contain geochemical analyses of earth materials, mainly stream sediment samples, which can be used to delineate mineral occurrences. However, no comprehensive evaluation of geochemical data was completed for this report, as geochemical anomalies generated are generally documented in various government databases as mineral locations.

The USGS's National Geochemical Database (NGDB) consists of several online databases which provide results of approximately elemental geochemical analyses from rock, sediment, soil, water, and vegetative samples collected within Alaska. The data sets include:

- **NURE**: An extensive regional geochemical evaluation was conducted in Alaska as part of the U.S. Department of Energy's National Uranium Resource Evaluation (NURE) between 1974 and 1981. NURE data, mainly stream and lake sediment samples, include analysis of numerous elements in addition to elemental uranium concentrations (USGS 1997).
- **RASS**: The USGS's Rock Analysis Storage System (RASS) provides elemental geochemical data from rocks, stream sediments, soils, waters, and organic material that can be downloaded on a quadrangle basis. RASS is intended as a reconnaissance tool used in mineral exploration or environmental baseline studies, for purposes such as identifying the regional geochemical signature of an area. The dataset primarily contains analyses generated from assessments and investigations of the non-fuel mineral resources. Stream sediments were chosen as the principal sample medium for these regional programs because they represent the weathering products of many rock sources within the larger drainage basin, which allows for lower sample density. (USGS 1999 and 2000a).
- **PLUTO**: PLUTO is a USGS database that provides the results of geochemical analyses on plutonic and volcanic igneous rock samples. PLUTO contains data generated from many disparate investigations such as geologic mapping, volcanic hazards, and energy resources (Baedecker et al. 1998).

2. ADGGS and former Alaska Division of Mines and Geology

The State of Alaska has made geochemical data from state projects available through the ADGGS website (http://www.dggs.dnr.state.ak.us/webgeochem/). The State's "WebGeochem" is a searchable database containing the results of about 18,000 separate geochemical analyses. Sample types include rock, soil, stream sediment, pan concentrate, drill core, and other media.

III. DESCRIPTION OF MINERAL RESOURCES

A considerable body of Alaska geologic research has been published by the USGS, U.S. Bureau of Mines (USBM), and BLM. Many of these studies document specific mineral resources or occurrences and describe the potential for additional discovery. Resource development potential has been an important factor in the selection of Federal lands by the State and, with the passage of ANCSA and ANILCA, for the Native Corporations as well. As a result, many recent ADGGS and Native Corporation investigations assess the potential for mineral resource development in selected areas. The following subsections present a description of known mineral resources utilizing many of these sources, and also provide the basis for mapping mineral potential within the BSWI Planning Area.

Locatable Minerals

Locatable minerals include primarily metallic and certain nonmetallic industrial minerals that are generally found in lode or placer deposits. Cox and Singer (1992) define "mineral occurrence" as a concentration of a mineral considered to have some value or scientific interest, and "mineral deposit" as an occurrence of sufficient size and grade that it could have economic development potential.

With this in mind, the following subsections:
(1) present an overview of the information that is used to describe locatable minerals,
(2) summarize the existing mineral occurrences and deposits within the Planning Area, and,
(3) discuss the criteria used to determine the level of mineral potential for the occurrences.

1. Mineral Occurrences

There is an abundance of publicly available information detailing mineral occurrences within the BSWI Planning Area. Two databases were used to provide site-specific mineral occurrence information on a state-wide basis, the BLM's Alaska Minerals Information System (AMIS) and the USGS's Alaska Resource Data File (ARDF).

The AMIS database was the primary source of site specific data for this report. The AMIS database project was an effort to develop a modern relational database to enable mineral occurrence information storage and retrieval for the BLM Alaska Mineral Assessments program. AMIS is based on the original Mineral Availability System/ Mineral Industry Location (MAS/MILS) database developed by the USBM from 1975 to 1995. BLM's AMIS is a database containing spatial and commodity data for documented mineral occurrences, deposits, mines, and processing plant sites in Alaska (BLM 2008). Data is held by and can be accessed from the BLM Alaska State Office, Division of Resources, Branch of Energy and Solid Minerals. Until the termination of the Alaska Mineral Assessment program in 2007, the data was updated on an area-by-area basis, supported by the Alaska Branch of Solid Minerals. That portion of the database covering the BSWI area was updated in 2009 as part of the present mineral assessment.

The ARDF is an online public database that records locations and descriptions for metallic mineral mines, prospects, and occurrences and certain other high-value industrial mineral commodities (USGS 2008a). It is compiled by USGS personnel and contract geologists who review mineral and geologic information available for individual quadrangles. These geologists generally have local expertise. ARDFs are published for each quadrangle in the BSWI Planning Area. Much of the data is based on earlier systematic listings compiled by USGS geologists (Berg and Cobb 1967, Cobb 1973), and are updated as funding is available. An update to the ARDF database was published in 2008, where existing files were not amended, but new mineral occurrences were added (Grybeck 2008).

The information in the AMIS database can be locally more thorough in regards to specific historical mine production (BLM 2008; USBM 1959, 1961). For this assessment the ARDF database was merged with the AMIS system. Most ARDF sites are now included as AMIS locations and AMIS entries contain a reference to any corresponding/associated ARDF sites. Currently within the BSWI Planning Area there are 445 AMIS sites.

2. Significant Mineral Deposit Types

The science of mineral prediction is based partly on classifications derived from mineral deposit models. Mineral deposit models describe the essential attributes of different classes of deposits, including the origin of the mineral-hosting rocks and their relationship to the commodity types found. Such models have been developed for numerous mineral types by the USGS and other researchers (e.g., Orris and Bliss 1991, Cox and Singer 1992, Mosier and Bliss 1992), and have been refined and expanded for Alaska-specific lode and placer deposits by Nokleberg and others (1987 and 1994). The models presented by Cox and Singer (1992) form the basis for the following discussion. In addition to the summaries provided here, the models are described in Appendix A.

The authors of each ARDF open-file report assigns deposit models to most mineral occurrences where enough evidence is available to make a determination. Mineral occurrences not described by ARDF were assigned deposit model types by the authors of this report. Although the AMIS and ARDF electronic databases list all reported occurrences and deposits regardless of economic potential, Nokleberg and Others (1987, 1993, and 1994) provide summaries of those lode deposits considered most significant based on size, favorable geology, likelihood of economic develop-

ment, and industry interest at the time of press. The ADGGS, through its annual Alaska's Minerals Industry Report series, provides some level of updating to the list of significant mineral deposits (Szumigala et al. 2008).

Using data from the ARDFs (USGS 2008a), the ADGGS Special Report series, the list of Significant Deposits was amended to include additional sites not known or fully developed at the time of Nokleberg's publications and to highlight occurrences with resource volume data. The final list consists of 30 deposit types and is herein referred to as the "Significant Deposits" data set. The deposit types are listed by model number separately for lode and placer as determined by Cox and Singer (1992) with some additions from Mosier and Bliss (1992); Nokleberg et al. (1987, 1993, and 1994) and the present study. Table 2 presents a summary of the geological setting for those deposit types. The distribution of deposit types within the BSWI Planning Area is shown in **Figure 15 map**.

a. Felsic-dike-hosted quartz veins with gold (present study model 99: 31 occurrences)

This deposit type consists of quartz +/- carbonate veinlet networks with Au associated with sulfides related to hypabyssal intrusions in sedimentary terranes. Veinlet stockworks are concentrated within extensional fracture systems formed between major strike-slip faults. Native gold occurs with arsenopyrite, pyrite, and typically younger stibnite. The Independence Mine, located 22 miles west of McGrath, is the site of the only lode production from this deposit type within BSWI.

Donlin Creek

The following summary of Donlin geology is taken from the works of Mertie (1936), Bundtzen and Miller (1997), Miller et al (2005), NovaGold Resources, (2006), Hanson et al. (2009) and Szumigala et al. (2009).

The relationship between the felsic-dike-hosted vein systems and placer deposits within BSWI has been recognized for years. However it wasn't until recently that these deposits were evaluated for lode gold potential. The Donlin Deposit has received considerable attention in recent years and has the highest locatable mineral potential in the BSWI RMP area. It is located 12 miles north of Crooked Creek, a village on the Kuskokwim River (**Figure 16**).

The Donlin Creek area lies between two regional, northeast-trending, right-lateral faults: the Denali−Farewell fault system to the south, and the Iditarod−Nixon Fork faultsystem to the north. Folding in the region probably occurred soon after sedimentation, since folds are truncated by the volcanic-plutonic complexes. East-trending open folds are prominent east of the Donlin Creek area, but appear truncated to the west by the Donlin Creek fault, a splay of the Iditarod−Nixon Fork fault.

Two distinct styles of mineralization occur within the Donlin Creek trend. The first consists of copper and gold-bearing stockwork veinlets in hornfels. Silicification is locally associated with the veins, and contact metamorphism (hornfelsing) of the sedimentary rocks adjacent to host intrusive rocks is common in areas containing this style of mineralization. The second style consists of auriferous arsenopyrite-bearing quartz and sulphide-only veins associated with Late Cretaceous to early Tertiary sericite-altered rhyodacite dikes and sills. This style makes up the majority of the resource at Donlin.

The bulk of the gold occurs in the lattice structure of arsenopyrite. Stibnite, realgar and native arsenic are commonly observed associated with zones of higher-grade gold mineralization but do not appear to host any significant gold mineralization compared to arsenopyrite. Disseminated gold-bearing arsenopyrite can also be found typically adjacent to veins and vein zones. Pyrite

▲**Figure 16.** Aerial view looking East at the Donlin Creek site. Camp facilities and airstrip are on the foreground. A stockwork of gold-bearing quartz veinlets underlies the ridge on the far side of the airstrip.

is the most common mineral and appears to be the earliest sulphide phase. It is ubiquitous in the rhyodacite, and occurs as disseminated grains or micro-fracture fillings. The gold mineralization is structurally controlled, refractory, and occurs within a one by four-mile zone.

North–northeast-oriented fracture zones that dip to the southeast are the primary control on gold-bearing vein distribution within the north-northeast mineralized corridors. Composite vein zones or mineralized corridors range up to 100 ft in width and extend for thousands of ft along strike. Intrusive rocks and to a lesser extent competent massive greywacke are the most favored host rocks, and act as a secondary control on the mineralization.

Gold distribution in the deposit closely mimics the intrusive rocks, which contain about 74% of the deposit resource. Structural zones in competent sedimentary units account for the remaining 26%. Mineralized material in the sill-dominant part of the deposit tends to be higher grade and more continuous. The most extensive and highest grade mineralized zones are located where “feeder” dikes intersect the sill sequence. Mineralized zones follow steeply-dipping dikes and sills or a vertical range of at least 3100 ft.

iNSERT FIGURE 15 HERE -

Distribution of deposit types within the Bering Sea-Western Interior Planning Area

Backside of fold-out Map Figure 15.

Table 2. Mineral Deposit Model Classifications after Cox and Singer (1992), Bering Sea-Western Interior Planning Area

Lithotectonic/Lithologic setting		Deposit model occurring in BSWI Planning Area (see note)	No. of AMIS sites	Associated commodities
Mafic and ultramafic intrusions				
Mafic-ultramafic rocks in tectonically unstable areas	Flood basalts	**Noril'sk (5b)**	4	Cu-Ni-PGE
	Ophiolites	**Podiform chromite (8a)**	1	Cr,Ni, PGE
	norites	**Synorogenic-synvolcanic (7a)**	1	Ni, Cu
Felsic Intrusives				
Mainly phanero-crystalline intrusive rocks	Deposits near contact	**Zn-Pb skarn (18c)**	16	Ag, Pb, Zn, Cu
		Cu –Au skarn (18a)	9	Cu (Au)
	Deposits within intrusions	**Porphyry Cu-Mo (21a)**	8	Cu-Mo
		Plutonic-hosted Au-Cu polymetalllic (100)	16	Au,Cu
		Felsic-dike-hosted quartz veins (99)	31	Au
		Porphyry Cu-Au (20c)	7	Au, Cu
		Porphyry Mo, low-F (21b)	3	Mo
	Deposits within wallrocks	**Polymetallic veins (22c)**	76	Au, Ag, Pb, Cu, Zn
		Thorium-rare-earth veins (11d)	7	Th, rare earths
		Polymetallic replacement (19a)	14	Ag, Pb, Zn, Cu,
		Tungsten-bearing veins (15a)	1	W, Sn
		Low-sulfide Au-quartz vein (36 a)	5	Au, As, Cu, Sb, Pb, Mo.
		Sn-polymetallic veins(22b)	9	Sn, Ag, Pb, Zn
Extrusive rocks				
Porphyro-aphanitic intrusions present	Deposits in older clastic sedimentary rocks	**Simple Sb (27d)**	6	Sb, Au, Hg
	Deposits in felsic to intermediate volcanic rocks	**Volcanic-hosted sulfides(22a**	1	Cu, As, Sb
		Silica-carbonate Hg(27c)	27	Hg, Sb
		Epithermal quartz-alunite veins (25e)	3	Au, cu, pb, Zn, W
		Hot springs Au(25a)	1	Au, Sb, Ag, As, Zn, Cu
		Creede eipthermal veins (25b)	2	Au, Pb, Zn, Cu,
Felsic-mafic extrusive rocks		**Besshi Type massive sulfides (24b)**	1	Cu
Sedimentary rocks				
Clastic sedimentary rocks	No associated igneous rocks	**Sedimentary exhalatvie (31a)**	9	Zn, Pb, Cu
		Southeast Missouri Zn-Pb (32a)	11	Zn-Pb
		Bedded barite(31b)	1	Ba
Regionally metamorphosed rocks (Derived mainly from eugeosynclinal rocks)				
		Low-sulfide Au-quartz vein (36 a)	5	Au, As, Cu, Sb, Pb, Mo.
Surficial and unconformity-related (Depositional)				
Clastic sedimentary rocks		**Placer Au-PGE (39a)**	162	Au, PGE
		Shoreline placer (39c)	1	Ti
		Placer Sn (39e)	2	Sn, Zr, Ti,

434 Total number of Deposit Model determinations in Bering Sea-Western Interior Planning Area
11 Sites where Deposit Model is Unknown or Undetermined

b. Copper – Gold Skarns
(Cox and Singer model 18a: 9 occurrences

This deposit type consists of sulfides occurring in calc-silicate contact metasomatic rocks. Rock types consist of tonalite to monzogranite intruding carbonate rocks or calcareous clastic rocks. Mineralogy consists of chalcopyrite, pyrite, hematite, magnetite, bornite, and pyrrhotite. Also molybdenite, bismuthinite, sphalerite, galena, cosalite, arsenopyrite, enargite, tennantite, loellingite, cobaltite, and tetrahedrite may be present. Gold and silver may be important products. Textures range from granoblastic to hornfelsic in sedimentary rocks. Bladed pyroxenes are common.

Alteration consists of diopside, andradite, wollastonite, tremolite in outer zone and marble peripheral zone. Igneous rocks may be altered to epidote, pyroxene, garnet (endoskarn). Retrograde alteration to actinolite, chlorite, and clays may be present. Irregular or tabular ore bodies in carbonate rocks and calcareous rocks near igneous contacts or in xenoliths in igneous stocks. Rock analyses may show copper-gold-silver-rich inner zones grading outward to gold-silver zones with high Au:Ag ratio and outer lead-zinc-silver zone. Cobalt-arsenic-antimony-bismuth may form anomalies in some skarn deposits.

Nixon Fork Mine

The Nixon Fork Mine, located 8 miles north of Medfra, is the primary example of this deposit type (**Figure 17**). It consists of small contact metamorphic skarn deposits occurring in irregular structurally controlled zones within carbonate host rocks near the contact with a Late Cretaceous-age monzonite pluton. Mineable ore bodies have maximum dimensions of 16 ft by 230 ft and are lenticular without well defined walls. Gangue minerals consist of garnet, diopside, epidote, and apatite. Mineralization consists of auriferous chalcopyrite and pyrite along with lesser amounts of bornite and chalcocite which have undergone oxidization. Most metal values occur in exoskarn

▲**Figure 17.** Nixon Fork Mine surface facilities including camp and milling complex (arrow). View to the northeast.

10 to 30 ft into the marble front. In places the deposit has been oxidized to a mixture of free gold and secondary copper minerals. Some supergene enrichment of gold values has taken place (Bundtzen, 1999b).

c. Plutonic-hosted Gold-Copper polymetallic stockwork and vein deposits
(present study model 100: 16 occurrences

This deposit type consists of Late Cretaceous-age granite, alaskite, and minor granodiorite sills, dikes, and small stocks containing copper and gold in veins and stockworks. Veins occur within a shear zone cutting intrusive rocks or immediately adjacent volcanic and sedimentary rocks. Mineralogy includes pyrite, free gold, arsenopyrite, scheelite, stibnite, silver sulfosalts, and minor cinnabar. The intrusive rocks of the Iditarod-Flat and Moore Creek area contain some of the best examples of this deposit type.

Golden Horn Mine

At the Golden Horn Mine near Flat, quartz-filled shear zones occur within monzodiorite of the Black Creek and Chicken Mountain volcanic-plutonic complexes near the contact with shale and sandstone of the Upper Cretaceous Kuskokwim Group. The quartz veins contain free gold, arsenopyrite, chalcopyrite, cinnabar, lead-antimony sulfosalts, stibnite, sphalerite, and scheelite.

Chicken Mountain

Auriferous quartz vein stockworks occur within shear zones cutting monzonite within the cupola of the Late-Cretaceous Chicken Mountain pluton just south of Flat (**Figure 23**). Mineralization consists of stibnite, cinnabar, arsenopyrite, and chalcopyrite. These veins are thought to the source of much of the placer gold found in the streams draining Chicken Mountain.

Broken Shovel – Moore Creek Lode

The Broken Shovel Prospect is located near the headwaters of Moore Creek, 55 miles southwest of McGrath (**Figure 18**). Workings expose a northeast-trending 5-ft wide vein hosted in Late-Cretaceous monzonite. The vein has been traced for 660 ft along strike. Mineralization consists of visible gold, arsenopyrite, scheelite, and lead-antimony sulfosalts (Bundtzen et al., 2004).

Vinasale Mountain

The Vinasale Prospect is located on Vinasale Mountain, 16 miles south of McGrath and just east of the Kuskkwim River. The mountain is underlain by a Late Cretaceous composite intrusive complex consisting of quartz monzonite, rhyolite

▲**Figure 18.** Trenches and drill sites at the Broken Shovel Prospect near Moore Creek. View to the north.

porphyry, shonkinite, and monzonite breccias. The intrusive rocks cut clastic rocks of the Late Cretaceous Kuksokwim Group. Silicification in the intrusive rocks occurs as veins, segregations and silica-flooded zones. Smaller veins and veinlets host coarse-grained pyrite, galena, arsenopyrite, sphalerite, stibnite, jamesonite, microscopic native silver, and minor gold. Locally the siliceous zones contain disseminated pyrite and arsenopyrite. Gold appears to be concentrated in the lattice structures of the arsenopyrite, pyrite, and other sulfide minerals (Bundtzen 1999a).

Bonanza Ridge – NYAC area

Cretaceous granodiorite-monzonite intrusive rocks near the headwaters of the Tuluksak River, 36 miles south of Aniak have been the focus of exploration efforts in recent years (**Figure 19**). Quartz vein and fracture stockworks occur within the intrusive rocks. Mineralization consists of gold-bearing quartz along along with pyrite, chalcopyrite, magnetite, bismuthinite, and molybdenite hosted in the Bonanaza pluton and in north-south trending high-angle fault zones adjacent to the pluton (Wenz 2005).

d. Low-sulfide Au-quartz veins
(Cox and Singer model 36a: 5 occurrences)

Gold occurs in massive persistent quartz veins mainly in regionally metamorphosed volcanic rocks and volcanic sediments, located in fault and joint systems produced by regional compression. Veins are persistent along regional high-angle faults and joint sets. Mineralogy consists of quartz with native gold along with pyrite, galena, sphalerite, chalcopyrite, arsenopyrite, and pyrrhotite.

Terra

The Terra deposit is located 94 miles southeast of McGrath in the Terra Cotta Mountains (Figure 20). Finely disseminated native gold occurs with

Figure 19. Bonanza Ridge mineral occurrence and associated color anomaly near the headwaters of the Tuluksak River. View to the northeast.

Figure 20. Exposure of gold-bearing quartz vein at the Terra site

minor sulfides and sulfosalts in tectonic breccias and carbonate-quartz veins in monzonite and diorite intrusive rocks of the Hartman sequence and Jurassic or Lower Cretaceous hornfelsed sedimentary rocks of the Kahiltna terrane.

The Hartman sequence forms a north-south trending diorite dike with dimensions of approximately 490 ft wide by 1 mile long. This dike hosts the majority of the known gold-bearing quartz veins at Terra. Veins are composed of banded quartz and range from 4 inches to 3 ft wide. Besides native gold the veins contain arsenopyrite, pyrite, stibnite, pyrrhotite, sphalerite, and chalcopyrite. Drilling shows the veins to have subsurface continuity of 328 ft along strike and 820 ft down dip. Locally the veins are extremely rich with samples containing up to 20 oz/ton gold and 33 oz/ton silver (Hudson and Millholland 2002; Klipfel and Giroux 2008).

e. Noril'sk Flood Basalt
(Cox and Singer model 5b: 4 occurrences)

Massive to disseminated sulfides occur in small, shallow mafic to ultramafic intrusives. Host rocks consist of flood basalts, picritic intrusive rocks, picritic gabbro, norite, olivine gabbro, dolerite, intrusive and volcanic breccias. Magma has intruded through evaporites or pyritic shale, or some external source of sulfur, and formed sills in flood basalts during active faulting.

Mineralization consists of lenses, layers of massive, matrix, and disseminated sulfides in ophitic, subophitic, gabbroic, cumulate. Mineralogy includes pyrrhotite, pentlandite, chalcopyrite, cubanite, millerite, vallerite pyrite, bornite, gersdorffite, sperrylite, platinum group element (PGE) alloys, polarite, PGE tellurides, arsenides, and antimonides.

Roberts Platinum Group Minerals (PGM)

At the Roberts occurrence, nickel, copper, and PGE are hosted in a late Triassic-aged differentiated, olivine gabbro to peridotite dike to sill-like intrusion cutting silty limestone and shale of the Late Cambrian to Early Ordivician Lyman Hills Formation (**Figure 21**). The site is located 59 miles southeast of McGrath. Dimensions are 1410 ft by 164 ft and geophysics indicates that it dips steeply to the west. Mineralization consists of disseminated and network-style sulfides in the lower and middle part of the sill. These include chalcopyrite, pyrite, magnetite, pyyrhotite, bravoite, galena, Bi-Te sulfosalts, and pentlandite. Samples contain up to 0.23 oz/ton platinum and 0.22 oz/ton palladium (Bundtzen 1999a; Brozdowski and Taylor 2009).

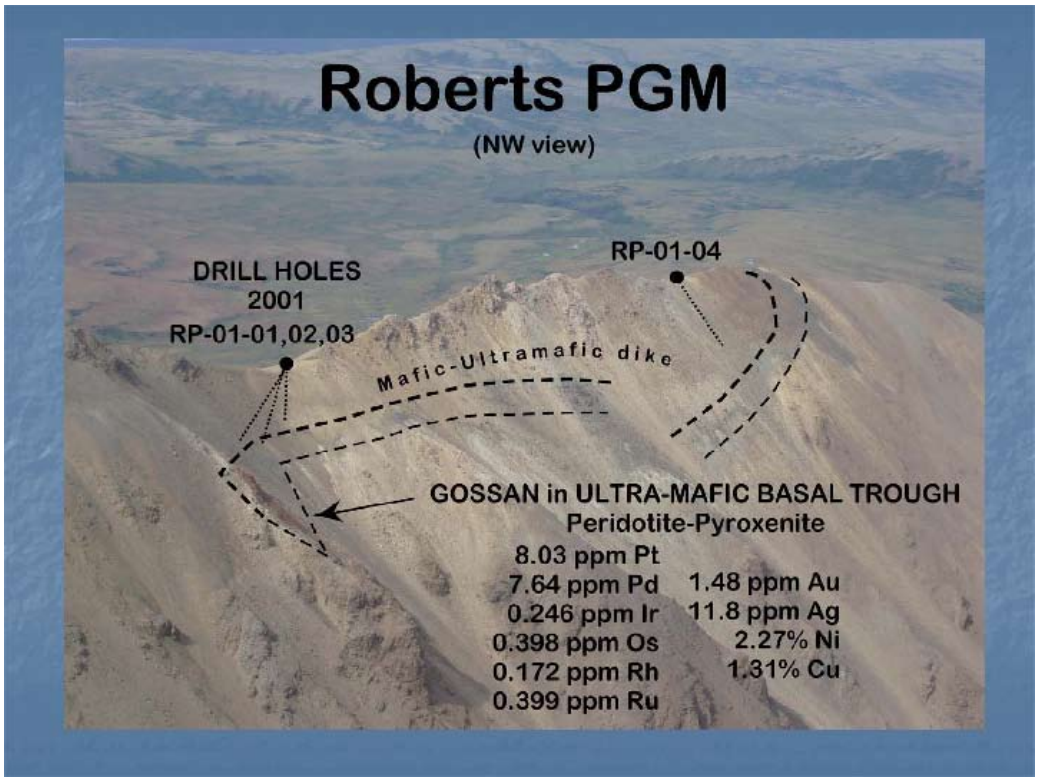


Figure 21. Roberts Platinum Group Mineral (PGM) occurrence showing geology, drill hole locations, and assays. View to the northwest. Photo courtesy of Nycon Resources Inc.

f. Synorogenic-Synvolcanic Ni-Cu
(Cox and Singer model 7a:1 occurrence)

Massive lenses, matrix and disseminated sulfide in small to medium sized gabbroic intrusions in greenstone belts. Host rocks consist of norite, gabbro-norite, pyroxenite, peridotite, troctolite, and anorthosite forming layered or composite igneous complexes. Phase and cryptic layering sometimes present, rocks usually cumulates. Rocks are intruded synvolcanically or during orogenic development of a metamorphic terrane containing volcanic and sedimentary rocks.

Mineralogy consists of pyrrhotite, pentlandite, chalcopyrite, pyrite, titanium-magnetite, chromium-magnetite, graphite with by-product Co and PGE. Deposits occur most often in metamorphic and greenstone belts. Predominantly disseminated sulfides; commonly highly deformed and metamorphosed so primary textures and mineralogy have been altered. Deformation about the same age as the deposit. Sulfides commonly are in the more ultramafic parts of the complex and near the basal contacts of the intrusion.

Chip-Loy

The Chip-Loy deposit, located 61 miles southeast of McGrath, consists of an irregular, steeply dipping layer of massive to disseminated, nickelian pyrrhotite accompanied by other sulfides in an elongate, composite, diabase intrusion. The diabase, which ranges from gabbro to diorite, has been decribed as a pipe in plan view or as a dike. The intrusion trends in a northeast direction and cuts mid-Silurian Terra Cotta Mountains Sandstone, a formation of the Dillinger subterrane, a continental margin assemblage of Lower Paleozoic age and has been assign as early Tertiary age (Bundtzen 1999a).

Sulfides consist mainly of pyrrhotite and chalcopyrite, with minor cubanite, and sphalerite,

and trace galena, bravoite, violarite, tetradymite (Bi2Te2S), and undetermined cobalt-nickel-iron arsenides. The sulfides are interwoven with ilmenite and other rock-forming minerals such as plagioclase and olivine. The northeast trending, sulfide-bearing zone is about 102-ft-long (335 m) and 33- to 49-ft-wide, but is quite irregular along strike. Fifty percent of the nickel and cobalt is believed to exist in pyrrhotite; the remainder is in pentlandite and other nickeliferous and cobaltiferous minerals (Bundtzen 1999a).

g. Southeast Missouri Pb-Zn
(Cox and Singer model 32a: 11 occurrences)

Stratabound, carbonate-hosted deposits of galena, sphalerite, and chalcopyrite in rocks having primary and secondary porosity, commonly related to reefs on paleotopographic highs. Host rocks are shallow-water marine carbonates. Deposits commonly occur at margins of clastic basins. Most deposits occur in Cambrian to Lower Ordivician strata.

Reef Ridge

The Reef Ridge deposit is located approximately 32 miles northeast of Medfra. It is the largest of a cluster of similar deposit types. Host rocks consist mostly of vuggy dolomite containing tectonic breccias. Mineralization consists of secondary smithsonite and hydrozincite, with minor flecks of galena and pyrite that have been introduced into the tectonic breccias. The breccias occur along high-angle faults. Mineralization is exposed in zones up to 1200 ft long. From 1976 to 1982 core drilling and trenching were done on the property. Drill intercepts across 154 ft averaged 20% zinc. Drilling results indicate an inferred resource of 1,980,000 tons grading 6.5% zinc (Bundtzen 1999b).

h. Silica-carbonate mercury
(Cox and Singer model 27c: 27 occurrences)

This deposit type consists mostly of cinnabar and stibnite occurring in veins and vein breccias in close spatial association with Late Cretaceous and early Tertiary mafic to felsic intrusions that cut sedimentary rocks. Realgar, orpiment, pyrite, native mercury, gold and hematite are also present. The lodes commonly occur as small, discontinuous veins that can occasionally reach 3 ft in width (Cox and Singer 1992, Gray et al. 1997).

Red Devil Mine Area

The BSWI Planning Area contains Alaska's only mercury-producing district. The Red Devil Mine, located 6.5 miles northwest of Sleetmute, is the most significant of this deposit type and the largest mercury producer in the area. Host rocks consist of interbedded greywacke and shale of Upper Cretaceous Kuskokwim group cut by albite rhyolite and diabase dikes. Diabase dikes are altered to quartz chalcedony, carbonate, and sericite. Mineralization is concentrated along or near intersections of altered dikes and NW-trending faults, mainly parallel bedding planes. Mercury-bearing minerals consist mostly of cinnabar mostly as open-space filling with abundant stibnite in a quartz-rich gangue; with less common realgar, orpiment and other antimony minerals. Stibnite-cinnabar ratio increases with depth. Ore shoots are reported to not continue below 460-480 ft in depth (MacKevett and Berg 1963; Bundtzen and Miller 1997, 2004; BLM 2008).

The Red Devil Mine has about 9,600 ft of underground workings on five main levels. From 1933 to 1971 approximately 36,000 flasks of mercury (1flask equals 76 lbs) were produced. Drilling indicates a measured reserve of 6,550 tons of 7 lb/ton Hg, or 0.35% Hg, with indicated reserves of 286,200 tons at 8.4 lb/ton Hg, or 0.42% Hg. This reserve is split between the Barometer, Mercury, Vermillion, and Red Devil mineralized areas, with

1,900 tons of the reserve at Red Devil (Muntzert et al. 1975).

Interest has been shown in the potential for economic amounts of gold associated with the mercury deposits. However, no significant discoveries have been made (Muntzert et al. 1975; BHP-Utah International 1988, 1990; BLM 2008).

The site has been selected as part of the Sleetmute Village Townsite, but is currently undergoing remediation and clean-up by the BLM. After clean-up efforts are completed the surface rights will be deeded to the Kuskokwim Corp. The subsurface estate has been conveyed to the Calista Corp.

i. Placer Au-PGE
(Cox and Singer model 39a: 162 occurrences)

In general, placer deposits as associated with high-energy alluvial environments where stream gradients flatten and river velocities lessen, as at the inside of meanders, below rapids and falls, beneath boulders, and in vegetation mats. Winnowing action of surf caused gold concentrations in raised, present, and submerged beaches. Mineralogy consists of native gold commonly with attached quartz, platinum-iron alloys, and osmium-iridium alloys. In addition placers can contain anomalous amounts of silver, arsenic, mercury, antimony, copper, and iron plus heavy minerals magnetite, chromite, ilmenite, hematite, pyrite, zircon, garnet, and rutile. Gold nuggets have decreasing silver content with distance from source. Gold occurs in a variety of nugget forms including flattened, rounded edges, flaky, flour gold extremely fine grained flakes, and very rarely equidimensional nuggets (Cox and Singer 1986).

The highest gold values occur at or near the base of gravel deposits in various gold "traps." This includes natural riffles consisting of fractured bedrock, dikes, and bedding planes trending transverse to direction of water flow. Gold concentrations also occur within gravel deposits above clay layers which form"false bedrocks" that constrain the downward migration of gold particles. Gold-bearing placers are commonly derived from various gold vein-type deposits as well as porphyry copper, copper-skarn, and polymetallic replacement deposits (Cox and Singer 1986).

Placer deposits within the BSWI Planning Area have historically been the most productive and the main deposit type being mined during this study. Placer gold is the main commodity produced along with lesser amounts of platinum group elements (PGE), cinnabar, and scheelite. Some of the deposits proved quite rich, such as Flat Creek in the Iditarod District, which produced over 650,000 oz of gold. Source rocks for most of the placers include Cretaceous-aged volcanic-plutonic and felsic dike complexes. These roughly parallel the trend of the Iditarod-Nixon Fork fault in a northeast-southwest trend through the heart of the BSWI Planning Area (**Figure 10**).

The following descriptions of placer deposit types within the BSWI Planning Area are largely based on material from Miller et al. (2005).

Modern stream placers.

These placers are concentrated in the modern stream valley bottoms proved to be some of the richest deposits in the area and responsible for the majority of the placer gold production in the area (**Figure 22**). They underlie the mostly low-gradient active stream valleys with overburden ranging from 3 to 20 ft. The majority of the gold lay on or near bedrock. This deposit type has produced large nuggets. The third largest in Alaska (124 oz) was recovered on Ganes Creek in 1985. Several of the long wide drainages containing this deposit type were mined on a large scale using bucket line dredges. This includes the valleys of Ganes, Otter, and Yankee Creeks plus the Tuluksak River valley. The Tuluksak River and Ganes Creek drainages make up some of the longest continuous paystreaks in southwest Alaska.

Figure 22. Placer mining operation in modern stream and bench gravels on Shamrock Creek near the headwaters of the Tuluksak River. 2008 photo.

Bench placers.

These deposits were formed by ancestral streams and left perched on the modern stream valley margins as the result of tectonic uplift and stream down cutting (**Figure 22**). They may also be the result of stream migration during asymmetrical valley formation. The bench deposits were not mined in the early days due to the difficulty of getting water to the sites for washing gravel. However they contain the majority of potential placer resources within the BSWI Planning Area. Benches vary from a few ft to over 60 ft above the modern steam valleys. Bench placers have been mined extensively on Ganes, Yankee, and Creeks in the Innoko and on Flat and Otter Creeks in the Iditarod district.

Residual and eluvial placers.

These placers form directly over the top or downslope of weathering mineralized bedrock. The residual placers form where gold is concentrated within grus and clay-rich layers formed during the weathering process. Eluvial placers form as the result of this material mixing from other surface detritus and migrating down slope due to surface creep. Some of the best examples of this type in the BSWI Planning Area are located on the slopes of Chicken Mountain near Flat in the Iditarod district (**Figure 23**). The source of the gold is gold-bearing vein systems within the Chicken Mountain pluton. These deposits have only been partially exploited due to the lack of nearby water sources. However, they can contain high gold values. At the headwaters of Happy Creek, which drains the west side of the Chicken pluton, samples of eluvial placer material contained up to 0.056 oz/cy gold. In this area overburden averages about 6 ft.

Figure 23. Residual placer workings at the Idaho Bench on the northwest slope of Chicken Mountain. Siliceous shear zones and quartz veins cutting the Chicken Mountain pluton are the likely source of the gold in the placers.

3. Historic Production

The BSWI Planning Area includes all or portions of 11 mining districts as established by Ransome and Kerns (1954). The Ophir, Akiak, and Iditarod districts are classified as some of Alaska's major

gold producing areas. Total production from all the districts within BSWI combined is estimated at nearly 3.2 million ounces gold and 150,750 oz silver, 2.1 million pounds copper, and 41,767 flasks of mercury. The location of placer mining areas and lode deposits with significant production within the BSWI Planning Area are shown in **Figure 24 map**.

An inventory of historic mining activity is used to identify the specific commodities and deposit types most likely to be developed or discovered, and in what areas in the future. Furthermore, the lands encompassed by the BSWI Planning Area reflect a substantial history of mining and mineral exploration. Placer gold is the main historic commodity produced, although several historic producing lode deposits exist.

The following subsections briefly describe the historic production of locatable resources, by deposit type and/or resource, in the BSWI Planning Area. **Tables 3 and 4**, respectively, present an estimated summary of placer and lode gold produced in the BSWI Planning Area described in terms of Mining Districts (Ransome and Kerns 1954, USGS 2008a, BLM 2008).

a. Placer Deposits

There are reports of prospectors working in the Kuskokwim River basin as early as 1889. However the first significant discovery of gold took place in 1906 when a party of prospectors including Thomas Gane, F.C. H. Spencer, Mike Roke, and John Maki discovered gold on Ganes Creek, a tributary of the Innoko River. Ganes and Maki would eventually leave their names on creeks in the area. News of this discovery brought more prospectors into the area which led to further discoveries on nearby creeks. This resulted in establishment of the community of Ophir which was a supply point for many of the mines in the Innoko District (Maddren 1910).

The first discoveries in the Iditarod District were made on Otter Creek by John Beaton and W.A. Dikeman late in 1908 (Maddren 1910). This discovery resulted in one of the last major gold rushes in Alaska and establishment of the towns of Flat and Iditarod which served as a supply points for the gold diggings (**Figures 25 and 26**). Iditarod was established at the head of navigation on the Iditarod River. From there supplies were trammed overland an additional 7 miles to Flat. Two bucket-line dredges operated in the Flat area; the last

Figure 25. Historic mining camps on Otter Creek near the town of Flat in 1913. Photo courtesy of the U.S. Geological Survey.

Figure 24 fold-out map goes here.

Backside of Fig. 24 fold-out map.

Table 3. Historic placer production, Bering Sea-Western Interior Planning Area

DISTRICT	NAME	*PRODUCTION	ACTIVE IN 2008	MINERAL POTENTIAL
Akiak	BEAR CREEK (NYAC)	340,000 oz Au, 25,347 oz Ag	No	Medium
	CANYON CREEK	13,000 oz Au, 1,600 oz Ag	No	High
	CRIPPLE CREEK	6,500 oz Au, 366 oz Ag	No	High
	EAGLE CREEK	Unknown	No	Medium
	EAGLE CREEK GULCH	Small	No	Low
	EUREKA CREEK	Small	No	High
	GRANITE CREEK (NYAC)	3,100 oz Au, 250 oz Ag	No	Low
	MARVEL CREEK	50,000 oz Au, 2,077 oz Ag	Yes	High
	MARY LOU GULCH	800 oz Au	No	Low
	SHAMROCK CREEK (NYAC)	Unknown	Yes	High
	SPRUCE CREEK (NYAC)	40,000 oz Au	No	Low
	STUYAHOK RIVER (FLAT CREEK)	23,000 oz Au	No	Medium
	TINY GULCH (NYAC)	400 oz Au	No	Low
	TULUKSAK RIVER (NYAC)	345,000 oz Au, 25,500 oz Ag	No	Medium
Georgetown	CROOKED CREEK	2,140 oz Au	No	Medium
	DONLIN CREEK	4,170 oz Au, 119 oz Ag	No	High
	FORTYSEVEN CREEK PLACER	891 oz Au, 5,000 lbs Scheelite	No	High
	GRANITE-WILLOW CREEKS	3,250 oz Au, 400 oz Ag	Yes	High
	JULIAN CREEK	11,600 oz Au, 1,650 oz Ag	Yes	High
	LEWIS GULCH	6,039 oz Au	Yes	High
	MILLIE CREEK	Unknown	No	Low
	MURRAY GULCH	1,542 oz Au, 230 oz Ag	No	High
	QUARTZ GULCH	1,968 oz Au, 14 oz Ag	No	Medium
	QUEEN GULCH	Included with Donlin Ck	No	Low
	RUBY GULCH	145 oz Au	No	High

(continued)

Table 3. *(continued)*

DISTRICT	NAME	*PRODUCTION	ACTIVE IN 2008	MINERAL POTENTIAL
Georgetown *(continued)*	SNOW GULCH	8,238 oz Au	No	Low
	TAYLOR CREEK (UPPER)	2,500 oz Au	Yes	High
	TAYLOR MOUNTAINS WEST PLACER	Small	No	Medium
Iditarod	BLACK CREEK	27,925 oz Au	No	Low
	CHICKEN CREEK	24,800 oz Au, 3,174 oz Ag	No	Medium
	FLAT CREEK	650,000 oz Au	No	Medium
	HAPPY CREEK	127,486 oz Au, 17,210 oz Ag	No	Medium
	IDAHO BENCH	76,400 oz Au	No	Medium
	MALAMUTE PUP	1,907 oz Au, 241 oz Ag	No	Low
	OTTER CREEK	417,000 oz Au	No	High
	PRINCE CREEK	33,864 oz Au, 3,979 oz Ag	No	High
	SLATE CREEK	3,483 oz Au, 592 oz Ag	No	Low
	WILLOW CREEK	41,948 oz au, 5033 oz Ag	No	High
Innoko	ANVIL CREEK	3,394 oz Au, 12 oz Ag	No	Medium
	BEAR CREEK	10,412 oz Au, 1,150 oz Ag	No	Medium
	BEAVER CREEK	Small	No	Medium
	BEDROCK CREEK	Small	No	Low
	BOOB CREEK	6,270 oz Au, 320 oz Ag, 30 oz PGE	No	High
	BUTTE CREEK	Small	No	Low
	COLORADO CREEK	110,000 oz Au	Yes	High
	CRIPPLE CREEK	38,542 oz Au, 401 oz Ag	No	High
	DEEP CREEK	276 oz Au, 23 oz Ag	No	Medium
	DODGE CREEK	408 oz Au, 40 oz Ag	No	Medium
	DOMINION CREEK	Unknown	No	Medium
	ESPERANTO CREEK	4,429 oz Au, 699 oz Ag	No	High

(continued)

Table 3. *(continued)*

DISTRICT	NAME	*PRODUCTION	ACTIVE IN 2008	MINERAL POTENTIAL
Innoko (continued)	ESTER CREEK	1,210 oz Au, 210 oz Ag	Yes	High
	FOURTH OF JULY CREEK	45 oz Au	No	Medium
	GANES CREEK (LOWER)	combined with U. Ganes Ck	No	High
	GANES CREEK (UPPER)	104,000 oz Au, 13,318 oz Ag	Yes	High
	INNOKO RIVER (LOWER)	Unknown	Yes	High
	IRON CREEK	small	No	Medium
	JOFFRE CREEK	Unknown	No	Medium
	LAST CHANCE GULCH	Small. Included with Ganes Ck	No	Low
	LITTLE CREEK	7,807 oz Au, 1,829 oz Ag	No	High
	MACKIE CREEK	1,949 oz Au	No	Medium
	MADISON CREEK	3,103 oz Au, 338 oz Ag	No	Medium
	OPHIR CREEK	66,489 oz Au, 7,004 oz Ag	No	Medium
	SIX (LAST CHANCE) GULCH	Small	No	Low
	SPAULDING CREEK	Unknown	No	Medium
	SPRUCE CREEK	7,948 oz Au, 1,591 oz Ag	No	Medium
	TAMARACK CREEK	Combined with Spruce Ck	No	Low
	VICTOR GULCH	2,690 oz Au, 332 oz Ag	No	Medium
	YANKEE CREEK	58,120 oz Au, 7,505 oz Ag	Yes	High
Marshall	BOBTAIL CREEK	2,000 Au	No	Low
	BUSTER CREEK	6,860 oz Au	No	High
	DISAPPOINTMENT CREEK	Small	No	Low
	ELEPHANT CREEK	4099 oz Au, 735 oz Ag	No	Low
	MONTEZUMA CREEK	1,126 oz Au	No	Low
	WILLOW CREEK	85,000 oz Au	No	High
	WILSON CREEK	1,051 oz Au, 53 oz Ag	No	Low

(continued)

Table 3. *(continued)*

DISTRICT	NAME	*PRODUCTION	ACTIVE IN 2008	MINERAL POTENTIAL
McGrath	ALDER CREEK	123 oz Au, 24 oz Ag	No	Medium
	BIRCH GULCH	1,004 oz Au, 50.9 oz Ag	No	Medium
	CANDLE CREEK	138, 377 oz Au, 11,963 oz Ag, 83 flasks Hg	No	High
	CARL CREEK TRIBUTARY	18 oz Au	No	Low
	CROOKED CREEK	Small	No	Low
	CRYSTAL GULCH	1,511 oz Au	No	Medium
	ENCIO GULCH	Small	No	Medium
	HIDDEN CREEK	4,435 oz Au, 230 oz Ag	No	Medium
	HOLMES GULCH	1,065 oz Au	No	Medium
	MOORE CREEK	54,066 oz Au, 12,520 oz Ag	Yes	High
	RUBY CREEK (LOWER)	1,522 oz Au	No	Medium

*Production data from: U.S. Bureau of Mines (1961); Bundtzen (1999 a&b); Bundtzen and Miller (2004); Dashevsky (2002a); Hudson (2001 a&b; Hudson and Millholland (2002 a&b); Keith and Miller (1996).

Table 4. Historic Lode Production, Bering Sea-Western Interior Planning Area

District	Deposit	*Production	Deposit Type	Commodities	Mineral Potential
Akiak	CINNABAR CREEK MINE	500 **flasks Hg	Silica-carbonate Hg	Hg	Low
	KOLMAKOF MINE	250 flasks Hg	Silica-carbonate Hg	Hg	Low
Georgetown	ALICE AND BESSIE MINE	120 flasks Hg	Silica-carbonate Hg	Hg	Low
	BAROMETER	32 flasks Hg	Silica-carbonate Hg	Hg	Low
	BROKEN SHOVEL	Small	Silica-carbonate Hg	Hg	Low
	FULLER AND WILLIS	Small	Silica-carbonate Hg	Hg	Low
	MOUNTAIN TOP MINE	165 flasks Hg	Silica-carbonate Hg	Hg	High
	WHITE MOUNTAIN MINE	3,500 flasks Hg	Silica-carbonate Hg	Hg	Low
	CINNABAR CHIEF	Small	Silica-carbonate Hg	Hg	Low
	RED DEVIL MINE	36,000 flasks Hg	Silica-carbonate Hg	Hg	High
Iditarod	DECOURCY MOUNTAIN MINE	1,200 flasks Hg	Silica-carbonate Hg	Hg	High
	GOLDEN HORN MINE	2,707 oz Au, 2,620 oz silver, 9,337 lbs lead, and 518 lbs zinc	Plutonic-hosted Cu-Au polymetallic	Au, Ag, Pb, Zn	High
Innoko	INDEPENDENCE MINE	479 oz Au	Felsic-dike-hosted qtz veinlets w/Au	Au	Medium
McGrath	NIXON FORK MINE	197,248 oz Au, 2.1 million lbs Cu	Cu-Au skarn	Au, Ag, Cu	High
	TERRA MINE	Small	Low-sulfide gold quartz veins	Au, Ag, As, Sb, Cu, Pb	High

***Data from** Bundtzen (1999 a&b), Bundtzen and Miller (2004), Dashevsky (2002 a), Hudson (2001 a&b), Hudson and Millholland (2002 a&b), Keith and Miller (1996)

****One flask** contains approximately 76 lbs Hg

Figure 26. Historic placer mining operation on Flat Creek in 1913. Miners are removing shallow overburden by hand methods to expose gold-bering gravel near bedrock. Photo courtesy of the U.S. Geological Survey.

shutting down in 1966. The Flat area contained the richest placer deposits within the BSWI Planning Area with production totaling 1.6 million oz gold and 30,865 oz silver. The entire Iditarod district is credited with being the third largest placer district in Alaska (Szumigala et al. 2009, USBM 1961, Bundtzen and Miller 2004).

Gold was discovered on the Tuluksak River, southwest of Aniak, during the winter of 1907-08.

Historic production from the drainage is estimated at nearly 729,000 oz gold and 52,000 oz silver It is one of the longest continuous paystreaks (16 miles) in southwest Alaska. A series of dredges, now inactive, mined gold-bearing gravels on the main drainage into the early 1980s (**Figure 27**). (USBM 1961, Hudson 2001a, Hudson and Millholland 2002a). No figures are available for recent production.

Gold was first found in the Marshall District, near the present village of Marshall in 1913. (Harrington, 1918). Mining, including the use of a dry-land dredge, was active in the area until 1973. Total production from the district is estimated at 100,136 oz gold (USBM 1961, Retherford 1987, Hudson and Millholland, 2002a).

The BSWI Planning Area contains 162 placer gold occurrences. Records show production from 90 of these placers. For the purposes of this report all placer occurrences are considered to be at least past producers. The ADGGS, in the 2008 Mineral Industry Report lists 12 separate companies or individuals that are estimated to be producing gold in the BSWI Planning Area in 2008 (Szumigala et al. 2009). This number of active operators may reflect an increase in mining activity associated with recent higher gold prices.

b. Lode Deposits

The first significant lode discovery in the district took place in 1918-1919 when John Strand discovered lode gold while prospecting for placers on the Nixon Fork of the Kuskokwim River (Mertie and Harrington 1924). This discovery would become the Nixon Fork Mine; the largest lode producer in the BSWI Planning Area. Production totals 197,248 oz gold and 2.1 million lbs of copper. In addition limited gold production came from the Independence Mine near Ophir and the Golden Horn Mine near Flat. Lode production totals are 200,434 oz gold and 2.1 million lbs copper.

Figure 27. Inactive bucket-line dredge on upper Bear Creek, a tributary of the Tuluksak River. Dredges operated on this drainage almost continuously from 1925 to 1988.

In recent years there has been limited lode gold production form the Terra Mine where finely disseminated native gold occurs with minor sulfides and sulfosalts in tectonic breccias and carbonate-quartz veins in monzonite and diorite intrusive rocks. The deposit has been worked intermittently by surface trenching beginning in 2000. Production is unknown, but presumed to be small. Mining took place in 2009 (Hudson and Millholland 2002b; Ben Porterfield, personal communication, 2009).

The mercury-bearing mineral cinnabar was noted by Russian explorers on the Kuskokwim River as early as 1838; the earliest known lode occurrence of cinnabar in Alaska. The demand for mercury in the amalgamation process in the gold mining industry resulted in the discovery of a series of cinnabar deposits, mostly between Sleetmute and Red Devil on the Kuskokwim River. The Red Devil mine was the largest of these, producing nearly 36,000 flasks of mercury (one flask equals 76 lbs) before closure in the early 1970s (**Figure 28**). Production in the BSWI Planning Area totals 44,442 flasks of mercury. The site of the Red Devil Mine, Alaska's largest mercury producer, is currently undergoing remediation and clean-up by the BLM. Other significant mercury-producing deposits include the White Mountain and DeCoursey Mountain Mines.

4. Mineral Terranes of Alaska

The word "terrane" is typically used where an assemblage of related rocks occupy a certain geographic area (Thrush 1968). Mineral terrane maps were developed to depict rock associations whose geologic settings are considered highly favorable for the existence of metallic mineral resources. Specific commodities and mineral deposit types are more likely to exist within each terrane, based on a terrane's particular geologic nature. Unmapped areas are generally evaluated as having poor to only moderate mineral potential.

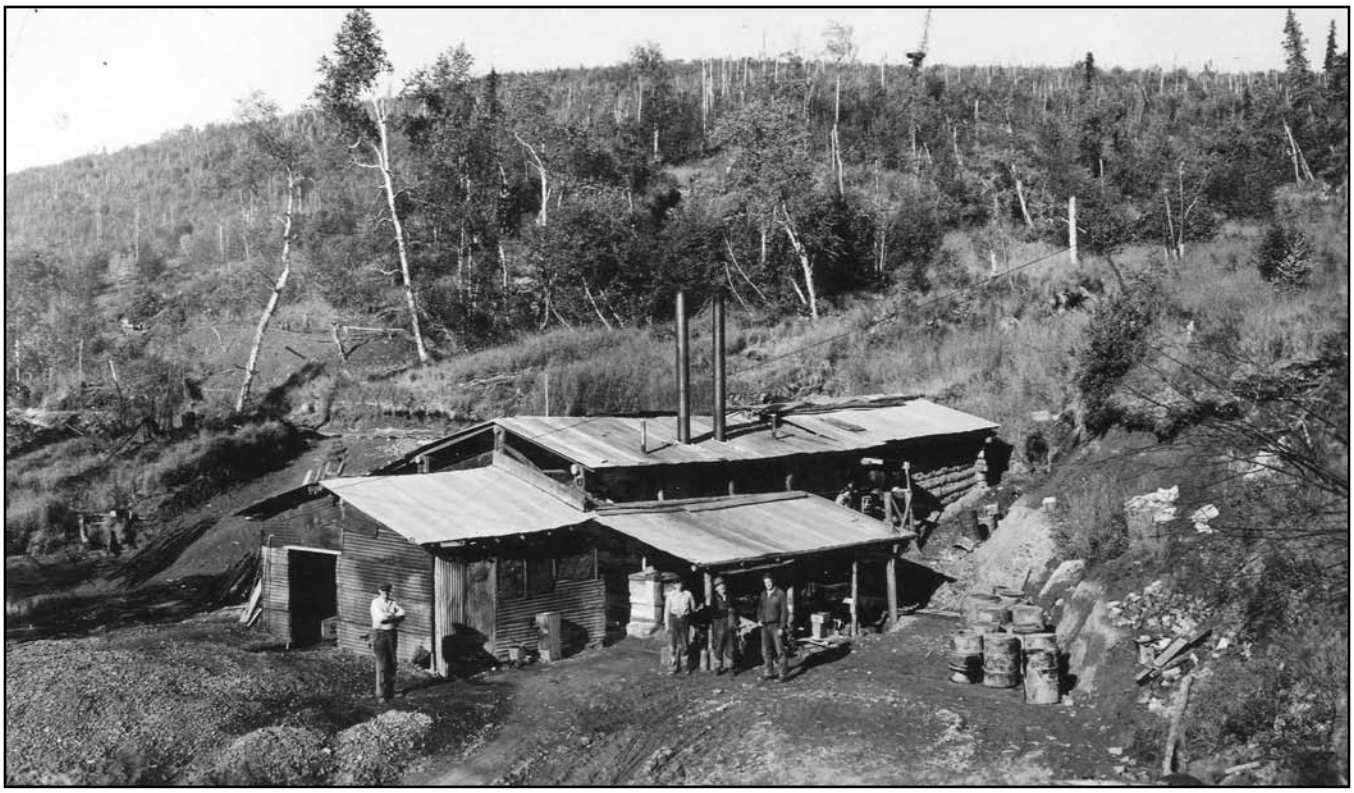


Figure 28. Mercury retort house at the Red Devil Mine in 1941. Photo courtesy of the U.S. Geological Survey

Mineral Terranes of Alaska (MTA) were originally described and mapped in Alaska by the USBM and subsequently revised and published several times by the Arctic Environmental Information and Data Center (AEIDC) (1982); Resource Data, Inc., et al., (1995); and Szumigala and Swainbank (1999).

Mineral deposit types are divided into categories by formation process and rock type. Syngenetic mineral deposits form about the same time as the rocks they are encased in, while epigenetic deposits form by metamorphic or hydrothermal alteration processes following host rock deposition (AEIDC, 1979). Further subdivisions of mineral terranes into rock types are based on the recognition that certain kinds of minerals are specifically associated with certain kinds of host rocks. For example, the metallic elements copper, nickel, and chromium, and the nonmetallic mineral asbestos, are typically associated with mafic igneous rocks or gabbro; while copper and zinc are typically associated with layered submarine volcanic rocks and sulfide-rich sediments, referred to as volcanogenic massive sulfide (VMS) deposits (AEIDC 1979, Hawley and AEIDC 1982). Mineral Terranes were used as a parameter to determine mineral resource potential within the BSWI Planning Area.

5. Mining Claims

Mining claim locations are available electronically from BLM (Federal) andADNR (State) for mining claims on a state-wide basis. Mining claim activity indicates industry interest in a region or locality, which is used to delineate areas of high-mineral occurrence and development potential. The distribution of Federal and State claims are shown in **Figure 29 map**. **Table 5** presents a summary of current claim activity wholly or partially coincident to the BSWI Planning Area.

Federal mining claim locations generally indicate a level of mineral potential and exploration known prior to 1971. There has been no opportunity to stake Federal mining claims on most if not all

Figure 29 fold-out map goes here.

Backside of Fig. 29 fold-out map.

Table 5. Mining Claims and Prospecting Sites, Bering Sea–Western Interior Planning Area

Type	Acres claimed[1]	Number of individual claims[2]	Number of unique owners[3]
Federal mining claims (unpatented)	**5,945**	**219**	**14**
State prospecting sites	102,689	652	67
State mining leases	0	0	0
State mining claims	818,710	5966	67
State claims total	**921,399**	**6618**	**134**
Grand total	**927,344**	**6837**	**148**

[1]State claims data based on a 11/23/2008 extract from State of Alaska database.
[2]Federal claims data based on a 10/23/2008 version of the data set.
[3]Unique names represent large mining companies, Native Corporations, individuals, or small associations.

BLM lands within the BSWI Planning Area since that time due to ANSCA and ANILCA land withdrawals. Some Federal mining claims are covered (over-staked) by later State mining claim activity on State-selected and dually State/Native-selected lands. It is likely that in the final conveyance, many of these dually-claimed parcels will not remain under Federal ownership due to the high level of mineral interest, as indicated by claim activity. Federal claims currently make up 3% of the total number of mining claims and prospecting sites in the BSWI Planning Area.

There are two types of State mining leasehold, the 40-acre mining claim and the 160-acre prospecting site, typically referred to under the common general term "claim." A legal mining claim is located (staked) to acquire the locatable mineral rights in an area. The location of a mining claim necessitates the prior discovery of locatable minerals within the claimed area. A prospecting site grants the owner an exclusive right to explore a parcel of State land up to 160 acres. During a prospecting sites' two-year term, owners have an exclusive right to record mining claims or leasehold locations within the boundaries of the site. The main difference between the prospecting site and a mining claim is that no legal "discovery" is necessary for locating a prospecting site. State claims and prospecting sites staked on State-selected Federal lands do not require the annual maintenance fees until the final land ownership is resolved. Once the final ownership status is determined, these State mining claims staked on Federal or Native lands will be declared null and void, and those on State-conveyed lands will require annual payments/assessment. State mining claims and prospecting sites currently make up 97% of the lands held under mining claims in the BSWI Planning Area. See **Figure 29 map.**

6. Undiscovered Mineral Occurrence Potential

Information discussing Undiscovered Mineral Occurrence Potential, specifically gold, silver, copper, lead, and zinc, is available through USGS Circular 1178 (USGS 2000b). Summary information contained in the report did not impact mineral potential ranking as determined by this Mineral Report. However, a list of important mineral deposits contained in this report was reviewed for consistency with those described in Section III.A.4, Significant Deposits.

7. Mineral Resource Reports

A number of investigations specific to mining districts and specific deposit localities have been conducted by the AEIDC, USBM, BLM, and the USGS over the past few decades. In the early 1970s, AEIDC mapped and described mineral deposits, metalliferous provinces, and mining activity throughout the state. The USBM and BLM have conducted mining district and site specific studies

throughout Alaska and the USGS have conducted numerous Alaska Mineral Resource Assessment Program (AMRAP) and other geologic studies throughout Alaska.

Significant Metalliferous Lode Deposits and Placer Districts of Alaska (Nokleberg et al. 1987) provides summaries of those lode deposits considered most significant based on size, favorable geology, likelihood of economic development, and industry interest at the time of press.

For over 20 years as part of the "Special Report" series, ADGGS has produced a series of annual reports documenting the status of exploration, development, and production for the Alaska mining industry (Bundtzen et al. 1986 and Szumigala et al. 2009). These annual reports document significant past activities and provide an update of current mineral resource development and production activities. "Selected significant mineral deposits and mineral districts in Alaska" are summarized as an Appendix in the more recent Special Report volumes, with current resource figures provided where available.

Mineral Deposits of Alaska (Goldfarb and Miller 1997) presents an overview of Alaskan mineral deposits through a series of 15 separate papers. Papers presented in this monograph on Alaskan mineral deposits primarily focus on describing general deposit types or commodity assemblages that occur in the state. Deposit-specific information available for the state's most significant deposits is also summarized, often providing resource tonnages and grades, complete with citations.

8. Strategic and Critical Minerals

Certain mineral commodities have been termed "strategic" or "critical" by the U.S. Government. Strategic minerals are those that are essential to national defense, for which we are mostly dependent on foreign sources for during war, and for which strict measures controlling conservation and distribution are necessary. Critical minerals are also essential to national defense, but their procurement during war is less serious because they are either produced domestically or can be obtained through more reliable foreign sources (Thrush, 1968).

Bundtzen, Eakins, and Conwell (1982) summarize significant sources and reserves of strategic and critical minerals in Alaska. In addition, the AMIS database (through its precursor MAS/MILS) was initially developed as a systematic assessment of strategic and critical minerals. Of the 17 strategic minerals known to occur in Alaska, 12 have been identified within the BSWI Planning Area; five of the seven critical minerals found in significant concentrations in Alaska also exist within the BSWI Planning Area. **Table 6** presents a summary of BSWI Planning Area strategic and critical mineral occurrences, based mainly on primary commodities.

9. Salable/Industrial Minerals

The primary mineral material commodity is sand and gravel used in construction and road maintenance. Sand, gravel, and stone production is surveyed by the ADGGS and reported in the annual Alaska's Mineral Industry reports. The state production of Sand and Gravel from 1967 to 1986 averaged 40 million tons per year. From 1987 to 2007 production averaged 14 million tons. The higher production levels in the seventies and eighties are related to the construction surrounding the Trans Alaska Pipeline with the annual production peaking in 1974 at 119 million tons.

The local demand for salable minerals, also called mineral materials, in the BSWI Planning Area is generally being met by producers located on private lands. Tenative plans to construct a natural gas pipeline across the Alaska Range through Rainy Pass to Donlin Creek will drive the materials demand higher, but engineering design (buried or above ground) will ultimately drive the level of demand. In addition, there is a proposed road route to Donlin Creek from the vicinity of Aniak that

Table 6. Strategic and Critical Mineral Occurrences, Bering Sea–Western Interior Planning Area

Commodity	Strategic/ Critical	Number of occurrences	Significant occurrences
Antimony	Strategic	6	Red Devil Mine, Broken Shovel (Cinnabar Creek)
Chromium	Strategic	6	Mt Hurst
Mercury	Strategic	27	Red Devil , White Mountain, Decourcy Mountain
Nickel	Strategic	4	Roberts PGE, Chip Loy
Platinum Group	Strategic	4	Boob Creek placer, Roberts PGE lode
Rare Earth	Strategic	3	Eudialyte, Windy Fork
Tin	Strategic	2	Win and Won
Tungsten	Strategic	1	Otter Creek placer, Golden Horn Mine
Barium	Critical	1	Gagaryah
Gold	Critical	3	Donlin Creek lode, Nixon Fork lode, NYAC placer
Silver	Critical	1	Nixon Fork
Zinc	Critical	11	Reef Ridge

could potentially cross Federal lands. However, because the proposed pipeline and road routes are mostly on State and private lands, it is foreseeable that most of the resource for the proposed routes will come from sources on those lands in the BSWI Planning Area.

The primary mineral material commodities used within the BSWI Planning Area are crushed rock, and sand and gravel. A total of 13 material sites were reported to be active in 2008 in Southwest Alaska which includes the BSWI Planning Area (**Figure 30**). These produced 205,200 tons of rock, sand, and gravel (Szumigala et al. 2009).

IV. RATIONALE FOR THE DEVELOPMENT OF POTENTIAL RATINGS

This section provides the rationale for generating potential ratings and explains the level of confidence criteria. The final result of this process is the generation of mineral occurrence and development potential map for locatable mineral resources in the area. This section outlines the how the rationale is used in generating mineral potential ratings and explains the level of confidence criteria for both locatable and salable mineral commodities. Areas of High Locatable Mineral Potential (LMP) will be tabulated and described in Section V - Mineral Occurrence and Development Potential.

Locatable

As stipulated under the Mining Law of 1872, and subsequent laws including the Materials Act of July 31, 1947, locatable minerals include a variety of uncommon minerals such as precious metals (e.g. Au and Pt) and base metals (e.g. Cu, Pb, and Zn). Minerals containing these common metals, and the rock they are contained in, are considered locatable. Locatable minerals can also include uncommon varieties of rock that are considered rare such as precious stones (e.g. jade and diamonds), industrial stones (e.g. garnet and quartz sand), or building/decorative stones (e.g. marble and high granite) that have building-stone quality.

1. Potential Ratings

Effort was given to locate and evaluate mineral occurrences and all other information that could affect mineral potential. There are numerous aspects of the physiography, geography, geology and cul-

Figure 30. This quarry site is 11 miles by road northeast of McGrath. The site provides mineral materials, including riprap and crushed rock, to the McGrath area. The quarry is on Doyon Corporation lands.

ture that influence the exploration, development, and extraction of mineral resources. The evaluation of mineral potential is focused on individual mineral occurrences and then on data sets that can be used to further indicate future mineral resource development.

Each section of land in the Public Land System within the BSWI Planning Area was given a mineral potential score based on the sum of various attributes associated with mineral development potential. The mineral potential score for each section is composed of the number and quality of mineral occurrences located within the section and the intersection of areas designated as being significant to mineral potential. The mineral occurrences extracted from the AMIS database were evaluated by three attributes: general locatable mineral development potential, current production, and deposit type.

2. Mineral Occurrence Potential

To determine the general locatable mineral development potential, mineral occurrences were divided into lode and placer deposit types and given high, medium and low scores based on the following criteria:

a. Lode Deposits

High Locatable Mineral Potential [High LMP]

Occurrences designated as High LMP are based on available data including (in order of priority):

- High mineral grades and continuity.

- Historic mineral production and/or defined resources.
- Current activity including drilling.

Medium Locatable Minerals Potential [Medium LMP]

- Either high mineral grades or continuity exists, but not both.
- Mineralization is limited in extent due to deposit geology and/or low grades.
- Can include active claims and current activity including drilling.

Low Locatable Mineral Potential [Low LMP]

- Neither high grades nor continuity of mineralization exists.
- No active claims or current activity.
- Can include minor or isolated stream sediment, soil, and pan concentrate geochemical anomalies

b. Placer Deposits

High Locatable Mineral Potential [High LMP]

- >50,000 oz Au production.
- Active claims or native corporation lands.
- Active operation +/-defined resource.

Medium Locatable Minerals Potential [Medium LMP]

- < 50,000 oz Au production.
- Active claims or native corporation lands.
    - Inactive operation+/-defined resource.

Low Locatable Mineral Potential [Low LMP]

- Recorded production: minimal to none.
- No active claims.
    - Insignificant or unconfirmed claims of placer resources such as "reports of gold in creek."

The 445 mineral occurrences were each given a numerical score based on their estimated mineral potential, thus: High LMP = 10, Medium LMP = 5, and Low LMP = 1.

If a claim was listed in the Mineral Industry Report (Szumigala et al. 2006, 2007) as being a current producer the occurrence was given a score of 10; no current production = 0.

c. Deposit Types

Mineral deposit models, as discussed previously, describe the essential attributes of different classes of deposits, including the origin of the mineral-hosting rocks and their relationship to the commodity types found. Certain commodity and deposit types that are currently being explored or developed by mineral exploration companies become endowed with a higher level of development potential. The following mineral deposits are currently being explored for in southwest Alaska and in the case of Low-sulfide Au-quartz veins and Placer Au-PGE deposits, being developed and mined.

- Cu-Au Skarn
- Felsic-dike-hosted quartz veins with Au
- Low-Sulfide Au-quartz veins
- Placer Au-PGE
- Plutonic-hosted Au-Cu polymetallic stockwork and vein deposits
- Polymetallic veins
- SE Missouri Pb-Zn
- Noril'sk Flood Basalt
    - Zn-Pb Skarn

Mineral occurrences assigned one of these select deposit types are given a score of 2 and occurrenc-

es without one of these deposit types are given no score. The selected occurrences are believed to more likely be explored by exploration companies.

d. Regions of increased mineral potential

Besides the individual mineral occurrences that are located as single points there are areas both associated with and independent of the mineral occurrences that represent elevated mineral development potential. The areas considered to have higher mineral potential include historic and current state and Federal mining claims. Other areas include mineral terranes, state and native corporation selected and patented lands, and areas of known placer production.

e. Mineral Terranes

The Mineral Terranes of Alaska report (Hawley and AEIDC 1982), as previously mentioned, was developed to depict rock associations whose geologic settings are considered favorable for the existence of mineral resources. The area of each Mineral Terrane Area was spatially joined to the Public Land System sections, with the exception of the Mineral Terrane Area associated with coal resources, since energy is outside the purview of this report. A mineral potential score of 2 was assigned to each section of land that intersected a Mineral Terrane Area associated with a locatable mineral; all other sections were assigned a Mineral Terrane score of zero.

f. Producing Placer Areas

Another data set that seemed appropriate to assess BSWI Planning Area mineral potental is the areas of known placer gold production. Although published maps are available of Alaska's placer producing districts, they were not of sufficient scale for this evaluation.

The basins and drainages associated with the producing placer mines in the BSWI area were outlined by the authors and a mineral potential score of 5 is assigned to every section of land that intersects one of the placer producing areas.

g. Mining Claims

Mining Claims have been staked in the BSWI area for over 100 years. Claim locations have been recorded and tracked by individual Mining Districts since the 19th century and in the 1960s, centralized by the state. In the 1970s and 1980s claims were separated into state and Federal administrations. Many mining claims have been stacked and then allowed to lapse, and in some cases, relocated on the same deposit. The influence of significant historic mining claims has been captured as a part of mineral occurrences within the AMIS database. When oversite of all mining claims was under the State of Alaska, the Kardex claim tracking system was developed (BLM 2002a). Some reported mineral occurrences that were attributed to mining claims from the Kardex records but were never associated with a mineral occurrence on the ground, through research or field investigations, were deleted from the AMIS database.

Recent or current mining claims are believed to be one of the best indicators of future mineral resource development. Although mining claims are located to exercise a right to extract mineral resources, the timing of the claim location can be based on various economic influences. The discovery of a significant mineral deposit can initiate a rush of exploration on the surrounding lands and an increase in commodity prices can influence an exploration company to stake more land whereas the converse is also true. Claims can be staked when anomalous assay results are returned from reconnaissance sampling. Claims are also left to lapse when followup investigations of anomalous samples do not indicate larger mineral resources.

To give proper influence to mining claims, Federal and state mining claim locations from 2003 were compared to the set of Federal and state mining claims in 2008. Every section of land that inter-

sected a mining claim or state prospecting site in 2003 is given a score of 5. Every section of land that intersects a mining claim or prospecting site in 2008 was also given a score of 5. A section of land intersecting a mining claim located before 2003 and maintained through 2008 has at least a score of 10, whereas claims that were dropped because of low commodity prices or claims that were staked as commodity prices rebounded later in the decade were given a score of 5.

h. Mineral Patented Lands and Mineral Surveyed Lands

Some of the highest mineral potential in the BSWI area exists on patented and mineral surveyed patented lands. Mineral patents, or actual title of the lands covered by the mining claims, require a miner to prove to the Federal government that their claims hold a resource that could support a profitable mine. This is one of the highest standards that could be applied to indicate mineral potential. A survey of a mining claim is required before a patent is considered and although it is far short of proving a potential profitable deposit exists, for a miner to pay for a Mineral Survey in this region of Alaska shows a significant confidence in the deposit even if the claim doesn't proceed to patent.

There are 28 patented mining claims in the BSWI Planning Area and 3 unpatented, but surveyed mining claims. Sections of land that intersect the Patented and Mineral Surveyed mining claims were given an additional score of 10. This score is comparable in magnitude to mining claims that have been held from 2003 through 2008.

i. Selected or Patented State or Native Corporation Land

The State of Alaska and Native Corporations have been selected and have been conveyed Federal lands since the passing of ANCSA. The priority for selecting lands has been in part for mineral resource potential. Native Corporation lands, although available for mineral development in cooperation and approval of the appropriate Native group, are not available for claim location.

State-selected lands are open for claim location but are not open to mineral activities since they are managed by the BLM until conveyance occurs. After conveyance the state land is generally open to claim location and approved mining activities. To give weight to Native Corporation selection and patenting and to State of Alaska selection, every section of land that intersects these lands are given a score of "1."

3. Application of Potential Ratings

The sum of each mineral potential score was calculated for every section of land within the BSWI Planning Area based on the attributes outlined in the previous sections. **Figure 31** presents a summary of the most pertinent site specific factors involved with assigning potential. Scores of 10 and greater defined high LMP areas. Scores between 5 and 9 defined medium LMP areas, and scores of less than 5 was considered to be low LMP. Appendix C tabulates total score by section. Areas of high LMP are tabulated by mining district in **Table 7**. These sites are also listed in Appendix B along with medium and low LMP areas. **Figure 32 map** displays mineral potential areas within the BSWI Planning Area.

Confidence Level: The level of certainty with which determinations of mineral potential were made is termed "Confidence Level." The Confidence Level for the LMP areas is reflected by the High, Medium, and Low LMP designations. The mere density of data reflects various levels of activity in respective areas which reflects the level of confidence for the assigned LMP designation. In other words, a high density of mines, prospects and occurrences is usually surrounded more mining claims or is more likely to be given a producing Placer District designation. The resulting LMP boundary will have a higher level of confidence than a Low LMP with less data to evaluate. A

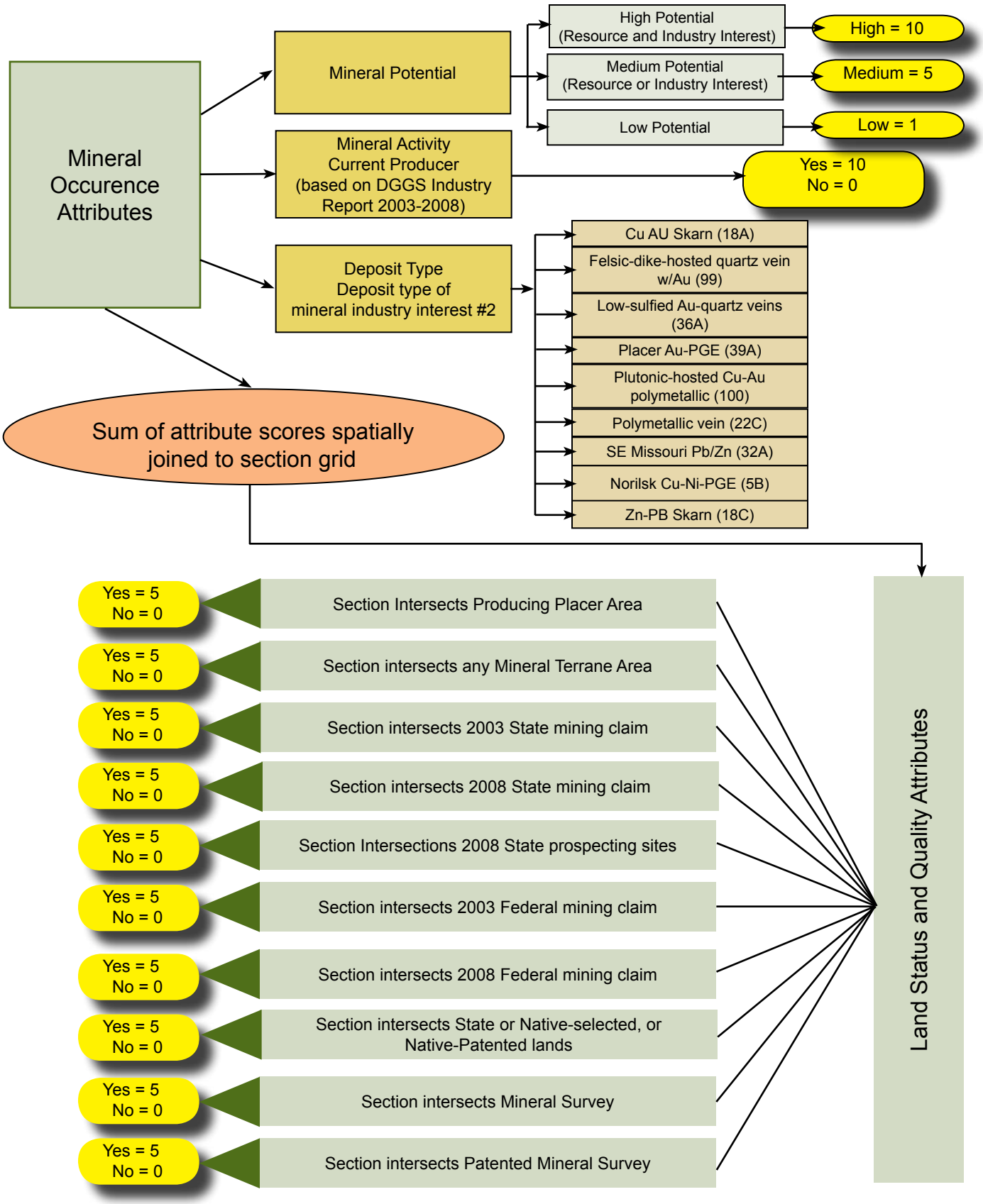


Figure 31. Flow chart showing parameters and assigned values used to determine locatable mineral potential.

Figure 32 fold-out MAP goes here.

Backside of Fig. 32 fold-out map.

High LMP boundary has a high Confidence Level, a Medium LMP will have a medium Confidence Level and a Low LMP will have a low Confidence Level.

a. Salable

As stated in Section III.B – Salable Mineral Resources, the local demand for mineral materials in the BSWI Planning Area is generally being met by producers located on private lands. These producers will continue to provide larger portions of the future requirements. There will be less demand for mineral materials from public lands in the future.

V. MINERAL OCCURRENCE AND DEVELOPMENT POTENTIAL

Areas of high LMP are tabulated and described in the following sections and graphically presented in Mineral Potential map, **Figure 32 map**.

Locatable Occurrence and Development Potential

This section describes what the authors believe to be the most significant High LMP areas within the BSWI Planning Area. Sources for additional deposit-specific information, such as resources/reserves, grade, tonnage, and recent activity are identified where possible.

1. Areas with High LMP Rating

The following section presents the rationale and occurrence information used in the delineation of the High LMP Areas presented in **Table 7** and **Figure 32 map**. Within the BSWI Planning Area, a total of 57 sites were considered to have high LMP. Only those high LMP rated areas with documented mining and/or exploration activity from 2003 to 2008 will be described here. This includes 17 sites which are listed alphabetically. It should be noted that only those mineral deposit models that are actually documented to occur in a given High LMP area are tabulated and discussed. Additional deposit model occurrences - while possibly based on Mineral Terrane mapping and other strictly geologic characteristics - are not substantiated by any documented exploration or development information and are not addressed in this section.

a. Chicken Mountain-Flat High LMP Area

The Flat area contains 22 LMP sites and has a long history of placer and some lode mining dating back to 1909. It is located near the geographic center of the BSWI Planning Area. The Flat area proved to be one of the richest placer districts within the RMP with production totaling 1.6 million oz gold and 30,865 oz silver. As such it ranks as the 4th largest gold-producing area in Alaska. Flat Creek is the highest producing drainage (650,000 oz gold) in the BSWI Planning Area. Mining was initially by hand methods and two bucketline dredges worked the area until 1966. In recent years, operations have been active on Otter, Willow, and Prince Creeks. At 417,000 oz gold, Otter Creek is second to Flat Creek in total production for the district. It is estimated that Otter Creek gravels, west of the town of Flat, contain a 1,000,000 cy gravel resource averaging 0.1 oz/cy. In 2008 there were no active placer mining operations in the Flat area (USBM 1961, Bundtzen et al. 2004).

The Flat LMP area is one of the few places in the BSWI Planning Area where lode production has taken place. The Golden Horn mine produced 2,707 oz gold and 2,620 oz silver. Mineralization occurs within quartz-filled shear zones in monzodiorite near the contact with shale and sandstone of the Upper Cretaceous Kuskokwim Group. Drilling has outlined a minimum inferred resource of 148,000 tons averaging 0.35 oz gold/ton and 75 oz silver/ton (USBM 1961, Bundtzen et al. 2004, Szumigala et al. 2009).

Considerable exploration work, including drilling, from 1987 to 1989 on Chicken Mountain, outlined an indicated resource totaling 16 million tons,

Table 7. High Locatable Mineral Potential Areas in the Bering Sea–Western Interior Planning Area.

District	Name	Production Status	Deposit Type	Land Status
Akiak	CANYON CREEK	Past producer	Placer Au-PGE	State
	CRIPPLE CREEK	Past producer	Placer Au-PGE	State
	EUREKA CREEK	Past producer	Placer Au-PGE	State
	GEMUK MTN	No production	Au-polymetallic	State
	KISA	No production	Felsic-dike-hosted qtz veinlets	State
	MARVEL CREEK	Producer	Placer Au-PGE	State
	NYAC PLACER	Producer	Placer Au-PGE	Calista Corp./ BLM
	NYAC LODE	No production	Plutonic-hosted cu-au polymetallic	Calista Corp.
	OPHIR CREEK	No production	Placer Au-PGE	BLM
	RUSSIAN MTS	No production	Polymetallic veins	Calista Corp.
Georgetown	DONLIN CREEK (RUBY GULCH)	Past producer	Placer Au-PGE	Calista Corp.
	DONLIN CREEK (LEWIS GULCH)	Producer	Placer Au-PGE	Calista Corp.
	DONLIN CREEK LODE	No production	Felsic-dike-hosted qtz veinlets	Calista Corp.
	FORTYSEVEN CREEK	Past producer	Placer Au-PGE	State
	GRANITE-WILLOW CREEKS	Producer	Placer Au-PGE	State
	JULIAN CREEK	Past producer	Placer Au-PGE	State
	MOUNTAIN TOP	Past producer	Silica-cabonate Hg	State
	OSKAWALIK RIVER	No production	Polymetallic replacement deposits and veins	State
	RED DEVIL	Past producer	Silica-cabonate Hg	BLM
	MURRY GULCH	Past producer	Placer Au-PGE	State
	TAYLOR CREEK	Producer	Placer Au-PGE	State
Iditarod	CHICKEN MTN-FLAT	No production	Plutonic-hosted cu-au polymetallic	Doyon Ltd.
	DECOURCY MTN	Past producer	Silica-cabonate Hg	Calista Corp.
	FLAT CREEK	Past producer	Placer Au-PGE	BLM
	GOLDEN HORN MINE	Past producer	Plutonic-hosted Cu-Au polymetallic	State
	LITTLE CREEK	No production	Placer Au-PGE	State
	OTTER CREEK	Past producer	Placer Au-PGE	BLM
	PRINCE CREEK	Past producer	Placer Au-PGE	BLM
	WILLOW CREEK	Past producer	Placer-Au-PGE	BLM
Innoko	BEAVER MTS (Cirque)	No production	Polymetallic vein	State
	BOOB CREEK-MT HURST	Past producer	Placer Au-PGE	State
	COLORADO CREEK	Past producer	Placer Au-PGE	State

continued

Table 7. ***continued.***

District	Name	Production Status	Deposit Type	Land Status
Innoko	CRIPPLE CREEK	Past producer	Placer Au-PGE	State
	ESTER CREEK	Past producer	Placer Au-PGE	State
	ESPERANTO CREEK	Past producer	Placer Au-PGE	State
	GANES CREEK (LOWER)	Past producer	Placer Au-PGE	Patented
	GANES CREEK (UPPER)	Producer	Placer Au-PGE	Patented/State
	INNOKO RIVER (LOWER)	Producer	Placer Au-PGE	State
	LITTLE CREEK	Producer	Placer Au-PGE	Patented
	MONTANA CREEK	No production	Placer Au-PGE	State
	MOORE CREEK	Producer	Placer Au-PGE	State
	YANKEE CREEK (LOWER)	Past producer	Placer Au-PGE	Doyon Ltd.
	YANKEE CREEK (UPPER)	Producer	Placer Au-PGE	Patented/ Doyon Ltd./ State
	WIN	No production	Sn-polymetallic veins	State
Marshall	BUSTER CREEK	Past producer	Placer Au-PGE	Patented
	STUYAHOK - FLAT CREEK	No production	Felsic-dike-hosted qtz veinlets	Calista Corp.
	WILLOW CREEK	Past producer	Placer Au-PGE	Calista
McGrath	BOWSER	No production	Zn-pb skarn deposits	State
	BROKEN SHOVEL	No production	Plutonic-hosted Cu-Au polymetallic	State
	CANDLE CREEK	Past producer	Placer Au-PGE	State/ Doyon Ltd.
	EAGLE CREEK	Past producer	Placer Au-PGE	State
	NIXON FORK MINE	Past producer	Cu skarn deposits	BLM/ Doyon Ltd.
	ROBERTS PGM	No production	Noril'sk cu-ni-pge	State
	SHEEP CREEK	No production	Polymetallic replacement deposits and veins	Doyon Ltd.
	TERRA	Producer	Low-sulfide au-quartz veins	State
	TIN CREEK	No production	Zn-pb skarn deposits	Doyon Ltd.
	VINASALE	No production	Plutonic-hosted cu-au polymetallic	Doyon Ltd.
Tonzona	REEF RIDGE	No production	Southeast Missouri pb-zn	Doyon Ltd.

containing 0.04 oz/ton gold, 1.3 oz/ton silver and substantial quantities of copper, molybdenum and antimony (Bundtzen et al. 2004). There has been no further development of the deposit which is located on lands managed by Doyon Ltd. There was no exploration activity in 2008. A long history of production, estimated resources, active mining claims, and a high concentration of mineral occurrences place the Chicken Mountain – Flat area in the high LMP category.

b. Cripple Creek Mountains High LMP Area

A series of gold-bearing streams drain the volcanic-plutonic complex that makes up the core of the Cripple Creek Mountains, located 44 miles northwest of McGrath. These streams have been the focus of mining activity dating back to 1913. The area contains 15 mineral occurrences and has produced nearly 159,000 oz of gold and 1550 oz of silver. The most extensive mining has concentrated on Cripple and Colorado Creeks. In 2008, operations were active on Colorado and Montana Creeks.

There have been recent efforts to delineate the source of the placer gold in the area. In 2009, Tintina Gold Resources did extensive sampling and completed 12 core drill holes on the divide between Cripple and Colorado Creeks (Tintina Gold Resources, 2009). A potential plutonic-hosted Cu-Au polymetallic-type deposit was the target. No resource estimates have been made. The LMP area is covered by State mining claims. A long history of production, active mining claims, and a high concentration of mineral occurrences, and recent exploration activity place the Cripple Creek Mountains in the high LMP category.

c. Donlin High LMP Area

The Donlin lode deposit has been the target of extensive exploration efforts in recent years and has the highest rating of locatable mineral potential in the BSWI Planning Area. It is located 12 miles north of Crooked Creek, a village on the Kuskokwim River. As of 2008, over 1.4 million ft of drilling and 70,300 ft of trenching had been done on the property, first by West Gold, starting in 1989 and most recently through a joint venture between NovaGold Resources and Barrick Gold U.S. As of 2009 measured/indicated resources totaled 94.6 million tons with an average grade of 0.06 oz/ton gold. The total measured/indicated resource is estimated at 6.01 million oz gold. Additional inferred resources place total contained metal at 29.3 million oz gold.It is considered to be the 25th largest deposit in the world (NovaGold Resources Inc., 2009; Hanson et al. 2009). The Donlin high LMP area contains 7 documented mineral occurrences.

The Donlin deposit is located on lands managed by the Calista Corporation. However proposed roads to the site from the Kuskokwim River could cross BLM-managed lands. If the project moves ahead to the development stage, it is estimated to have a 20-year mine life. Drilling and other exploration took place on the property in 2009 (Hansen et al. 2009).

There is also high LMP for placer gold deposits in the Donlin Creek area. Snow, Ruby, Queen, Quartz, and Lewis Gulches have produced over 20,000 oz of gold and a mining operation was active on Lewis Gulch in 2008. The operator mines under a lease agreement with Calista Native Corporation, which owns the land. A history of placer gold production, Native Patented lands, a concentration of mineral occurrences along with a high level of exploration activity, and estimated resources, place Donlin in the high LMP category.

d. Gemuk Mountain High LMP Area

Rocks in the Gemuk Mountain area, located 67 miles south of Aniak, contain gold-polymetallic mineralization spread over a large area. Gold mineralization is associated both with the hornfelsed contact of the Gemuk Pluton, and with intrusive-hosted shears and veins. High-grade stibnite-gold vein float describes a mineralized shear on the

hornfelsed margin of the Gemuk Pluton. The mineralized discovery vein occurs as discontinuous pods of quartz-stibnite up to 6 inches wide. Samples from the veins contain up to 100 ppm (2.9 oz/ton gold and greater than 1% stibnite. (BLM unpublished data, 2005). Newmont North American Exploration Ltd. staked 47 state mining claims over the mineralized area during 2006 which contains a single mineral occurrence. A large block of active mining claims, high sample values, and recent exploration activity place the Gemuk Mountain area in the high LMP category.

e. Granite-Willow Creek High LMP Area

Placer mining has taken place on Granite and Willow Creeks since 1925. Production totals are a minimum of 3,250 oz Au and 400 oz silver. In 1994 it was estimated that the creek held a resource totaling 41,212 cy and containing 1,600 oz gold. The high LMP area contains 4 documented mineral occurrences and there was an active mining operation on the creek in 2009. (Bundtzen et al. 2004; L.E. Wyrick, miner at Moore Creek, personal communication, 2009).

The headwaters of Willow Creek have also been the target of lode exploration dating back to the late 1980s. This included efforts by Battle Mountain Gold and Placer Dome Inc. The most recent efforts were made by Full Metal Minerals Corp. in 2007. Deposit types include plutonic-hosted Au-polymetallic and gold-bearing quartz-stibnite veins. Exploration activity includes airborne geophysics, trenching, and drilling (Bundtzen et al. 2004). No resource estimates have been made. Samples collected from one of the quartz-stibnite veins by BLM geologists, contained 0.05 oz/ton gold and 2.7% antimony. Both the placer and lode are situated on State mining claims. A history of placer gold production, estimated resources, active mining claims, and current mining and exploration activity place the Granite-Willow Creek area in the high LMP category.

f. Julian Creek High LMP Area

The Julian Creek area, located 39 miles north of McGrath, has a long history of placer mining dating back to 1911. Estimated production is 11,600 oz gold and 1,650 oz silver (Bundtzen et al. 2004). In 2008 there was placer exploration activity taking place at the site. In addition, the creek headwaters has potential for felsic-dike hosted gold deposits similar to Donlin Creek, 40 miles to the southwest. This similarity has sparked exploration activity in the area by a series of companies including Placer Dome Inc. and most recently Barrick Gold U.S. Considerable trenching and some airborne geophysics have been done in the area, but no drilling. No resources have been delineated. A sample collected from one of the trenches by BLM geologists contained 174 ppb gold and 2,290 ppm arsenic. The area contains three mineral occurrences and is situated on a combination of state placer and lode claims. A history of placer gold production, active mining claims, and current mining and exploration activity place the Julian Creek area in the high LMP category.

g. Kisa High LMP Area

Disseminated pyrite-arsenopyrite and gold mineralization is associated with deep-red weathering intermediate to felsic dike rocks just north of Kisaralik Lake, located 90 miles south of Aniak. Sulfide-bearing dikes and associated quartz veins contain up to 8.28ppm gold, 7ppm silver, >1.00% arsenic, 6.26% antimony, 594 ppm copper, 322 ppm mercury, and 300 ppm lead (Frost et al. 1992; BLM unpublished data 2005). Locally, quartz veins carry gaudy pyrite-arsenopyrite-stibnite mineralization.

Interest in the mineral potential of the area dates back to 1987 when Cominco American staked mining claims over mineralized rocks. The current operator, Kisa Gold Mining, Inc., subsidiary Gold Crest Mines, controls 32 State mining claims over a 4520-acre area. Since 2007, the company has conducted exploration in the area including

over 3,000 ft of core drilling, rock sampling and geophysics. Drilling resulted in average grades of up to 0.038 oz/ton gold across 145 ft. Grades of up to 0.253 oz/ton gold were encountered. No resource estimates are currently available (Gold Crest Mines Inc. 2010). The area contains a single mineral occurrence site and is located entirely on State lands. The combination of active mining claims and recent exploration activity, including drilling, place the Kisa area in the high LMP category.

h. Marvel, Eureka, and Cripple Creeks High LMP Area

Placer deposits on Marvel and Cripple Creeks have produced a combined total of 51,500 oz gold and 2,366 oz silver over a 100-year period (USBM 1961). The current operator has been mining on the creek since 1990 with plans to continue into the future. The Eureka and Cripple Creek high LMP areas are located to the north and south of Marvel Creek respectively. Both have a history of production and contain potential resources. The LMP area contains five documented mineral occurrences, but the only active mining claims in the area are located on Marvel Creek. All of these high LMP sites are located on State lands and covered by State mining claims. A long history of production, active mining claims, and current mining activity place the Marvel Creek area in the high LMP category.

i. Moore Creek High LMP Area

Moore Creek has a long history of placer gold production, dating back to 1911. Estimated production is 54,066 of gold and 12,520 oz silver. The drainage contains 7 documented mineral occurrences and is covered by a large block of State placer and lode claims. Beginning in 2005 upper Moore Creek has been the site of a commercial recreational mining venture. In 2009, over 86 oz of gold were recovered by recreational miners (Moore Creek Mining 2009). At the Broken Shovel Prospect, near the headwaters of Moore Creek, an inferred resource containing 16,000 tons averaging 4.4 oz/ton silver and an unknown gold content has been outlined (Bundtzen et al. 2004).

From 2006 to 2008, Full Metal Minerals Corp. carried out an exploration program for potential Plutonic-hosted Cu-Au polymetallic-type deposits related to the Broken Shovel Prospect. Exploration consisted of trenching followed by a drilling program. Mineralization has been defined in three separate zones. Samples collected across a 36-ft wide zone contained 0.26 oz/ton gold. No resource estimates have been released (Full Metal Minerals Corp. press release, 2009). The area is covered by active State mining claims. The combination of a long history of production, active mining claims, current recreational mining, and lode exploration activity place the Moore Creek area in the high LMP category.

j. Nixon Fork High LMP Area

The Nixon Fork Mine is located 8 miles north of Medfra. From 1920 to 1999, the mine produced 197,248 oz gold, 2.1 million pounds of copper, and significant silver from copper-gold skarn deposits. Current measured/indicated resources total 164,639 tons with a weighted average grade of 0.70 oz/ton gold with an undisclosed additional amount of copper and silver (Szumigala et al. 2009). The property was acquired in 2009 by the Pacific North West Capital Corp., which has plans to put the operation back to production (Pacific North West Capital Corp., 2009).The mine area is covered by a combination of BLM-managed Federal claims and Doyon Corp. lands and contains a total of 11 mineral occurrences. Placers in the area have been historically mined, but there has been no recent activity in the area. The combination of a long history of both lode and some placer production, active Federal claims and Native patented lands, estimated resources, a high concentration of mineral occurrences, and current exploration activity place Nixon Fork in the high LMP category.

k. NYAC High LMP Area

Quartz vein stockworks within intrusive rocks near the headwaters of the Tuluksak River, 36 miles south of Aniak, have been the focus of recent exploration efforts including drilling, beginning in 1996. Mineralization consists of gold-bearing quartz along along with pyrite, chalcopyrite, magnetite, bismuthinite, and molybdenite hosted in the Bonanaza pluton and in north-south trending high-angle fault zones adjacent to the pluton. A total of 14 mineral occurrences are concentrated within this area.

Tonogold Resources, in conjunction with Calista Corp., began an aggressive exploration program in the area in 2005. Surface sampling and drilling resulted in gold values of up to 0.15 oz/ton gold across 6.6 ft of mineralized material. Anomalous bismuth in soil samples occurs over a 3,200 by 1,000 ft area. The Wallace Prospect consisting of gold-bearing quartz veins is located approximately five miles southwest of the Bonanza occurrence, but in the same high LMP area. Exploration, including drilling, took place in 2009. No resources have as yet been delineated for the area (Wenz 2005,Tonogold 2006). The sites are located on Calista Corporation lands, but there are Federal mining claims nearby.

Placer deposits in the upper Tuluksak River drainage have a long history of mining, dating back to 1908. It is one of the longest continuous paystreaks (16 miles) in southwest Alaska. A series of dredges, now inactive, mined gold-bearing gravels on the main drainage into the early 1980s. The majority of the lands in the area are managed by the Calista Corporation. However in 2009, mining took place on Federal claims in Shamrock Creek, a tributary of Bear Creek, which drains into the Tuluksak River. The operators (NYAC Mining Co.) have plans to continue operations on those claims for the next few years. Based on the 1982-83 drill programs, the Northland Dredging Co. estimated a resource of over 25,000 unrefined ounces for its leased area on the Tuluksak River floodplain, opposite the mouth of Granite Creek. A long history of placer gold production, a high concentration of mineral occurrences, and active mining claims, along with current mining and exploration activity place NYAC in the high LMP category.

l. Ophir High LMP Area

The Ophir area, the center of which is located 32 miles northwest of McGrath, was the site of the initial discovery of gold in the Innoko Mining District in 1906. Drainages in the area with High LMP include Ganes, Yankee, Little, and Ester Creeks, and the lower Innoko River. This large LMP area contains 30 mineral occurrences. Ganes Creek and its tributaries have produced approximately 121,400 oz of gold and the third largest gold nugget (124 oz) in Alaska (USBM 1961, Bundtzen et al. 2004, Miller et al. 2005, Dashevsky 2002a).

The majority of the claims running up the core of Ganes Creek are patented. The lands surrounding the main drainage are a combination of State of Alaska and Doyon Corp. At 8 miles, the paystreak in Ganes Creek is second only in length to the Tuluksak River drainage. The present operator (Clark-Wiltz Mining) is currently mining on the upper portion of the creek where a minimum 437,000 cy resource has been delineated. In addition the same operator is hosting recreational gold miners on the patented claims. From 2001 to 2009, recreational miners using metal detectors recovered 1,500 oz of gold (Clark-Wiltz Mining, 2010).

Other creeks having high LMP due to active claims and current mining activity include upper and lower Yankee Creek, Little Creek, Ester Creek, and the lower Innoko River. These areas are all covered by either patented or State mining claims. In 2008 there were active mining operations on Ester and Yankee Creeks and the lower Innoko River.

The highlands on the divide between Ganes Creek and Yankee Creek have in recent years been the focus of several lode exploration efforts. The Independence Mine is also located in this LMP area; a deposit that saw a small amount of lode gold production in 1912. Mineralization consists of gold-bearing quartz-carbonate veins and felsic dikes; the same deposit type as makes up the large Donlin lode deposit, 96 miles to the southwest. The Independence Mine site lies within a broad 3.7 mile-long gold-in-soil anomaly (Battle Mountain Exploration Co. 1990). This similarity has stimulated much of the exploration effort in the area. Exploration includes geophysics, drilling, and trenching. The most recent efforts were those carried out by Great Basin Gold Ltd in 2008. No resource estimates have been published. The area lies within a combination of State and Doyon Corp. lands. The State portion is covered by a large block of State mining claims. High placer gold production, a long history of mining, active mining claims and Native patented lands, a high concentration of mineral occurrences, along with recent mining and exploration activity, place Ophir in the high LMP category.

m. Roberts PGE High LMP Area

This LMP area includes five mineral occurrences and is located 59 miles southeast of McGrath. At the Roberts occurrence, nickel, copper, and platinum group elements (PGE) are hosted in a late Triassic-aged differentiated, olivine gabbro to peridotite dike to sill-like intrusion cutting silty limestone and shale of the Late Cambrian to Early Ordivician Lyman Hills Formation. Dimensions are 1410 ft by 164 ft and geophysics indicates that it dips steeply to the west. Mineralization consists of disseminated and network-style sulfides in the lower and middle part of the sill. These include chalcopyrite, pyrite, magnetite, pyyrhotite, bravoite, galena, Bi-Te sulfosalts, and pentlandite (Bundtzen 1999a, Brozdowski and Taylor 2009). The mineralized zone within the intrusion ranges from 6.5- to 13-ft thick with a maximun strike length of 82 ft. Samples collected across a 1.5 ft wide are reported to contain 8.03 ppm platinum and 7.64 ppm palladium plus nickel and copper. Exploration efforts include geophysics and drilling. Between 1999 and 2005 a total of eight core holes were drilled at the site. The site was being investigated in 2009 by Nycon Resources Inc. and is covered by a large block of State mining claims (Bundtzen 1999a, Brozdowski and Taylor 2009).

This LMP area also contains the Chip Loy prospect, classified as a gabbroic nickel-copper-type deposit. This site has been drilled and is reported to contain a resource totaling 165,000 tons (Herreid 1968). Samples contain up to 3.30% nickel, and 2.10% copper. A total of four core holes have been drilled at the site (Smith and Albanese 1985, Bundtzen 1999a, Brozdowski and Taylor 2009). A combination of active mining claims, exploration activity including resource estimates, and current exploration activity place the Roberts LMP area in the high category.

n. Russian Mountains High LMP Area

The Russian Mountains are one of a series of volcanic-plutonic complexes that are scattered across the BSWI Planning Area. The area is located 15 northeast of Aniak and contains six documented mineral occurrences including two propects with recent exploration activity. These consist of intrusive-hosted polymetallic gold-silver-copper vein deposits. These prospects are situated on lands owned by the Calista Corporation.

In 2009, Full Metal Minerals completed a 4,300 ft core drilling program at three of the prospects in the Russian Mountains. Results from the Owhat Prospect included 0.25 oz/ton gold, 5.4 oz/ton silver, and 6.03% copper across a one-meter vein width (Full Metal Minerals 2009). The high LMP rating is due to a combination of recent exploration activity, including drilling, location on native-

patented lands, recent exploration activity, and high metal values.

o. Taylor Creek High LMP Area

Taylor Creek drains the south side of the Taylor Mountains, located 62 miles south of Sleetmute. Placer mining has taken place in the headwaters of Taylor Creek since 1940 and placer exploration was taking place in 2008. Production through 1951 is estimated at 2,500 oz gold (Cady 1955). Production since that time is unknown. Resources have been estimated at 200,000 to 300,000 cy with an average value of 0.017 oz/cy (Hawley 1974). It is unknown how much of this resource has since been mined out. Other areas within the LMP area that contain potential placer gold resources include Kiknik and Whitewater Creeks. There are a total of eight documented mineral occurrences within this LMP and the core area is covered by State mining claims. Due to a history of mining, active mining claims, and current mining and placer exploration, this area has been placed in the high LMP category.

p. Terra High LMP Area

This LMP area, located 94 miles southeast of McGrath, contains four documented mineral occurrences and is the site of a discovery of lode gold-bearing rocks made in the late 1990s. The Terra Deposit consists of low-sulfide gold-quartz veins. Mineralization is high grade with samples containing as much as 20 oz/ton gold. Veins are exposed for up to 6,000 ft along strike (Hudson and Millholland 2002b).

The deposit has been worked intermittently by surface trenching, beginning in 2000. Production is unknown, but presumed to be small. Mining took place in 2009 (Ben Porterfield, Terra claim owner, personal communication, 2009).

The property was optioned in 2004 by Anglo Gold Ashanti (USA) Inc., which later formed a joint venture with International Tower Hill Mines Ltd. From 2005 to 2007 a total of 27 core holes were drilled on the property. Drilling shows the veins to extend to a depth of 1150 ft. Average mineralized vein width is 4.2 ft with an average grade of 0.67 oz/ton gold. The deposit contains an inferred resource of 428,000 tons at an average grade of 0.36 oz/ton gold at a 0.15 oz/ton cutoff (Klipfel and Giroux 2008). The site is situated on 199 State mining claims. A combination of active mining claims, current mining and exploration activity, and estimated resources place Terra in the high LMP category.

q. Vinasale Mountain High LMP Area

There has been a small amount of placer gold produced from Alder Creek, which drains off the south side of Vinasale Mountain (Bundtzen 1999a). This area, located 16 miles south of McGrath, has been the focus of lode exploration efforts for plutonic-hosted polymetallic deposit types, beginning in 1990. Work by the Central Alaska Gold Co. and Placer Dome U.S. Inc. and ASA Montague included geophysics and 54,000 ft of core drilling. This resulted in determination of an indicated resource totaling 10.3 million tons grading 0.07 oz/ton gold (Bundtzen and Miller 1997). In addition, the prospect contains an inferred resource totaling 14.4 million tons averaging 0.067 oz/ton Au (Szumigala et al. 2009).

In 2008, Freegold Ventures Ltd. conducted exploration in the area in an effort to expand the known resources. This consisted mainly of geophysical surveys. Planned exploration efforts in 2010 include geophysics, geochemistry, and drilling (Freegold Ventures 2009). The 140,000 acre property containing two documented mineral occurrences is situated on lands owned by the Doyon Corp. The location on Native-patented lands, current exploration activity, and estimated resources place Vinasale Mountain in the high LMP category.

VI. RECOMMENDATIONS

The main objective of this report is to delineate areas with high potential for the discovery of locatable and salable minerals. Mineral potential for the resulting areas is based entirely on the data sets described in the body of this report. This report recommends that deposit types in those areas described by Section V (Mineral Occurrence and Development Potential) as having High Locatable Mineral Potential be used to formulate the Reasonably Foreseeable Development Scenario Report, which predicts future development over the 10- to 15-year lifespan of the completed RMP.

There are a number of high LMP areas within the BSWI Planning Area that fall within BLM-managed lands and are covered by Federal mining claims. These include: 1) Nixon Fork Mine area; 2) Flat-Chicken Mountain area; 3) Ophir Creek drainage (Kilbuck Mountains); 4) and the NYAC (Shamrock Creek) area. Present and future mineral exploration and mining activities in these areas could have impacts on BLM-managed lands extending outside the mining claim boundaries. Though located on Native-patented lands, the access routes to the Donlin deposit will likely cross and have possible impacts on BLM-managed lands.

VII. STATEMENT OF QUALIFICATION

Report text and graphics were prepared by Joseph Kurtak (Geologist), and Paxton McClurg (GIS specialist) for the BLM Anchorage Field Office, 4700 BLM Road, Anchorage and John Hoppe (Geologist), and Robert M. Ellefson (Geologist), Division of Resources, Branch of Energy and Solid Minerals, headquartered in the Alaska State Office in Anchorage.

VIII. CURRENT MANAGEMENT AND EXISTING LAND USE PLAN

Southwest Management Framework Plan

The 1981 Southwest Management Framework Plan provides land and resource use and development recommendations within the planning area. The1984 Iditarod/George Environmental Assessment implements recommendations found in the Southwest Management Framework Plan and provides for the conditions under which land and resource use and development may occur.

The area is open to appropriation and disposition under the Public Land Laws is managed in conformance with this plan and the provisions of the assessment. Currently less than 1% of the total acres taken up by mining claims and prospecting sites in the BSWI Planning Area are under Federal management. The majority of the mining and mineral exploration is taking place on State, Native Corporation, or private lands.

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- Caron McKee, technical writer/editor, BLM-Alaska State Office planning staff
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APPENDIX A

Documented Mineral Deposit Models

BERING SEA – WESTERN INTERIOR PLANNING AREA

References:

Cox and Singer (1992)
Mosier and Bliss (1992)
Bundtzen and Miller (1997)

1. DESCRIPTIVE MODEL OF NORIL'SK Cu-Ni-PGE
Model 5b

by Norman J. Page

DESCRIPTION

Massive to disseminated sulfides in small shallow mafic to ultramafic intrusives with an external source of sulfur.

GEOLOGICAL ENVIRONMENT

- **Rock Types:** Flood basalts, picritic intrusive rocks, picritic gabbro, norite, olivine gabbro, dolerite, intrusive and volcanic breccias. Associated with evaporites or some external source of sulfur.
- **Textures:** Ophitic, subophitic, gabbroic, cumulate.
- **Age Range:** Paleozoic.
- **Depositional Environment:** Magma has intruded through evaporites or pyritic shale, and formed sills in flood basalts during active faulting.
- **Tectonic Setting(s):** Rift environment.

DEPOSIT DESCRIPTION

- **Mineralogy:** Pyrrhotite + pentlandite + chalcopyrite + cubanite + millerite + vallerite + pyrite + bornite + gersdorffite + sperrylite + PGE alloys + polarite + PGE tellurides, arsenides, and antimonides.
- **Texture/Structure:** Lenses, layers of massive, matrix, and disseminated sulfide.
- **Alteration:** None related to ore.
- **Ore Controls:** External source of sulfur; sulfides form persistent basal layers to intrusion and dike-like bodies into country rock; and form in fault-bounded depressions.
- **Geochemical Signature:** Ni/Cu = 1.5 to 0.5, Co/Ni = 1/16; Pt/(Pd/Ni) = 1/500

EXAMPLES

Roberts PGM USAK (Bundtzen and others, 1999)
Noril'sk, USSR (Krauss and Schmidt, 1979).

2. DESCRIPTIVE MODEL OF SYNOROGENIC-SYNVOLCANIC Ni-Cu Model 7a

by Norman J. Page.

APPROXIMATE SYNONYMS

Gabbroid class (Ross and Travis, 1981), gabbroid associated (Marston and others, 1981).

DESCRIPTION

Massive lenses, matrix and disseminated sulfide in small to medium sized gabbroic intrusions in greenstone belts.

GEOLOGICAL ENVIRONMENT

- **Rock Types:** Norite, gabbro-norite, pyroxenite, peridotite, troctolite, and anorthosite forming layered or composite igneous complexes.
- **Textures:** Phase and cryptic layering sometimes present, rocks usually cumulates.
- **Age Range:** Archean to Tertiary, predominantly Archean and Proterozoic.
- **Depositional Environment:** Intruded synvolcanically or during orogenic development of a metamorphic terrane containing volcanic and sedimentary rocks.
- **Tectonic Setting(s):** Metamorphic belts, greenstone belts, mobile belts.
- **Associated Deposit Types:** Komatiitic Ni-Cu, dunitic Ni-Cu, talc-carbonate Ni-Au (no model available).

DEPOSIT DESCRIPTION

- **Mineralogy:** Pyrrhotite + pentlandite + chalcopyrite ± pyrite ± Ti-magnetite ± Cr-magnetite ± graphite--by-product Co and PGE.
- **Texture/Structure:** Predominantly disseminated sulfides; commonly highly deformed and metamorphosed so primary textures and mineralogy have been altered. Deformation about the same age as the deposit.
- Ore Control Sulfides commonly are in the more ultramafic parts of the complex and near the basal contacts of the intrusion.
- **Weathering:** Lateritic.
- **Geochemical Signature:** Ni, Cu, Co, PGE.

EXAMPLES

Sally Malay, AUWA (Thornett, 1981)
Rana, NRWY (Boyd and Mathiesen, 1979)
Moxie pluton, USMA (Thompson and Naldrett, 1984)

3. DESCRIPTIVE MODEL OF PODIFORM CHROMITE
Model 8a and 8b

by John P. Albers

APPROXIMATE SYNONYM: Alpine type chromite (Thayer, 1964).

DESCRIPTION: Podlike masses of chromitite in ultramafic parts of ophiolite complexes (see fig. 20).

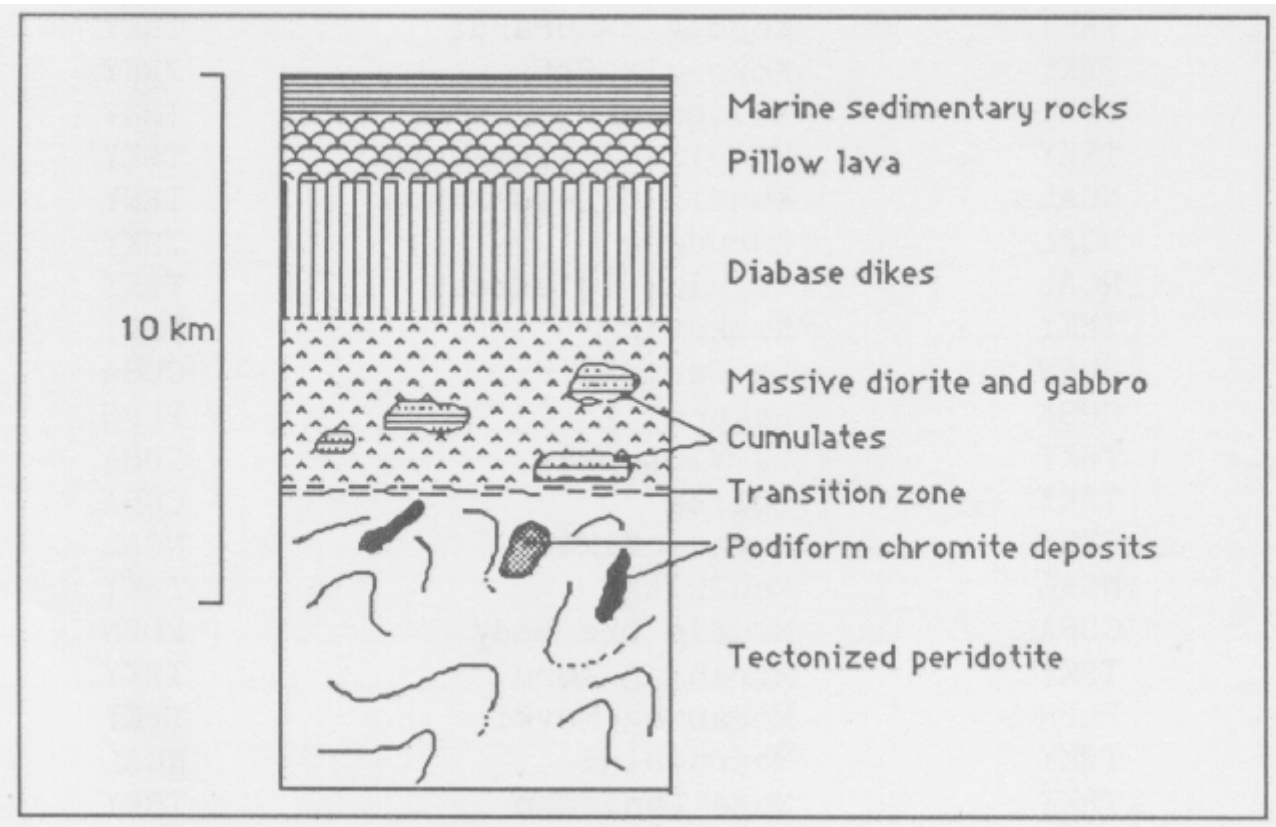


Figure 20. Cartoon cross section of a typical ophiolite sequence showing locations of podiform chromite deposits from Dickey (1975).

GENERAL REFERENCE Dickey (1975).

GEOLOGICAL ENVIRONMENT

- **Rock Types:** Highly deformed dunite and harzburgite of ophiolite complexes; commonly serpentinized.
- **Textures:** Nodular, orbicular, gneissic, cumulate, pull-apart; most relict textures are modified or destroyed by flowage at magmatic temperatures.
- **Age Range:** Phanerozoic.
- **Depositional Environment:** Lower part of oceanic lithosphere.
- **Tectonic Setting(s):** Magmatic cumulates in elongate magma pockets along spreading plate boundaries. Subsequently exposed in accreted terranes as part of ophiolite assemblage.

Associated Deposit Types: Limassol Forest Co-Ni-S-As.

DEPOSIT DESCRIPTION

- **Mineralogy**: Chromite ± ferrichromite ± magnetite ± Ru-Os-Ir alloys ± laurite.
- **Texture/Structure:** Massive coarse-grained to finely disseminated.
- **Alteration:** None related to ore.
- **Ore Controls:** Restricted to dunite bodies in tectonized harzburgite or lower portions of ultramafic cumulate (see fig. 99).
- **Weathering:** Highly resistant to weathering and oxidation.
- **Geochemical Signature:** None recognized.

EXAMPLES
High Plateau, Del Norte Cty, USCA (Wells and others, 1946)
Coto Mine, Luzon, PLPN (LeBlanc and Violette, 1983)

4. DESCRIPTIVE MODEL OF THORIUM-RARE-EARTH VEINS
Model 11d

by Mortimer H. Staatz

BRIEF DESCRIPTION

- SYNONYM: Rare-earth-thorium veins.
- **DESCRIPTION:** Various thorium and rare-earth minerals in a quartz-potassium feldspar-iron-oxide gangue in veins 1 to about 1,330 m long and less than 1 cm to about 16 m thick.

TYPICAL DEPOSITS:

- Last Chance vein, Lemhi Pass district, Montana (Staatz, 1979);
- Little Johnnie vein, Powderhorn district, Colorado (Olson and Wallace, 1956);
- Vein no. 12, southern Bear Lodge Mountains, Wyoming (Staatz, 1983);
- Wet Mountains area, Colorado (Armbrustmacher, 1988).

RELATIVE IMPORTANCE: A future thorium resource. Highest grade thorium resource in the United States, second largest total resource of thorium (Staatz and others, 1979). Rare earths important byproduct in some deposits; in others, the principal product.

COMMODITIES: Th, rare earths (mainly light rare earths, but at Laughlin Peak, New Mexico, the heavy rare earths most important).

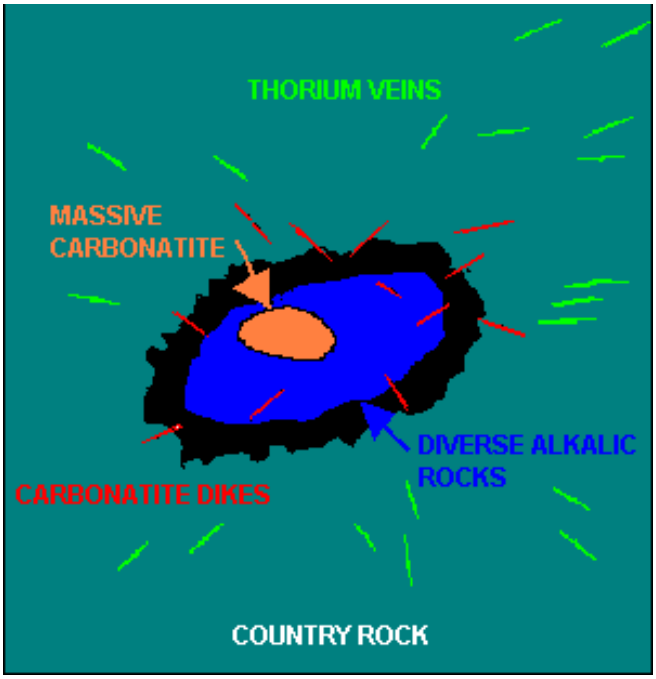
- OTHER COMMODITIES: None.

ASSOCIATED DEPOSIT TYPES (*suspected to be genetically related): Disseminated rare-earth minerals in both massive carbonatites and carbonatite dikes; example: one of the world's largest rare-earth deposits in a massive carbonatite at Mountain Pass, California (Olson and others, 1954).

REGIONAL GEOLOGIC ATTRIBUTES

- **TECTONOSTRATIGRAPHIC SETTING:** Commonly associated with diverse suites of alkaline rocks and carbonatites. Thorium-rare-earth veins generally occur in an outer ring around alkaline rocks (fig. 1). May be as far as 16 km beyond outer limits of the alkaline rocks. Veins most common in the eastern part of the Cordilleran belt associated with continental crustal rocks (Staatz and Armbrustmacher, 1982).
- **REGIONAL DEPOSITIONAL ENVIRONMENT:** Veins formed along fractures in brittle rocks. Vein fluids commonly traveled many kilometers before deposition. In a few areas, such as the Powderhorn district (Olson and Hedlund, 1981), all related igneous rocks are exposed. From the center, igneous alkaline rock complex surrounds a massive carbonatite and is bordered by fenite. Carbonatite dikes intrude outer part of alkaline rocks and neighboring country rock. Thorium-rare-earth veins intruded into an outer zone (fig. 1).

Plan view:



Cross section view:

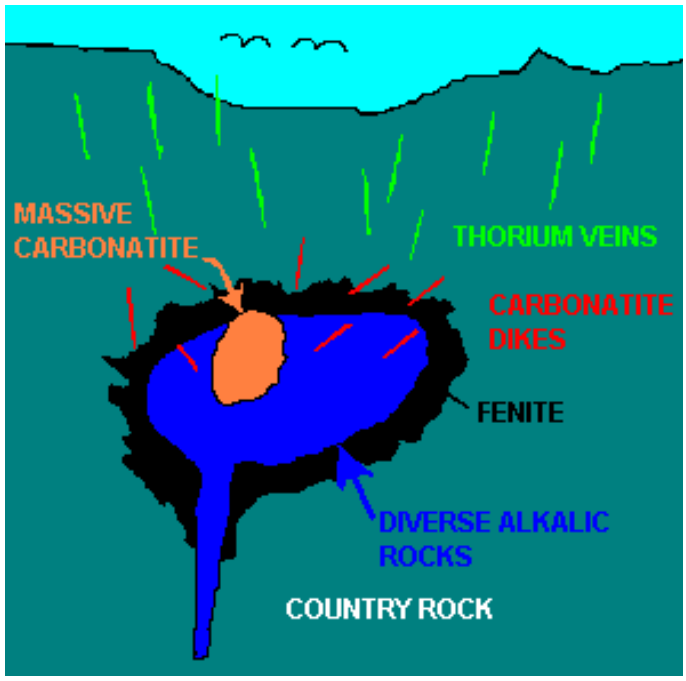


Figure 1. Idealized model showing relationship of thorium-rare-earth veins to alkalic rocks and carbonatites.

LOCAL GEOLOGIC ATTRIBUTES

- **HOST ROCKS:** Hard brittle rocks. Rocks include Precambrian quartzite, hornblende schist, gneiss, granite; Upper Cretaceous Dakota Sandstone; Tertiary trachyte, phonolite, and intrusive breccia.
- **ASSOCIATED ROCKS:** Alkalic rocks, carbonatites, fenites.
- **ORE MINERALOGY:** principal ore minerals in most deposits: thorite+monazite. Associated minerals: +brockite+allanite+bastnaesite. Exceptions: (1) Bear Lodge Mountains, Wyoming, no thorite, principally monazite+brockite+bastnaesite; (2) Laughlin Peak area, New Mexico, neither thorite nor monazite, principally either (a) brockite + xenotime or (b) thorium- and rare-earth-bearing crandallite.
- **GANGUE MINERALS:** Principal minerals: quartz+iron oxides (goethite and (or) hematite)+potassium feldspar. Minor minerals: +barite+apatite+magnetite +rutile+anatase+zircon (Staatz, 1974).
- **STRUCTURE and ZONING:** Veins usually fine grained and commonly heavily stained with iron oxides+manganese oxides. Mineral zoning unknown.
- **ORE CONTROLS:** Large alkaline rock body or bodies, whose magma was source of vein fluids within about 20 km of veins (Staatz, 1974). Joints and small faults that served both as conduits for ore fluids and as sites of deposition.
- **ISOTOPIC SIGNATURES:** Unknown.
- **FLUID INCLUSIONS:** Unknown.
- **STRUCTURAL SETTING:** All ore in tabular veins.

- **ORE DEPOSIT GEOMETRY:** Veins of potential economic interest range in length from about 60 to about 1,330 m and in thickness from about 0.3 to about 16 m. Veins may strike in almost any direction. Dips of all veins steep.
- **ALTERATION:** Iron minerals, where present, altered to goethite+lepidocrocite+hematite. Clay minerals not common; thorite often metamict, sometimes narrow zone of fenitization around vein.
- **EFFECT OF WEATHERING:** Probably aided in forming iron-oxide minerals.
- **EFFECT OF METAMORPHISM:** Not applicable.
- **GEOCHEMICAL SIGNATURE(S):** Some enrichment of Th and rare earths in alkaline igneous rocks. Th tends to disperse rapidly in stream sediments short distances below veins (Staatz and others, 1971). Heavy metals in stream sediments not diagnostic.
- **GEOPHYSICAL SIGNATURE(S):** Radiation due to thorium used to locate most veins. Generally located by hand-held geiger counter or scintillometer. Most veins too narrow and (or) poorly exposed to locate with airborne radiation counters.
- **OTHER EXPLORATION GUIDES:** Unknown.
- **OVERBURDEN:** Most known veins have some part exposed at surface. Veins have been traced from original exposure under as much as 10 m of overburden.

5. DESCRIPTIVE MODEL OF PORPHYRY Cu - SKARN-RELATED DEPOSITS Model 18a

by Dennis P. Cox

DESCRIPTION Chalcopyrite in stockwork veinlets in hydrothermally altered intrusives and in skarn with extensive retrograde alteration (see fig. 50).

GENERAL REFERENCE Einaudi and others (1981), p. 341-354.

GEOLOGICAL ENVIRONMENT

- **Rock Types:** Tonalite to monzogranite intruding carbonate rocks or calcareous clastic rocks.
- **Textures:** Porphyry has microaplitic groundmass.
- **Age Range:** Mainly Mesozoic and Tertiary, but may be any age.
- **Depositional Environment:** Epizonal intrusion of granitic stocks into carbonate rocks. Intense fracturing.
- **Tectonic Setting(s):** Andean-type volcanism and intrusion superimposed on older continental shelf carbonate terrane.
- **Associated Deposit Types:** Skarn copper, replacement Pb-Zn-Ag.

DEPOSIT DESCRIPTION

- **Mineralogy:** Chalcopyrite + pyrite + magnetite in inner garnet pyroxene zone; bornite + chalcopyrite + sphalerite + tennantite in outer wollastonite zone. Scheelite and traces of molybdenite and galena may be present. Hematite or pyrrhotite may be predominant.
- **Texture/Structure:** Fine granular calc-silicates and quartz sulfide veinlets.
- **Alteration:** Potassic alteration in pluton is associated with andradite and diopside in calcareous rocks. Farther from contact are zones of wollastonite or tremolite with minor garnet, idocrase, and clinopyroxene. These grade outward to marble. Phyllic alteration in pluton is associated with retrograde actinolite, chlorite, and clay in skarn.
- **Ore Controls:** Intense stockwork veining in igneous and skarn rocks contains most of the copper minerals. Cu commonly accompanies retrograde alteration.
- **Weathering** Cu carbonates, silicates, Fe-rich gossan.
- **Geochemical Signature** Cu, Mo, Pb, Zn, Au, Ag, W, Bi, Sn, As, Sb.

EXAMPLES

- Ruth (Ely), USNV (Westra, 1982a_)
- Gaspe', CNQU (Allcock, 1982_)
- Christmas, USAZ (Koski and Cook, 1982)
- Silver Bell, USAZ (Graybeal, 1982_)

6. DESCRIPTIVE MODEL OF W VEINS
Model 15a

by Dennis P. Cox and William C. Bagby

APPROXIMATE SYNONYM Quartz-wolframite veins (Kelly and Rye, 1979).

DESCRIPTION Wolframite, molybdenite, and minor base-metal sulfides in quartz veins (see fig. 39).

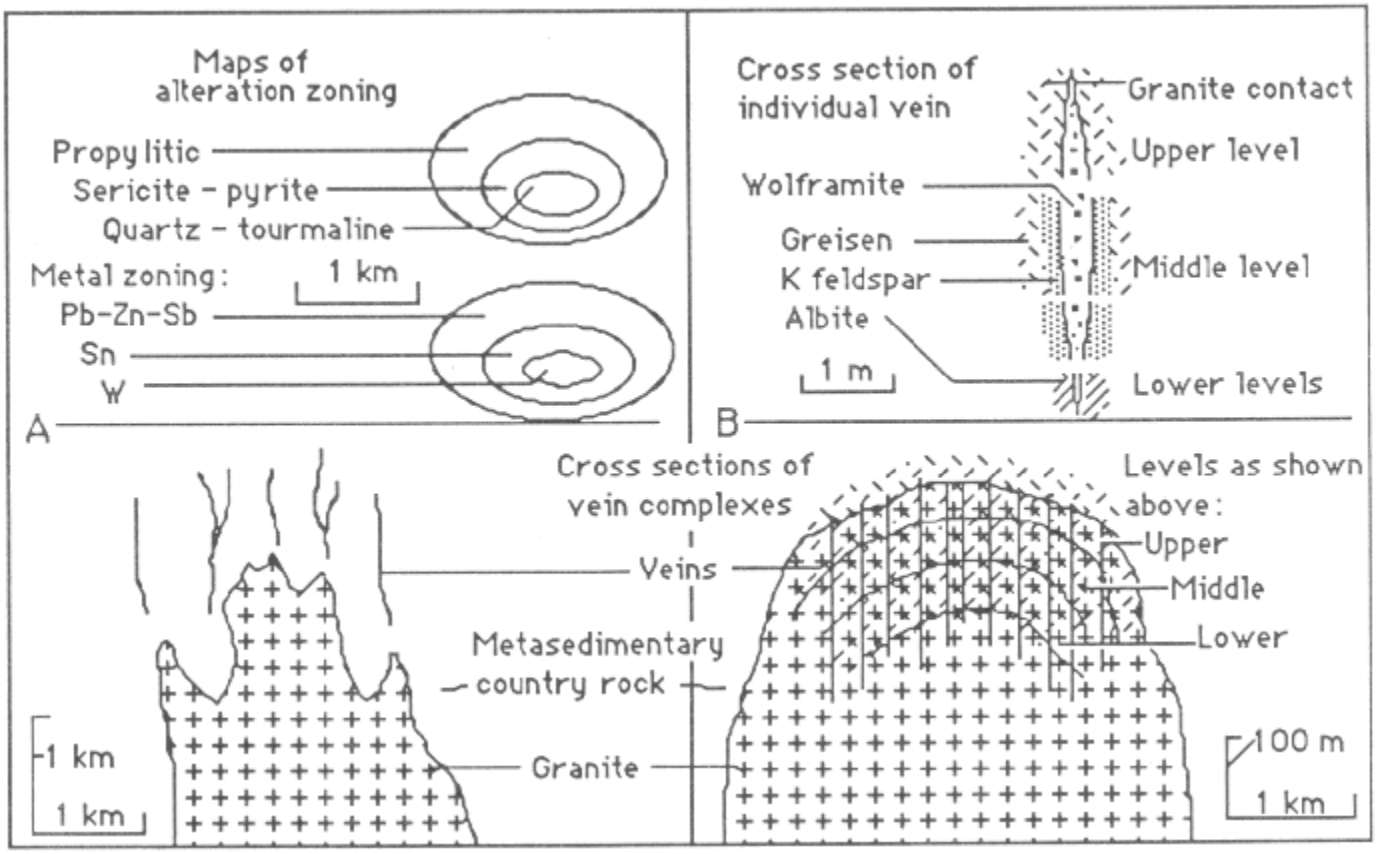


Figure 39. Maps and sections of W vein deposits illustrating mineral and alteration zoning. A, Chicote Grande deposit, Bolivia. B, Xihuashan deposit, China.

GEOLOGICAL ENVIRONMENT

- **Rock Types:** Monzogranite to granite stocks intruding sandstone, shale, and metamorphic equivalents.
- **Textures:** Phanerocrystalline igneous rocks, minor pegmatitic bodies, and porphyroaphanitic dikes.
- **Age Range:** Paleozoic to late Tertiary.
- **Depositional Environment:** Tensional fractures in epizonal granitic plutons and their wallrocks.

- **Tectonic Setting(s):** Belts of granitic plutons derived from remelting of continental crust. Country rocks are metamorphosed to greenschist facies.
- **Associated Deposit Types:** Sn-W veins, pegmatites.

DEPOSIT DESCRIPTION

- **Mineralogy** Wolframite, molybdenite, bismuthinite, pyrite, pyrrhotite, arsenopyrite, bornite, chalcopyrite, scheelite, cassiterite, beryl, fluorite; also at Pasto Bueno, tetrahedrite-tennantite, sphalerite, galena, and minor enargite.
- **Texture/Structure** Massive quartz veins with minor vugs, parallel walls, local breccia.
- **Alteration** Deepest zones, pervasive albitization; higher pervasive to vein-selvage pink K-feldspar replacement with minor disseminated REE minerals; upper zones, vein selvages of dark-gray muscovite or zinnwaldite (greisen). Chloritization. Widespread tourmaline alteration at Isla de Pinos.
- **Ore Controls** Swarms of parallel veins cutting granitic rocks or sedimentary rocks near igneous contacts.
- **Weathering** Wolframite persists in soils and stream sediments. Stolzite and tungstite may be weathering products.
- **Geochemical Signature** W, Mo, Sn, Bi, As, Cu, Pb, Zn, Be, F.

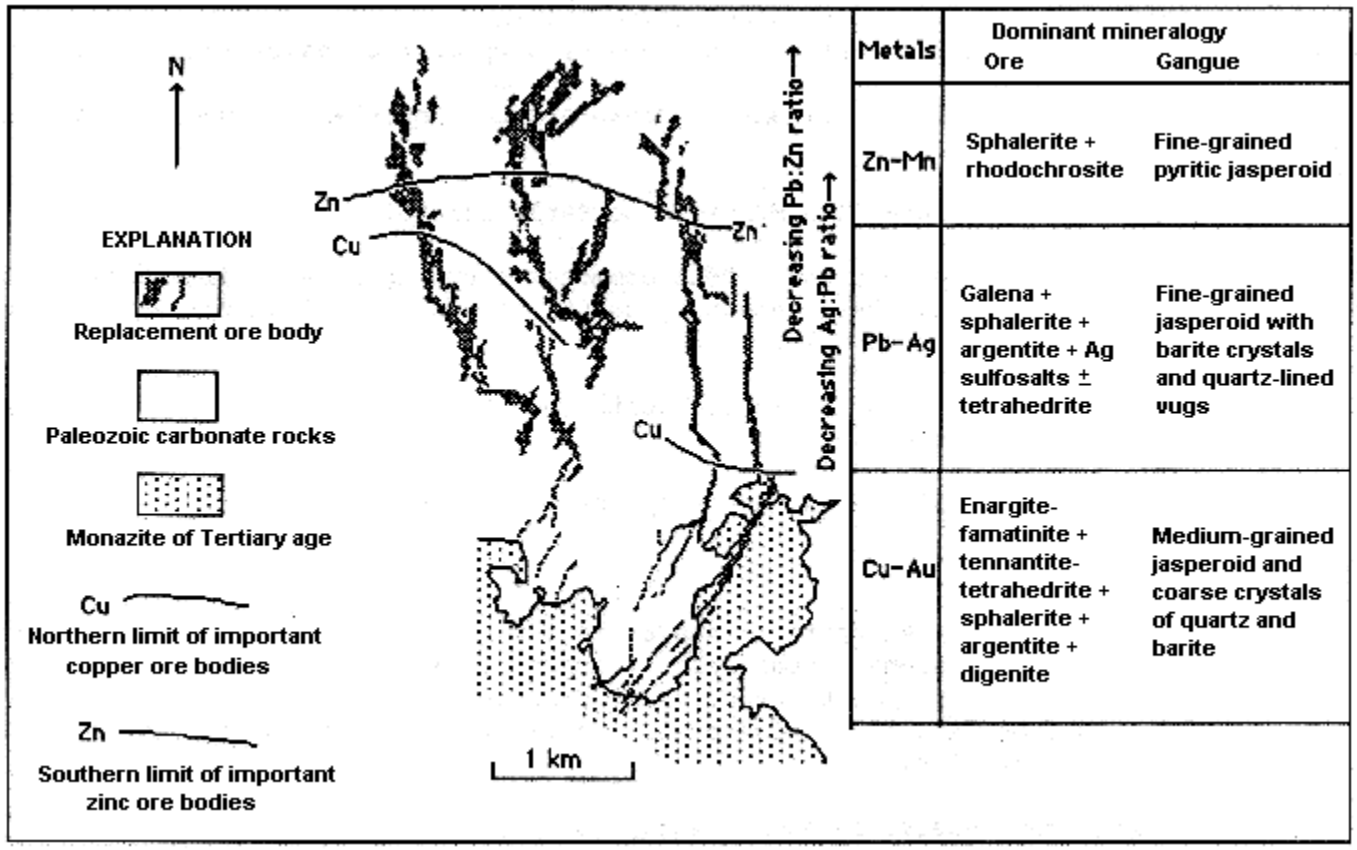
EXAMPLES

- Pasto Bueno, PERU (Landis and Rye, 1974)
- Xihuashan, CINA (Hsu, 1943; Giuliani, 1985; and personal visit)
- Isla de Pinos, CUBA (Page and McAllister, 1944)
- Hamme District, USNC (Foose and others, 1980)
- Round Mountain, USNV (Shawe and others, 1984)

7. DESCRIPTIVE MODEL OF Cu - Au SKARN DEPOSITS
Model 18b

by Dennis P. Cox and Ted G. Theodore

DESCRIPTION Chalcopyrite in calc-silicate contact metasomatic rocks (see fig. 57).



Metals	Dominant mineralogy Ore	Gangue
Zn-Mn	Sphalerite + rhodochrosite	Fine-grained pyritic jasperoid
Pb-Ag	Galena + sphalerite + argentite + Ag sulfosalts ± tetrahedrite	Fine-grained jasperoid with barite crystals and quartz-lined vugs
Cu-Au	Enargite-famatinite + tennantite-tetrahedrite + sphalerite + argentite + digenite	Medium-grained jasperoid and coarse crystals of quartz and barite

Figure 57. Cartoon cross section of Cu skarn deposit showing relationship between metamorphic zones, ore bodies, and igneous intrusion.

GENERAL REFERENCES Einaudi and Burt (1982), Einaudi and others (1981).

GEOLOGICAL ENVIRONMENT

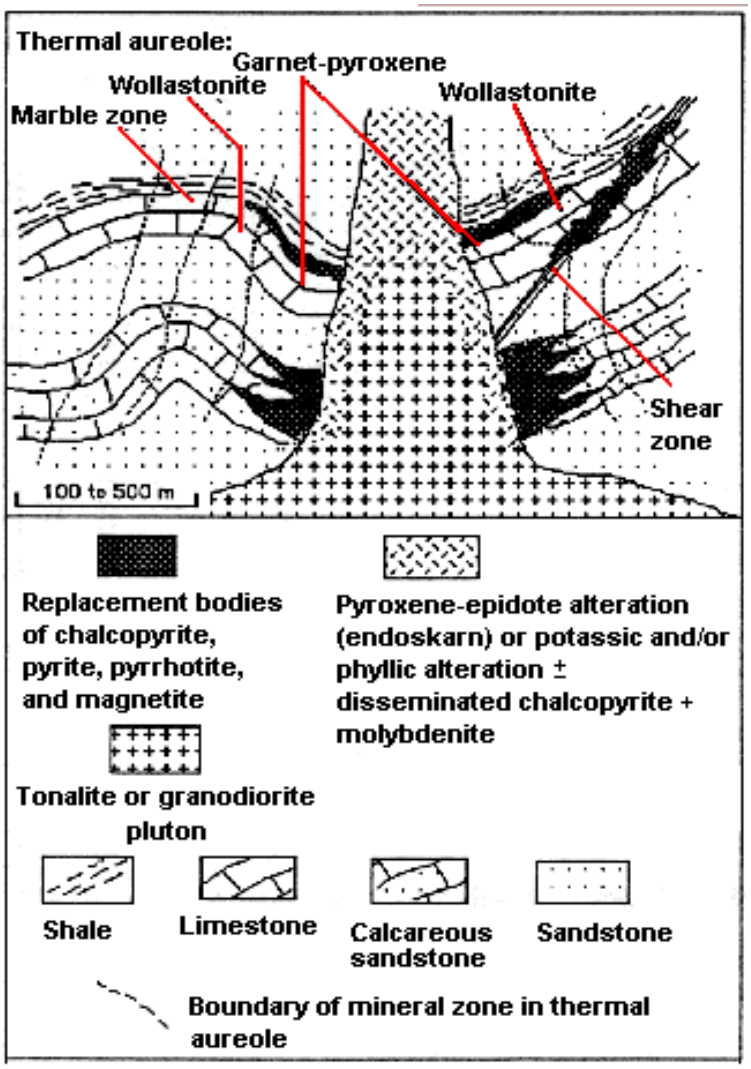
- **Rock Types** Tonalite to monzogranite intruding carbonate rocks or calcareous clastic rocks.
- **Textures** Granitic texture, porphyry, granoblastic to hornfelsic in sedimentary rocks.
- **Age Range** Mainly Mesozoic, but may be any age.
- **Depositional Environment** Miogeosynclinal sequences intruded by felsic plutons.
- **Tectonic Setting(s)** Continental margin late orogenic magmatism.
- **Associated Deposit Types** Porphyry Cu, zinc skarn, polymetallic replacement, Fe skarn.

DEPOSIT DESCRIPTION

- **Mineralogy** Chalcopyrite + pyrite ± hematite ± magnetite ± bornite ± pyrrhotite. Also molybdenite, bismuthinite, sphalerite, galena, cosalite, arsenopyrite, enargite, tennantite, loellingite, cobaltite, and tetrahedrite may be present. Au and Ag may be important products.
- **Texture/Structure** Coarse granoblastic with interstitial sulfides. Bladed pyroxenes are common.
- **Alteration** Diopside + andradite center; wollastonite + tremolite outer zone; marble peripheral zone. Igneous rocks may be altered to epidote + pyroxene + garnet (endoskarn). Retrograde alteration to actinolite, chlorite, and clays may be present.
- **Ore Controls** Irregular or tabular ore bodies in carbonate rocks and calcareous rocks near igneous contacts or in xenoliths in igneous stocks. Breccia pipe, cutting skarn at Victoria, is host for ore. Associated igneous rocks are commonly barren.
- **Weathering** Cu carbonates, silicates, Fe-rich gossan. Calc-silicate minerals in stream pebbles are a good guide to covered deposits.
- **Geochemical Signature** Rock analyses may show Cu-Au-Ag-rich inner zones grading outward to Au-Ag zones with high Au:Ag ratio and outer Pb-Zn-Ag zone. Co-As-Sb-Bi may form anomalies in some skarn deposits. Magnetic anomalies.

EXAMPLES

- Nixon Fork (Newberry and others, 1997)
- Mason Valley, USNV (Harris and Einaudi, 1982)
- Victoria, USNV (Atkinson and others, 1982)
- Copper Canyon, USNV (Blake and others, 1979)
- Carr Fork, USUT (Atkinson and Einaudi, 1978)



8. DESCRIPTIVE MODEL OF Zn-Pb SKARN DEPOSITS
Model 18c

by Dennis P. Cox

DESCRIPTION Sphalerite and galena in calc-silicate rocks.

GENERAL REFERENCES Einaudi and Burt (1982); Einaudi and others (1981).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Granodiorite to granite, diorite to syenite. Carbonate rocks, calcareous clastic rocks.
- **Textures** Granitic to porphyritic; granoblastic to hornfelsic.
- **Age Range** Mainly Mesozoic, but may be any age.
- **Depositional Environment** Miogeoclinal sequences intruded by generally small bodies of igneous rock.
- **Tectonic Setting(s)** Continental margin, late-orogenic magmatism.
- **Associated Deposit Types** Copper skarn.

DEPOSIT DESCRIPTION

- **Mineralogy** Sphalerite + galena ± pyrrhotite ± pyrite ± magnetite ± chalcopyrite ± bornite ± arsenopyrite ± scheelite ± bismuthinite ± stannite ± fluorite. Gold and silver do not form minerals.
- **Texture/Structure** Granoblastic, sulfides massive to interstitial.
- **Alteration** Mn-hedenbergite ± andradite ± grossular ± spessartine ± bustamite ± rhodonite. Late stage Mn-actinolite ± ilvaite ± chlorite ± dannemorite ± rhodochrosite.
- **Ore Controls** Carbonate rocks especially at shale-limestone contacts. Deposit may be hundreds of meters from intrusive.
- **Weathering** Gossan with strong Mn oxide stains.
- **Geochemical Signature** Zn, Pb, Mn, Cu, Co, Au, Ag, As, W, Sn, F, possibly Be.
- Magnetic anomalies.

EXAMPLES

- Badnews USAK (Bundtzen, 1999)
- Ban Ban, AUQU (Ashley, 1980)
- Hanover-Fierro district, USNM (Hernon and Jones, 1968)

9. DESCRIPTIVE MODEL OF POLYMETALLIC REPLACEMENT DEPOSITS
Model 19a

by Hal T. Morris

APPROXIMATE SYNONYM Manto deposits, many authors.

DESCRIPTION Hydrothermal, epigenetic, Ag, Pb, Zn, Cu minerals in massive lenses, pipes and veins in limestone, dolomite, or other soluble rock near igneous intrusions (see fig. 68).

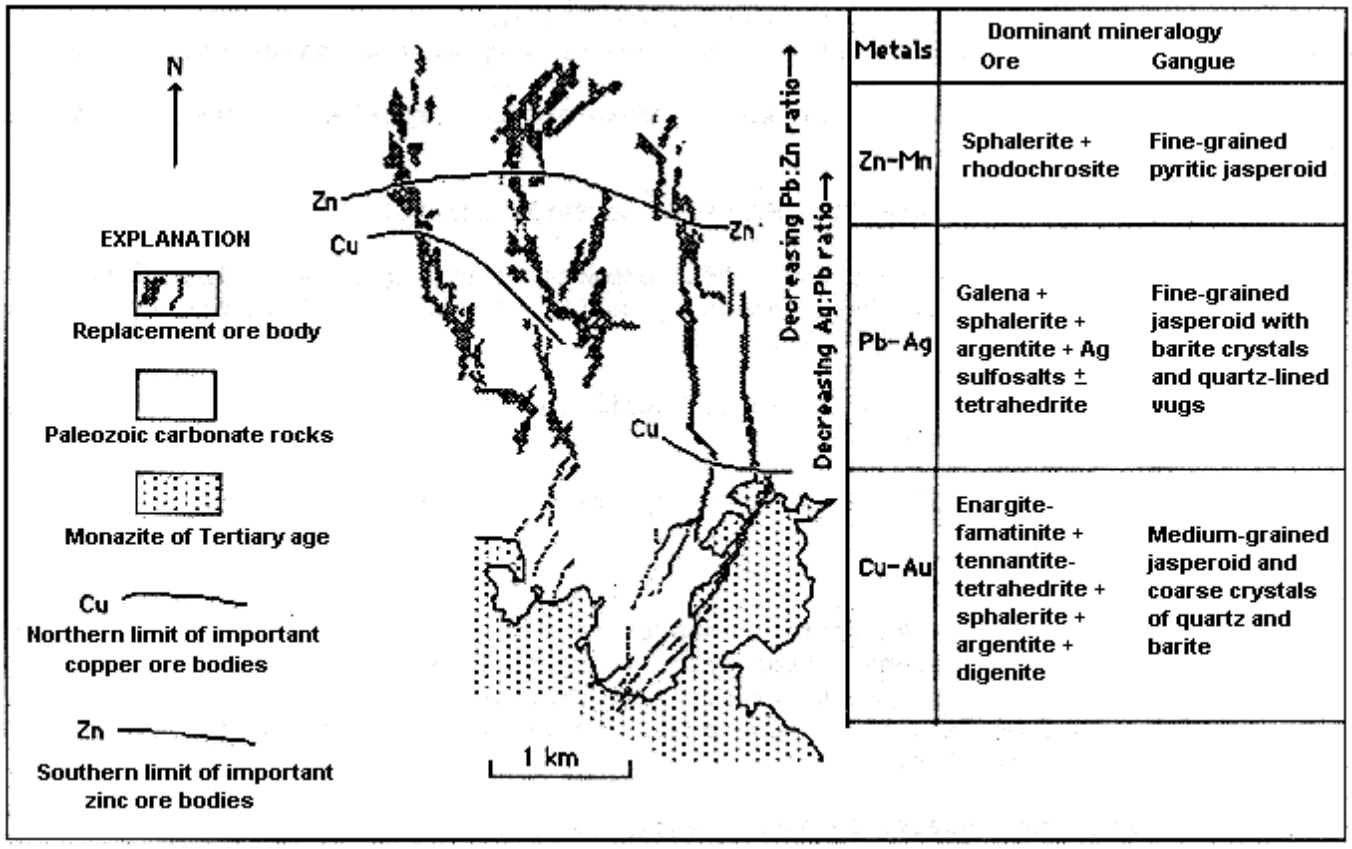


Figure 68. Generalized map showing metal and mineral zoning in polymetallic replacement deposits in the Main Tintic district, Utah. Modified from Morris (1968)).

GENERAL REFERENCE Jensen and Bateman (1981), p. 134-146.

GEOLOGICAL ENVIRONMENT

- **Rock Types** Sedimentary rocks, chiefly limestone, dolomite, and shale, commonly overlain by volcanic rocks and intruded by porphyritic, calc-alkaline plutons.
- **Textures** The textures of the replaced sedimentary rocks are not important; associated plutons typically are porphyritic.
- **Age Range** Not important, but many are late Mesozoic to early Cenozoic.

- **Depositional Environment** Carbonate host rocks that commonly occur in broad sedimentary basins, such as epicratonic miogeosynclines. Replacement by solutions emanating from volcanic centers and epizonal plutons. Calderas may be favorable.
- **Tectonic Setting(s)** Most deposits occur in mobile belts that have undergone moderate deformation and have been intruded by small plutons.
- **Associated Deposit Types** Base metal skarns, and porphyry copper deposits.

DEPOSIT DESCRIPTION

- **Mineralogy** Zonal sequence outward: enargite + sphalerite + argentite + tetrahedrite + digenite ± chalcopyrite, rare bismuthinite; galena + sphalerite + argentite ± tetrahedrite ± proustite ± pyrargyrite, rare jamesonite, jordanite, bournonite, stephanite, and polybasite; outermost sphalerite + rhodochrosite (see fig. 68). Widespread quartz, pyrite, marcasite, barite. Locally, rare gold, sylvanite, and calaverite.
- **Texture/Structure** Ranges from massive to highly vuggy and porous.
- **Alteration** Limestone wallrocks are dolomitized and silicified (to form jasperoid); shale and igneous rocks are chloritized and commonly are argillized; where syngenetic iron oxide minerals are present, rocks are pyritized. Jasperoid near ore is coarser grained and contains traces of barite and pyrite.
- **Ore Controls** Tabular, podlike and pipelike ore bodies are localized by faults or vertical beds; ribbonlike or blanketlike ore bodies are localized by bedding-plane faults, by susceptible beds, or by preexisting solution channels, caverns, or cave rubble.
- **Weathering** Commonly oxidized to ochreous masses containing cerrusite, anglesite, hemimorphite, and cerargyrite.
- **Geochemical Signature** On a district-wide basis ore deposits commonly are zoned outward from a copper-rich central area through a wide lead-silver zone, to a zinc- and manganese-rich fringe. Locally Au, As, Sb, and Bi. Jasperoid related to ore can often be recognized by high Ba and trace Ag content.

EXAMPLES

- East Tintic district, USUT (Morris and Lovering, 1979)
- Eureka district, USNV (Nolan, 1962)
- Manto deposit, MXCO (Prescott, 1926)

10. DESCRIPTIVE MODEL OF Sn-POLYMETALLIC VEINS
Model 20b

by Yukio Togashi (Geological Survey of Japan)

APPROXIMATE SYNONYMS Polymetallic xenothermal (Imai and others, 1978), Bolivian subvolcanic multistage.

DESCRIPTION Multistage Cu-Zn-Sn-Ag-bearing veins associated with felsic ignimbrites and subvolcanic intrusions.

GENERAL REFERENCES Nakamura and Hunahashi (1970), Grant and others (1977).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Rhyolitic tuff, welded tuff and tuff breccia. Rhyolitic to basaltic dikes. Sandstone, slate, chert, and basic tuff.
- **Textures** Welded and airfall tuff. Porphyritic-aphanitic intrusives.
- **Age Range** Late Cretaceous to Miocene in Japan, Miocene in Bolivia, but may be any age.
- **Depositional Environment** Fissures in and around felsic ignimbrite.
- **Tectonic Setting(s)** Continental margin. Syn-late orogenic.
- **Associated Deposit Types** Polymetallic replacement, epithermal Ag veins, porphyry Sn.

DEPOSIT DESCRIPTION

- **Mineralogy** Cassiterite, chalcopyrite, sphalerite, pyrrhotite, pyrite, galena, scheelite, wolframite, arsenopyrite, native bismuth, bismuthinite, argentite, native gold, magnetite, molybdenite, and complex sulfosalt minerals including teallite, frankeite, cylindrite, and stannite.
- **Texture/Structure** Multistage composite veins with Sn, Cu, Zn, and Ag minerals occurring in the same vein.
- **Alteration** Minor quartz-chlorite-sericite alteration close to veins. Tourmaline, fluorite, or siderite may be present.
- **Ore Controls** Veins, breccia veins, and breccia pipes. Metal zoning sequence is Sn + W to Cu + Sn, Cu + Zn, Pb + Zn, Pb + Ag, Au + Ag from center to periphery, or from depths to shallow levels. Zones are commonly superimposed or “telescoped” to produce complex veins.
- **Weathering** Limonitization. Cassiterite in soils and gossans.
- **Geochemical Signature** Cu, Zn, Sn, Pb, W, Au, Ag, Bi, As.

EXAMPLES

- Ashio, Akenobe, Ikuno, Kishu, JAPN (Nakamura, 1970)
- Potosi, BLVA (Turneaure, 1971)

11. DESCRIPTIVE MODEL OF PORPHYRY Cu-Au
Model 20c

by Dennis P. Cox

DESCRIPTION Stockwork veinlets of chalcopyrite, bornite, and magnetite in porphyritic intrusions and coeval volcanic rocks. Ratio of Au (ppm) to Mo (percent) is greater than 30 (see Figure 77).

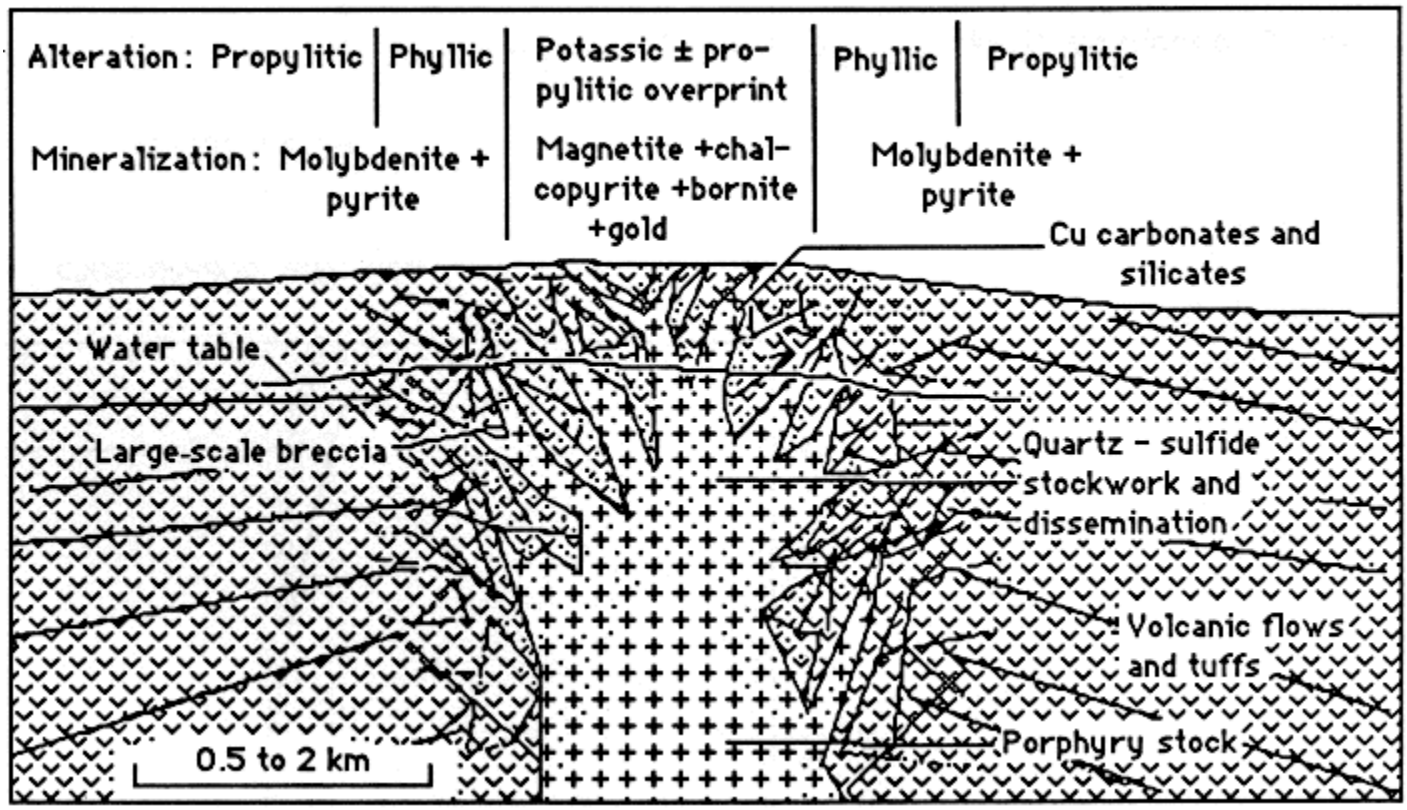


Figure 77. Cartoon cross section of porphyry Cu-Au deposit. Modified from Langton and Williams (1982).

GENERAL REFERENCES Sillitoe (1979), Cox and Singer (in press).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Tonalite to monzogranite; dacite, andesite flows and tuffs coeval with intrusive rocks. Also syenite, monzonite, and coeval high-K, low-Ti volcanic rocks (shoshonites).
- **Textures** Intrusive rocks are porphyritic with fine- to medium-grained aplitic
- groundmass.
- **Age Range** Cretaceous to Quaternary.
- **Depositional Environment** In porphyry intruding coeval volcanic rocks. Both involved and in large-scale breccia. Porphyry bodies may be dikes. Evidence for volcanic center; 1-2 km depth of emplacement.

- **Tectonic Setting(s)** Island-arc volcanic setting, especially waning stage of volcanic cycle. Also continental margin rift-related volcanism.
- **Associated Deposit Types** Porphyry Cu-Mo; gold placers.

DEPOSIT DESCRIPTION

- **Mineralogy** Chalcopyrite ± bornite; traces of native gold, electrum, sylvanite, and hessite. Quartz + K-feldspar + biotite + magnetite + chlorite + actinolite + anhydrite. Pyrite + sericite + clay minerals + calcite may occur in late-stage veinlets.
- **Texture/Structure** Veinlets and disseminations.
- **Alteration** Quartz ± magnetite ± biotite (chlorite) ± K-feldspar ± actinolite, ± anhydrite in interior of system. Outer propylitic zone. Late quartz + pyrite + white mica ± clay may overprint early feldspar-stable alteration.
- **Ore Controls** Veinlets and fractures of quartz, sulfides, K-feldspar magnetite, biotite, or chlorite are closely spaced. Ore zone has a bell shape centered on the volcanic-intrusive center. Highest grade ore is commonly at the level at which the stock divides into branches.
- **Weathering** Surface iron staining may be weak or absent if pyrite content is
- low in protore. Copper silicates and carbonates. Residual soils contain anomalous amounts of rutile.
- **Geochemical Signature** Central Cu, Au, Ag; peripheral Mo. Peripheral Pb, Zn, Mn anomalies may be present if late sericite pyrite alteration is strong. Au (ppm):Mo (percent) >30 in ore zone. Au enriched in residual soil over ore body. System may have magnetic high over intrusion surrounded by magnetic low over pyrite halo.

EXAMPLES

- Von Frank Mountains south USAK (Bundtzen, 1999)
- Dos Pobres, USAZ (Langton and Williams, 1982)
- Copper Mountain, CNBC (Fahrni and others, 1976)
- Tanama, PTRC (Cox, 1985)

12. DESCRIPTIVE MODEL OF PORPHYRY Cu-Mo
Model 21a

by Dennis P. Cox

DESCRIPTION Stockwork veinlets of quartz, chalcopyrite, and molybdenite in or near a porphyritic intrusion. Ratio of Au (in ppm) to Mo (in percent) less than 3 (See fig. 82).

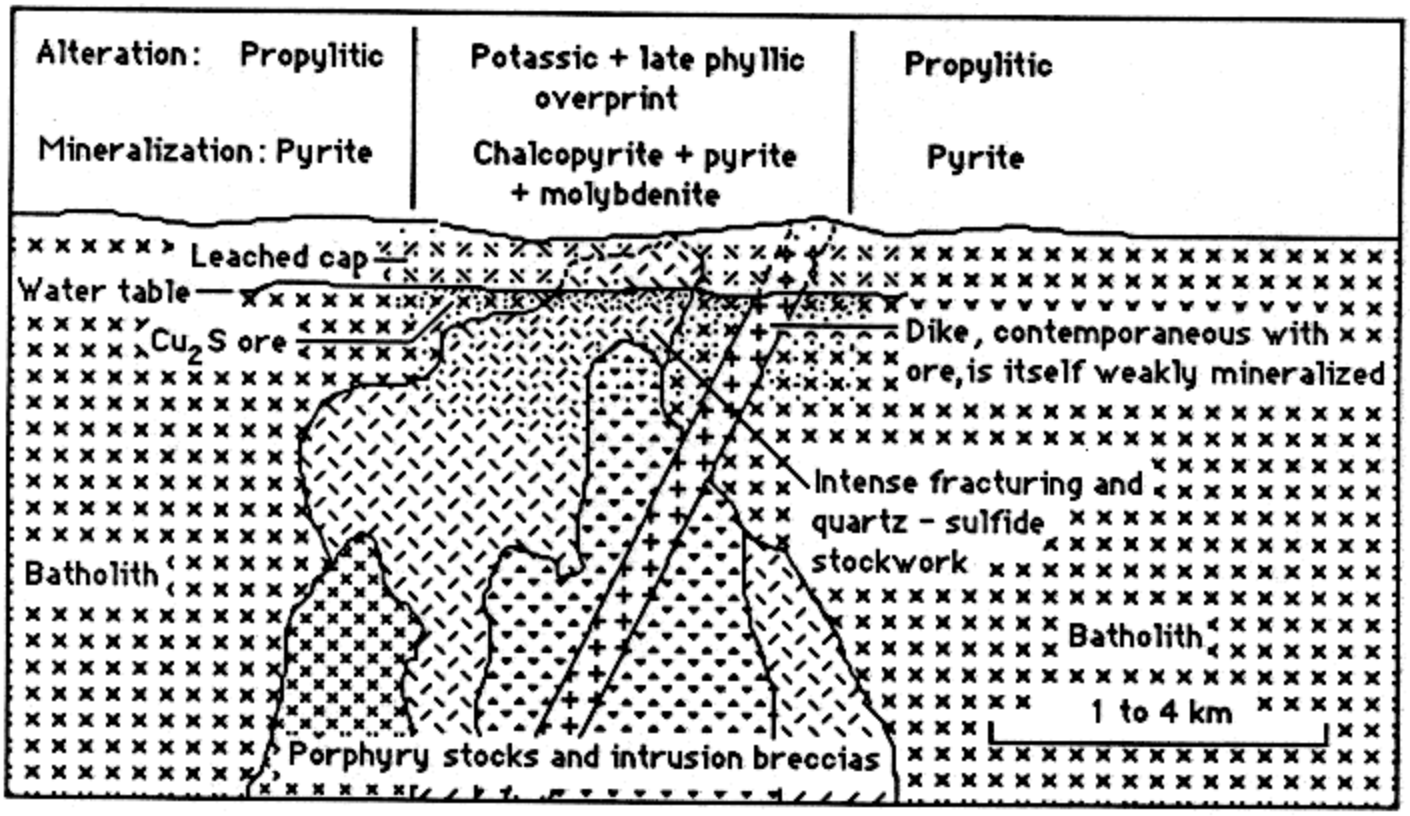


Figure 82. Cartoon cross section of porphyry Cu-Mo deposit showing relationship between mineral- and alteration-zoning and igneous intrusion.

GENERAL REFERENCE Titley (1982).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Tonalite to monzogranite stocks and breccia pipes intrusive into batholithic, volcanic, or sedimentary rocks.
- **Textures** Intrusions contemporaneous with ore commonly are porphyries with fine- to medium-grained aplitic groundmass. Porphyry texture may be restricted to small dikes in some deposits (Brenda).
- **Age Range** Mainly Mesozoic to Tertiary, but can be any age.
- **Depositional Environment** High-level intrusive porphyry contemporaneous with abundant dikes, faults, and breccia pipes. Cupolas of batholiths.

- **Tectonic Setting(s)** Numerous faults in subduction-related volcanic plutonic arcs. Mainly along continental margins but also in oceanic convergent plate boundaries.
- **Associated Deposit Types** Cu, Zn, or Fe skarns may be rich in gold, gold + base-metal sulfosalts in veins, gold placers. Volcanic-hosted massive replacement and polymetallic replacement.

DEPOSIT DESCRIPTION

- **Mineralogy** Chalcopyrite + pyrite + molybdenite. Peripheral vein or replacement deposits with chalcopyrite + sphalerite + galena ± gold. Outermost zone may have veins of Cu-Ag-Sb-sulfides, barite, and gold.
- **Texture/Structure** Veinlets and disseminations or massive replacement of favorable country rocks.
- **Alteration** Quartz + K-feldspar + biotite (chlorite) ± anhydrite (potassic alteration) grading outward to propylitic. Late white mica + clay (phyllic) alteration may form capping or outer zone or may affect the entire deposit. High-alumina alteration assemblages may be present in upper levels of the system (see table 3).
- **Ore Controls** Ore grade is, in general, positively correlated with spacing of veinlets and mineralized fractures. Country rocks favorable for mineralization are calcareous sediments; diabase, tonalite, or diorite.
- **Weathering** Intense leaching of surface; wide areas of iron oxide stain. Fractures coated with hematitic limonite. Supergene copper as chalcocite may form blanket below leached zone. Residual soils may contain anomalous amounts of rutile.
- **Geochemical Signature** Cu + Mo + Ag ± W + B + Sr center; Pb, Zn, Au, As, Sb, Se, Te, Mn, Co, Ba, and Rb in outer zone. Locally Bi and Sn form distal anomalies. High S in all zones. Ratio of Au (ppm): Mo (percent)<3. Magnetic low.

EXAMPLES

- McLeod USAK (Dashevsky, 2002)
- Brenda, CNBC (Soregaroli and Whitford, 1976)
- Sierrita Esperanza, USAZ (West and Aiken, 1982)
- McCloud, AK

13. DESCRIPTIVE MODEL OF PORPHYRY Mo, LOW-F
Model 21b

by Ted G. Theodore

APPROXIMATE SYNONYM Calc-alkaline Mo stockwork (Westra and Keith, 1981).

DESCRIPTION Stockwork of quartz-molybdenite veinlets in felsic porphyry and in its nearby country rock.

GENERAL REFERENCE Westra and Keith (1981).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Tonalite, granodiorite, and monzogranite.
- **Textures** Porphyry, fine aplitic groundmass.
- **Age Range** Mesozoic and Tertiary.
- **Depositional Environment** Orogenic belt with calcalkaline intrusive rocks.
- **Tectonic Setting(s)** Numerous faults.
- **Associated Deposit Types** Porphyry Cu-Mo, Cu skarn, volcanic hosted Cu-As-Sb.

DEPOSIT DESCRIPTION

- **Mineralogy** Molybdenite + pyrite + scheelite + chalcopyrite + argentian tetrahedrite. Quartz + K-feldspar + biotite + calcite + white mica and clays.
- **Texture/Structure** Disseminated and in veinlets and fractures.
- **Alteration** Potassic outward to propylitic. Phyllic and argillic overprint (see table 3).
- **Ore Controls** Stockwork in felsic porphyry and in surrounding country rock.
- **Weathering** Yellow ferrimolybdite after molybdenite. Secondary copper enrichment may form copper ores in some deposits.
- **Geochemical Signature** Zoning outward and upward from Mo + Cu ± W to Cu + Au to Zn + Pb, + Au, + Ag. F may be present but in amounts less than 1,000 ppm.

EXAMPLES

- Buckingham, USNV (Blake and others, 1979)
- USSR deposits (Pavlova and Rundquist, 1980)
- McCleod, AK (Dashevsky, 2002)

`14. DESCRIPTIVE MODEL OF VOLCANIC-HOSTED Cu-As-Sb
Model 22a

by Dennis P. Cox

APPROXIMATE SYNONYM Enargite massive sulfide (Sillitoe, 1983)

DESCRIPTION Stratabound to pipelike massive copper sulfosalt deposits in volcanic flows, breccias, and tuffs near porphyry systems.

GENERAL REFERENCES Sillitoe (1983), Ashley (1982).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Andesite, dacite, flows, breccias, and tuffs.
- **Textures** Fine grained, porphyritic, brecciated.
- **Age Range** Mainly Tertiary.
- **Depositional Environment** Volcanic terrane, uppermost levels of intrusive systems.
- **Tectonic Setting(s)** Continental margins and island arcs.
- **Associated Deposit Types** Porphyry Cu-Mo, porphyry Mo low-F.

DEPOSIT DESCRIPTION

- **Mineralogy** All contain pyrite. In addition, enargite + luzonite + tennantite (Lepanto), enargite + covellite + chalcocite + bornite + chalcopyrite (Bor), enargite + luzonite + tetrahedrite (Resck), tetrahedrite + sphalerite + chalcopyrite + arsenopyrite (Sam Goosly). Most contain a few parts per million Au; Sam Goosly is Ag-rich.
- **Texture/Structure** Massive ore, breccia filling, replacement of clasts by sulfides.
- **Alteration** Chalcedony plus high-alumina assemblages containing alunite, pyrophyllite, diaspore, dickite, andalusite. Dumortierite, tourmaline, barite, and scorzalite may be present.
- **Ore Controls** Tuff-breccias or breccia pipes are the channelways for ore solutions originating from younger porphyry copper systems. Known deposits are separated from typical porphyry type mineralization by 500 to 700 m.
- **Geochemical Signature** As, Sb, Cu, Zn, Ag, Au, ± minor Sn (Lepanto), and W (Sam Goosly).

EXAMPLES

- Lepanto, PLPN (Gonzales, 1956)
- Recsk, HUNG; Bor, YUGO (Sillitoe, 1983)
- Sam Goosly (Equity Silver), CNBC (Cyr and others, 1984)

15. DESCRIPTIVE MODEL OF POLYMETALLIC VEINS
Model 22c

by Dennis P. Cox

APPROXIMATE SYNONYM Felsic intrusion-associated Ag-Pb-Zn veins (Sangster, 1984).

DESCRIPTION Quartz-carbonate veins with Au and Ag associated with base metal sulfides related to hypabyssal intrusions in sedimentary and metamorphic terranes.

GEOLOGICAL ENVIRONMENT

- **Rock Types** Calcalkaline to alkaline, diorite to granodiorite, monzonite to monzogranite in small intrusions and dike swarms in sedimentary and metamorphic rocks. Subvolcanic intrusions, necks, dikes, plugs of andesite to rhyolite composition.
- **Textures** Fine- to medium-grained equigranular, and porphyroaphanitic.
- **Age Range** Most are Mesozoic and Cenozoic, but may be any age.
- **Depositional Environment** Near-surface fractures and breccias within thermal aureol of clusters of small intrusions. In some cases peripheral to porphyry systems.
- **Tectonic Setting(s)** Continental margin and island arc volcanic-plutonic belts. Especially zones of local domal uplift.
- **Associated Deposit Types** Porphyry Cu-Mo, porphyry Mo low-F, polymetallic replacement. Placer Au.

DEPOSIT DESCRIPTION

- **Mineralogy** Native Au and electrum with pyrite + sphalerite ± chalcopyrite ± galena ± arsenopyrite ± tetrahedrite-tennantite ± Ag sulfosalts ± argentite ± hematite in veins of quartz + chlorite + calcite ± dolomite ± ankerite ± siderite ± rhodochrosite ± barite ± fluorite ± chalcedony ± adularia.
- **Texture/Structure** Complex, multiphase veins with comb structure, crustification, and colloform textures. Textures may vary from vuggy to compact within mineralized system.
- **Alteration** Generally wide propylitic zones and narrow sericitic and argillic zones. Silicification of carbonate rocks to form jasperoid.
- **Ore Controls** Areas of high permeability: intrusive contacts, fault intersections, and breccia veins and pipes. Replacement ore bodies may form where structures intersect carbonate rocks.
- **Weathering** Minor gossans and Mn-oxide stains. Zn and Pb carbonates and Pb sulfate. Abundant quartz chips in soil. Placer gold concentrations in soils and stream sediments. Supergene enrichment produces high-grade native and horn silver ores in veins where calcite is not abundant.
- **Geochemical Signature** Zn, Cu, Pb, As, Au, Ag, Mn, Ba. Anomalies zoned from Cu-Au outward to Zn-Pb-Ag to Mn at periphery.

EXAMPLES

- Owhat USAK (Hudson, T., and Millholland, 2002)
- Mission USAK ((Hudson, T., and Millholland, 2002)
- St. Anthony (Mammoth), USAZ (Creasey, 1950)
- Wallapai District, USAZ (Thomas, 1949)

- Marysville District, USMT (Knopf, 1913)
- Misima I., PPNG (Williamson and Rogerson, 1983)
- Slocan District, CNBC (Cairnes, 1934)

16. DESCRIPTIVE MODEL OF BESSHI MASSIVE SULFIDE
Model 24b

by Dennis P. Cox

APPROXIMATE SYNONYM Besshi type, Kieslager.

DESCRIPTION Thin, sheetlike bodies of massive to well-laminated pyrite, pyrrhotite, and chalcopyrite within thinly laminated clastic sediments and mafic tuffs.

GENERAL REFERENCES Klau and Large (1980), Fox (1984).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Clastic terrigenous sedimentary rocks and tholeiitic to andesitic tuff and breccia. Locally, black shale, oxide-facies iron formation, and red chert.
- **Textures** Thinly laminated clastic rocks. All known examples are in strongly deformed metamorphic terrane. Rocks are quartzose and mafic schist.
- **Age Range** Mainly Paleozoic and Mesozoic.
- **Depositional Environment** Uncertain. Possibly deposition by submarine hot springs related to basaltic volcanism. Ores may be localized within permeable sediments and fractured volcanic rocks in anoxic marine basins.
- **Tectonic Setting(s)** Uncertain. Possibly rifted basin in island arc or back arc. Possibly spreading ridge underlying terrigenous sediment at continental slope.
- **Associated Deposit Types** None known.

DEPOSIT DESCRIPTION

- **Mineralogy** Pyrite + pyrrhotite + chalcopyrite + sphalerite ± magnetite ± valleriite ± galena ± bornite ± tetrahedrite ± cobaltite ± cubanite ± stannite ± molybdenite. Quartz, carbonate, albite, white mica, chlorite, amphibole, and tourmaline.
- **Texture/Structure** Fine-grained, massive to thinly laminated ore with colloform and framboidal pyrite. Breccia or stringer ore. Cross-cutting veins contain chalcopyrite, pyrite, calcite or galena, sphalerite, calcite.
- **Alteration** Difficult to recognize because of metamorphism. Chloritization of adjacent rocks is noted in some deposits.
- **Ore Controls** Uncertain. Deposits are thin, but laterally extensive and tend to cluster in en echelon pattern.
- **Weathering** Gossan.
- **Geochemical Signature** Cu, Zn, Co, Ag, Ni, Cr, Co/Ni >1.0, Au up to 4 ppm, Ag up to 60 ppm.

EXAMPLES

- Besshi, JAPN (Kanehira and Tatsumi, 1970)
- Motoyasu, JAPN (Yui, 1983)
- Kieslager, ASTR (Derkman and Klemm, 1977)
- Raul, PERU (Ripley and Ohmoto, 1977)

17. DESCRIPTIVE MODEL OF HOT-SPRING Au-Ag
Model 25a

by Byron R. Berger

DESCRIPTION Fine-grained silica and quartz in silicified breccia with gold, pyrite, and Sb and As sulfides (see fig. 105).

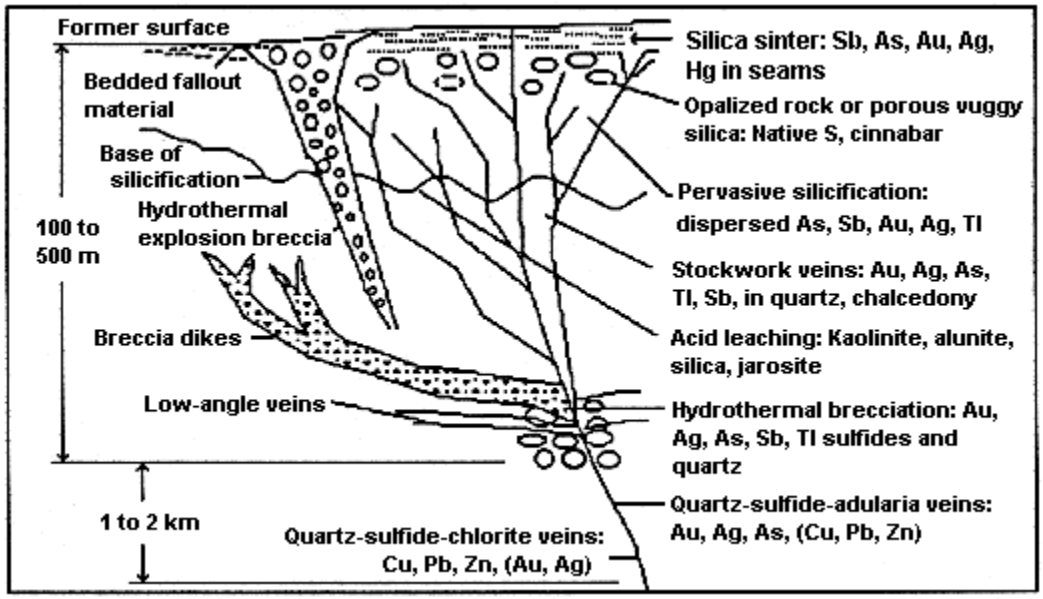


Figure 105. Cartoon cross section of hot-spring Au-Ag deposit.

GENERAL REFERENCE Berger (1985).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Rhyolite.
- **Textures** Porphyritic, brecciated.
- **Age Range** Mainly Tertiary and Quaternary.
- **Depositional Environment** Subaerial rhyolitic volcanic centers, rhyolite domes, and shallow parts of related geothermal systems.
- **Tectonic Setting(s)** Through-going fracture systems related to volcanism above subduction zones, rifted continental margins. Leaky transform faults.
- **Associated Deposit Types** Epithermal quartz veins, hot-spring Hg, placer Au.

DEPOSIT DESCRIPTION

- **Mineralogy** Native gold + pyrite + stibnite + realgar; or arsenopyrite ± sphalerite ± chalcopyrite ± fluorite; or native gold + Ag-selenide or tellurides + pyrite.
- **Texture/Structure** Crustified banded veins, stockworks, breccias (cemented with silica or uncemented). Sulfides may be very fine grained and disseminated in silicified rock.

- **Alteration** Top of bottom of system: chalcedonic sinter, massive silicification, stockworks and veins of quartz + adularia and breccia cemented with quartz, quartz + chlorite. Veins generally chalcedonic, some opal. Some deposits have alunite and pyrophyllite. Ammonium feldspar (buddingtonite) may be present.
- **Ore Controls** Through-going fracture systems, brecciated cores of intrusive domes; cemented breccias important carrier of ore.
- **Weathering** Bleached country rock, yellow limonites with jarosite and fine-grained alunite, hematite, goethite.
- **Geochemical Signature** Au + As + Sb + Hg + Tl higher in system, increasing Ag with depth, decreasing As + Sb + Tl + Hg with depth. Locally, NH4, W.

EXAMPLES

- McLaughlin, USCA (Averitt, 1945and Becker, 1888)
- Round Mountain, USNV (Tingley and Berger, 1985)
- Delamar, USID (Lindgren, 1900)

18. DESCRIPTIVE MODEL OF CREEDE EPITHERMAL VEINS
Model 25b

by Dan L. Mosier, Takeo Sato, Norman J Page, Donald A. Singer, and Byron R. Berger

APPROXIMATE SYNONYM Epithermal gold (quartz-adularia) alkali-chloride-type, polymetallic veins (see fig. 106).

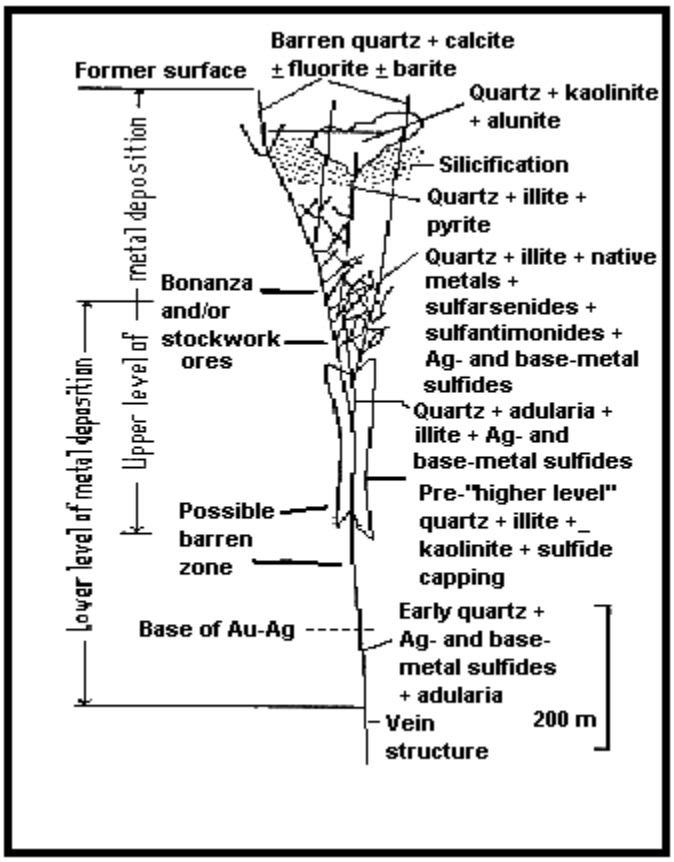


Figure 106. Cartoon cross section of typical Creede-type epithermal vein deposit.

DESCRIPTION Galena, sphalerite, chalcopyrite, sulfosalts, + tellurides + gold in quartz-carbonate veins hosted by felsic to intermediate volcanics. Older miogeosynclinal evaporites or rocks with trapped seawater are associated with these deposits.

GENERAL REFERENCES Buchanan (1980), Boyle (1979).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Host rocks are andesite, dacite, quartz latite, rhyodacite, rhyolite, and associated sedimentary rocks. Mineralization related to calc-alkaline or bimodal volcanism.
- **Textures** Porphyritic.
- **Age Range** Mainly Tertiary (most are 29-4 m.y.).

- **Depositional Environment** Bimodal and calc-alkaline volcanism. Deposits related to sources of saline fluids in prevolcanic basement such as evaporites or rocks with entrapped seawater.
- **Tectonic Setting(s)** Through-going fractures systems; major normal faults, fractures related to doming, ring fracture zones, joints associated with calderas. Underlying or nearby older rocks of continental shelf with evaporite basins, or island arcs that are rapidly uplifted.
- **Associated Deposit Types** Placer gold, epithermal quartz alunite Au, polymetallic replacement.

DEPOSIT DESCRIPTION

- **Mineralogy** Galena + sphalerite + chalcopyrite + copper sulfosalts + silver sulfosalts ± gold ± tellurides ± bornite ± arsenopyrite. Gangue minerals are quartz + chlorite ± calcite + pyrite + rhodochrosite + barite ± fluorite ± siderite ± ankerite ± sericite ± adularia ± kaolinite. Specularite and alunite may be present.
- **Texture/Structure** Banded veins, open space filling, lamellar quartz, stockworks, colloform textures.
- **Alteration** Top to bottom: quartz ± kaolinite + montmorillonite ± zeolites ± barite ± calcite; quartz + illite; quartz + adularia ± illite; quartz + chlorite; presence of adularia is variable.
- **Ore Controls** Through-going or anastomosing fracture systems. High-grade shoots where vein changes strike or dip and at intersections of veins. Hanging-wall fractures are particularly favorable.
- **Weathering** Bleached country rock, goethite, jarosite, alunite--supergene processes often important factor in increasing grade of deposit.
- **Geochemical Signature** Higher in system Au + As + Sb + Hg; Au + Ag + Pb + Zn + Cu; Ag + Pb + Zn, Cu + Pb + Zn. Base metals generally higher grade in deposits with silver. W + Bi may be present.

EXAMPLES

- Creede, USCO (Steven and Eaton, 1975; (Barton and others, 1977)
- Pachuca, MXCO (Geyne and others, 1963)
- Toyoha, JAPN (Yajima and Ohta, 1979)

19. DESCRIPTIVE MODEL OF EPITHERMAL QUARTZ-ALUNITE Au

Model 25e

by Byron R. Berger

APPROXIMATE SYNONYM Acid-sulfate, or enargite gold (Ashley, 1982).

DESCRIPTION Gold, pyrite, and enargite in vuggy veins and breccias in zones of high-alumina alteration related to felsic volcanism.

GENERAL REFERENCE Ashley (1982).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Volcanic: dacite, quartz latite, rhyodacite, rhyolite. Hypabyssal intrusions or domes.
- **Textures** Porphyritic.
- **Age Range** Generally Tertiary, but can be any age.
- **Depositional Environment** Within the volcanic edifice, ring fracture zones of calderas, or areas of igneous activity with sedimentary evaporites in basement.
- **Tectonic Setting(s)** Through-going fracture systems: keystone graben structures, ring fracture zones, normal faults, fractures related to doming, joint sets.
- **Associated Deposit Types** Porphyry copper, polymetallic replacement, volcanic hosted Cu-As-Sb. Pyrophyllite, hydrothermal clay, and alunite deposits.

DEPOSIT DESCRIPTION

- **Mineralogy** Native gold + enargite + pyrite + silver-bearing sulfosalts ± chalcopyrite ± bornite ± precious-metal tellurides ± galena ± sphalerite ± huebnerite. May have hypogene oxidation phase with chalcocite + covellite ± luzonite with late-stage native sulfur.
- **Texture/Structure** Veins, breccia pipes, pods, dikes; replacement veins often porous, and vuggy, with comb structure, and crustified banding.
- **Alteration** Highest temperature assemblage: quartz + alunite + pyrophyllite may be early stage with pervasive alteration of host rock and veins of these minerals; this zone may contain corundum, diaspore, andalusite, or zunyite. Zoned around quartz-alunite is quartz + alunite + kaolinite + montmorillonite; pervasive propylitic alteration (chlorite + calcite) depends on extent of early alunitization. Ammonium-bearing clays may be present.
- **Ore Controls** Through-going fractures, centers of intrusive activity. Upper and peripheral parts of porphyry copper systems.
- **Weathering** Abundant yellow limonite, jarosite, goethite, white argillization with kaolinite, fine-grained white alunite veins, hematite.
- **Geochemical Signature** Higher in system: Au + As + Cu; increasing base metals at depth. Also Te and (at El Indio) W.

EXAMPLES

- Goldfield, USNV (Ransome, 1909)
- Kasuga mine, JAPN (Taneda and Mukaiyama, 1970)
- El Indio, CILE (Walthier and others, 1982)
- Summitville, USCO (Perkins and Nieman, 1983)
- Iwato, JAPN (Saito and Sato, 1978)

20. DESCRIPTIVE MODEL OF SILICA-CARBONATE Hg Model 27c

by James J. Rytuba

APPROXIMATE SYNONYM New Almaden type.

DESCRIPTION Cinnabar at contact of serpentine and siltstone-graywacke above subduction-related thrust.

GENERAL REFERENCE Bailey (1964).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Serpentine, siltstone-graywacke.
- **Age Range** Tertiary.
- **Depositional Environment** Serpentinized intrusive rocks (sills and dikes) into siltstone, and graywacke and siltstone, fractures in altered serpentine.
- **Tectonic Setting(s)** Deposits occur in accreted terrane above subduction-related thrust fault.
- **Associated Deposit Types** Stibnite veins.

DEPOSIT DESCRIPTION

- **Mineralogy** Cinnabar, native Hg, other minor sulfides: pyrite, stibnite, chalcopyrite, sphalerite, galena, and bornite.
- **Texture/Structure** Replacement and minor veins.
- **Alteration** Replacement of serpentine by quartz and dolomite and minor hydrocarbons to form “silica-carbonate” rock.
- **Ore Controls** Contact of serpentine with siltstone especially where contact forms antiform. Ore primarily in silica-carbonate rock.
- **Geochemical Signature** Unknown, probably Hg + Sb + Cu + Zn.

EXAMPLES

- Red Devil USAK (Bundtzen and Miller, 2004)
- New Almaden, USCA (Bailey, 1964)

21. DESCRIPTIVE MODEL OF SIMPLE Sb DEPOSITS
Model 27d

by James D. Bliss and Greta J. Orris

APPROXIMATE SYNONYM Deposits of quartz-stibnite ore (Smirnov and others, 1983).

DESCRIPTION Stibnite veins, pods, and disseminations in or adjacent to brecciated or sheared fault zones.

GENERAL REFERENCES White (1962), Miller (1973).

GEOLOGICAL ENVIRONMENT

- **Rock Types** One or more of the following lithologies is found associated with over half of the deposits: limestone, shale (commonly calcareous), sandstone, and quartzite. Deposits are also found with a wide variety of other lithologies including slate, rhyolitic flows and tuffs, argillite, granodiorite, granite, phyllite, siltstone, quartz mica and chloritic schists, gneiss, quartz porphyry, chert, diabase, conglomerate, andesite, gabbro, diorite, and basalt.
- **Textures** Not diagnostic.
- **Age Range** Known deposits are Paleozoic to Tertiary.
- **Depositional Environment** Faults and shear zones.
- **Tectonic Setting(s)** Any orogenic area.
- **Associated Deposit Types** Stibnite-bearing veins, pods, and disseminations containing base metal sulfides + cinnabar + silver + gold + scheelite that are mined primarily for lead, gold, silver, zinc, or tungsten; low-sulfide Au-quartz veins; epithermal gold and gold-silver deposits; hot-springs gold; carbonate-hosted gold; tin-tungsten veins; hot-springs and disseminated mercury, gold-silver placers; infrequently with polymetallic veins and tungsten skarns.

DEPOSIT DESCRIPTION

- **Mineralogy** Stibnite + quartz ± pyrite ± calcite; minor other sulfides frequently less than 1 percent of deposit and included ± arsenopyrite ± sphalerite ± tetrahedrite ± chalcopyrite ± scheelite ± free gold; minor minerals only occasionally found include native antimony, marcasite, calaverite, berthierite, argentite, pyrargyrite, chalcocite, wolframite, richardite, galena, jamesonite; at least a third (and possibly more) of the deposits contain gold or silver. Uncommon gangue minerals include chalcedony, opal (usually identified to be -cristobalite by X-ray), siderite, fluorite, barite, and graphite.
- **Texture/Structure** Vein deposits contain stibnite in pods, lenses, kidney forms, pockets (locally); may be massive or occur as streaks, grains, and bladed aggregates in sheared or brecciated zones with quartz and calcite. Disseminated deposits contain streaks or grains of stibnite in host rock with or without stibnite vein deposits.
- **Alteration** Silicification, sericitization, and argillization; minor chloritization; serpentinization when deposit in mafic, ultramafic rocks.

- **Ore Controls** Fissures and shear zones with breccia usually associated with faults; some replacement in surrounding lithologies; infrequent open-space filling in porous sediments and replacement in limestone. Deposition occurs at shallow to intermediate depth.
- **Weathering** Yellow to reddish kermesite and white cerrantite or stibiconite (Sb oxides) may be useful in exploration; residual soils directly above deposits are enriched in antimony.
- **Geochemical Signature** Sb ± Fe ± As ± Au ± Hg; Hg ± W ± Pb ± Zn may be useful in specific cases.

EXAMPLES

- Wyrick Lode USAK (Bundtzen and others, 2004)
- Amphoe Phra Saeng, THLD (Gardner, 1967)
- Caracota, BLVA (U.S. Geological Survey Mineral Resources Data System)
- Coimadai Antimony Mine, AUVT (Fisher, 1952)
- Last Chance, USNV (Lawrence, 1963), Lake George, CNNB (Scratch and others, 1984)

22. DESCRIPTIVE MODEL OF SEDIMENTARY EXHALATIVE Zn-Pb
Model 31a

by Joseph A. Briskey

APPROXIMATE SYNONYMS Shale-hosted Zn-Pb; sediment-hosted massive sulfide Zn-Pb.

DESCRIPTION Stratiform basinal accumulations of sulfide and sulfate minerals interbedded with euxinic marine sediments form sheet- or lens-like tabular ore bodies up to a few tens of meters thick, and may be distributed through a stratigraphic interval over 1,000 m (see fig. 158).

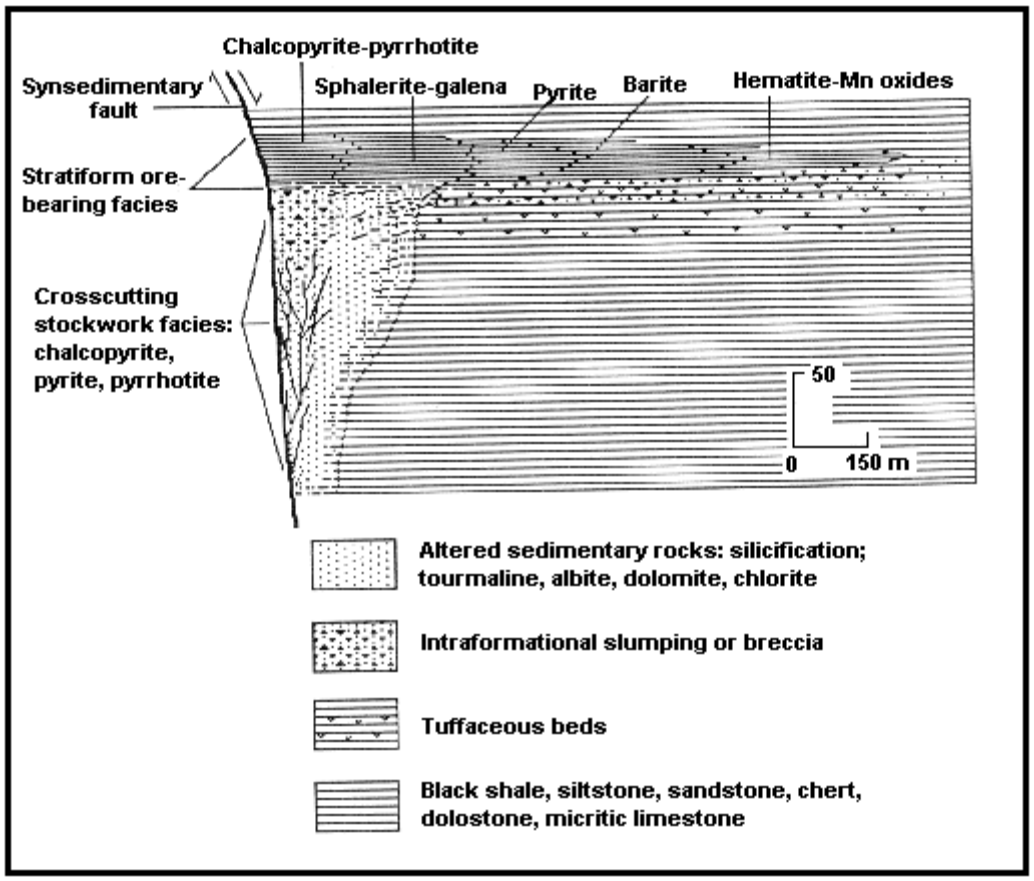


Figure 158. Cartoon cross section showing mineral zoning in sedimentary exhalative Zn-Pb deposits (modified from Large, 1980)

GENERAL REFERENCES Large (1980, 1981, 1983).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Euxinic marine sedimentary rocks including: black (dark) shale, siltstone, sandstone, chert, dolostone, micritic limestone, and turbidites. Local evaporitic sections

in contemporaneous shelf facies. Volcanic rocks, commonly of bimodal composition, are present locally in the sedimentary basin. Tuffites are the most common. Slump breccias, fan conglomerates, and similar deposits, as well as facies and thickness changes, are commonly associated with synsedimentary faults.

- **Textures** Contrasting sedimentary thicknesses and facies changes across hinge zones. Slump breccias and conglomerates near synsedimentary faults.
- **Age Range** Known deposits are Middle Proterozoic (1,700-1,400 m.y.); Cambrian to Carboniferous (530-300 m.y.).
- **Depositional Environment** Marine epicratonic embayments and intracratonic basins, with smaller local restricted basins (second- and third-order basins).
- **Tectonic Setting(s)** Epicratonic embayments and intracratonic basins are associated with hinge zones controlled by synsedimentary faults, typically forming half-grabens. Within these grabens (first-order basins), penecontemporaneous vertical tectonism forms smaller basins (second-order basins) and associated rises. Smaller third-order basins (tens of kilometers) within the second-order basins (102-105 km) are the morphological traps from the stratiform sulfides.
- **Associated Deposit Types** Bedded barite deposits.

DEPOSIT DESCRIPTION

- **Mineralogy** Pyrite, pyrrhotite, sphalerite, galena, sporadic barite and chalcopyrite, and minor to trace amounts of marcasite, arsenopyrite, bismuthinite, molybdenite, enargite, millerite, freibergite, cobaltite, cassiterite, valleriite, and melnikovite.
- **Texture/Structure** Finely crystalline and disseminated, monomineralic sulfide laminae are typical. Metamorphosed examples are coarsely crystalline and massive.
- **Alteration** Stockwork and disseminated sulfide and alteration (silicification, tourmalization, carbonate depletion, albitization, chloritization, dolomitization) minerals possibly representing the feeder zone of these deposits commonly present beneath or adjacent to the stratiform deposits. Some deposits have no reported alteration. Celsian, Ba-muscovite, and ammonium clay minerals may be present.
- **Ore Controls** Within larger fault-controlled basins, small local basins form the morphological traps that contain the stratiform sulfide and sulfate minerals. The faults are synsedimentary and serve as feeders for the stratiform deposits. Euxinic facies.
- **Weathering** Surface oxidation may form large gossans containing abundant carbonates, sulfates, and silicates of lead, zinc, and copper.
- **Geochemical Signature** Metal zoning includes lateral Cu-Pb-Zn-Ba sequence extending outward from feeder zone; or a vertical Cu-Zn-Pb-Ba sequence extending upward. NH3 anomalies may be present. Exhalative chert interbedded with stratiform sulfide and sulfate minerals; peripheral hematite-chert formations. Local (within 2 km) Zn, Pb, and Mn haloes. Highest expected background in black shales: Pb = 500 ppm; Zn = 1,300 ppm; Cu = 750 ppm; Ba = 1,300 ppm; in carbonates: Pb = 9 ppm; Zn = 20; Cu = 4 pmm; Ba = 10.

EXAMPLES

- Sullivan mine, CNBC (Hamilton and others, 1982)
- Meggen mine, GRMY (Krebs, 1981)
- Navan, Silvermines, Tynagh, IRLD (Boyce and others, 1983; Taylor, 1984)

23. DESCRIPTIVE MODEL OF BEDDED BARITE
Model 31

by Greta J. Orris

APPROXIMATE SYNONYM Stratiform barite.

DESCRIPTION Stratiform deposits of barite interbedded with dark-colored cherty and calcareous sedimentary rocks.

GEOLOGICAL ENVIRONMENT

- **Rock Types** Generally dark-colored chert, shale, mudstone, limestone or dolostone. Also with quartzite, argillite, and greenstone.
- **Age Range** Proterozoic and Paleozoic.
- **Depositional Environment** Epicratonic marine basins or embayments (often with smaller local restricted basins).
- **Tectonic Setting(s)** Some deposits associated with hinge zones controlled by synsedimentary faults.
- **Associated Deposit Types** Sedimentary exhalative Zn-Pb (see fig. 158).

DEPOSIT DESCRIPTION

- **Mineralogy** Barite ± minor witherite ± minor pyrite, galena, or sphalerite. Barite typically contains several percent organic matter plus some H2S in fluid inclusions.
- **Texture/Structure** Stratiform, commonly lensoid to poddy; ore laminated to massive with associated layers of barite nodules or rosettes; barite may exhibit primary sedimentary features. Small country rock inclusions may show partial replacement by barite.
- **Alteration** Secondary barite veining; weak to moderate sericitization has been reported in or near some deposits in Nevada.
- **Ore Controls** Deposits are localized in second- and third-order basins.
- **Weathering** Indistinct, generally resembling limestone or dolostone; occasionally weathered-out rosettes or nodules.
- **Geochemical Signature** Ba; where peripheral to sediment-hosted Zn-Pb, may have lateral (Cu)-Pb-Zn-Ba zoning or regional manganese haloes. High organic C content.

EXAMPLES

- Meggen, GRMY (Krebs, 1981)
- Magnet Cove, USAR (Scull, 1958)
- Northumberland, USNV (Shawe and others, 1969)

24. DESCRIPTIVE MODEL OF SOUTHEAST MISSOURI Pb-Zn Model 32a

by Joseph A. Briskey

SYNONYMS Carbonate-hosted Pb-Zn; Mississippi Valley type.

DESCRIPTION Stratabound, carbonate-hosted deposits of galena, sphalerite, and chalcopyrite in rocks having primary and secondary porosity, commonly related to reefs on paleotopographic highs (see fig. 166). (For grade-tonnage model see Appalachian Zn deposit model.)

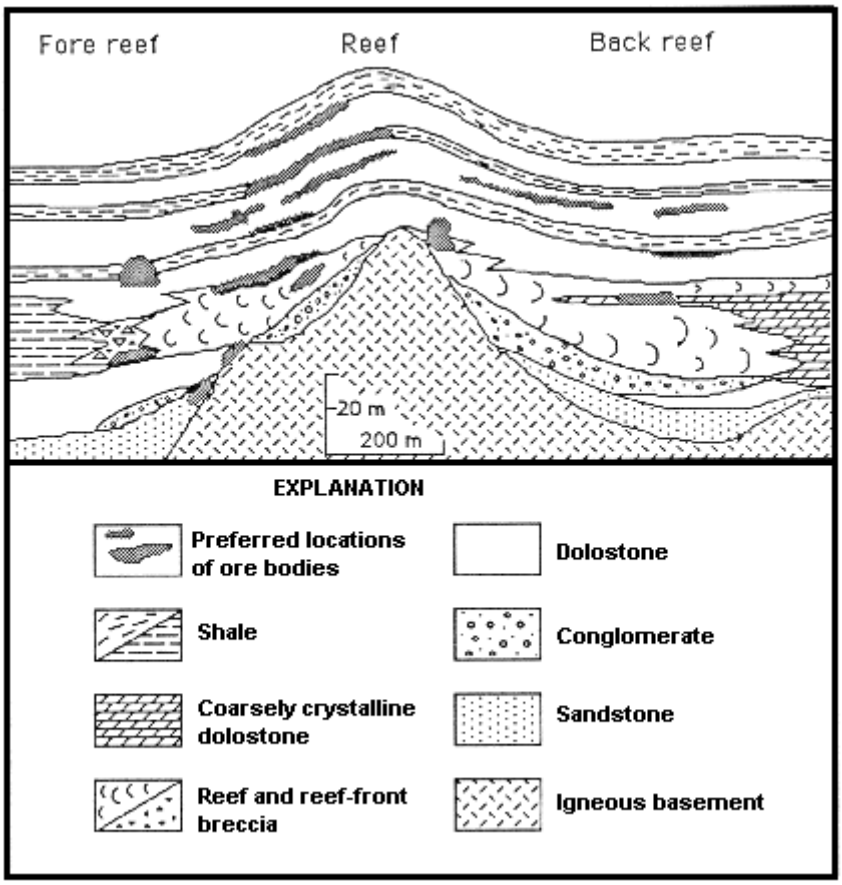


Figure 166. Cartoon cross section of a southeast Missouri Pb-Zn deposit (modified from Evans, 1977).

GENERAL REFERENCES Snyder and Gerdemann (1968), Thacker and Anderson (1977).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Dolomite; locally ore bodies also occur in sandstone, conglomerate, and calcareous shales.

- **Textures** Calcarenites are most common lithology. Tidalites, stromatolite finger reefs, reef breccias, slump breccias; oolites, crossbedding, micrites.
- **Age Range** Known deposits are in Cambrian to Lower Ordovician strata.
- **Depositional Environment** Host rocks are shallow-water marine carbonates, with prominent facies control by reefs growing on flanks of paleotopographic basement highs. Deposits commonly occur at margins of clastic basins.
- **Tectonic Setting(s)** Stable cratonic platform.
- **Associated Deposit Types** Precambrian volcanic-hosted magnetite; Ba-Pb deposits occur higher in the Cambrian section.

DEPOSIT DESCRIPTION

- **Mineralogy** Galena, sphalerite, chalcopyrite, pyrite, marcasite. Minor siegenite, bornite, tennantite, barite, bravoite, digenite, covellite, arsenopyrite, fletcherite, adularia, pyrrhotite, magnetite, millerite, polydymite, vaesite, djurleite, chalcocite, anilite, and enargite in order of abundance. Dolomite and minor quartz.
- **Texture/Structure** Early fine-grained replacement; main stage coarse-grained replacement and vuggy or colloform open space filling. Hypogene leaching of galena is common.
- **Alteration** Regional dolomitization; latter brown, ferroan, and bitumen-rich dolomite; extensive carbonate dissolution and development of residual shale; mixed-layer illite-chlorite altered to 2M muscovite; dickite and kaolinite in vugs; very minor adularia.
- **Ore Controls** Open-space filling and replacement, most commonly at the interface between gray and tan dolomite, but also in traps at any interface between permeable and impermeable units. Any porous units may host ore: sandstone pinchouts; dissolution collapse breccias; faults; permeable
- reefs; slump, reef, and fault breccias; coarsely crystalline dolostone.
- **Geochemical Signature** Regional anomalous amounts of Pb, Zn, Cu, Mo, Ag, Co, and Ni in insoluble residues. Zoning is roughly Cu (± Ni ± Co)-Pb-Zn-iron sulfide going up section; ores contain about 30 ppm Ag; inconsistent lateral separation of metal zones. Background for carbonates: Pb = 9 ppm; Zn = 20; Cu = 4.

EXAMPLES

- Reef Ridge USAK (Bundtzen, 1999)
- Viburnum subdistrict, USMO (Economic Geology 1977; Heyl, 1982)

25. DESCRIPTIVE MODEL OF LOW-SULFIDE Au-QUARTZ VEINS
Model 36a

by Byron R. Berger

APPROXIMATE SYNONYMS Mesothermal quartz veins, Mother Lode veins.

DESCRIPTION Gold in massive persistent quartz veins mainly in regionally metamorphosed volcanic rocks and volcanic sediments.

GEOLOGICAL ENVIRONMENT

- **Rock Types** Greenstone belts; oceanic metasediments: regionally metamorphosed volcanic rocks, graywacke, chert, shale, and quartzite. Alpine gabbro and serpentine. Late granitic batholiths.
- **Age Range** Precambrian to Tertiary.
- **Depositional Environment** Continental margin mobile belts, accreted margins. Veins age generally post-metamorphic and locally cut granitic rocks.
- **Tectonic Setting(s)** Fault and joint systems produced by regional compression.
- **Associated Deposit Types** Placer Au-PGE, kuroko massive sulfide, Homestake gold.

DEPOSIT DESCRIPTION

- **Mineralogy** Quartz + native gold + pyrite + galena + sphalerite + chalcopyrite + arsenopyrite ± pyrrhotite. Locally tellurides ± scheelite ± bismuth ± tetrahedrite ± stibnite ± molybdenite ± fluorite. Productive quartz is grayish or bluish in many instances because of fine-grained sulfides. Carbonates of Ca, Mg, and Fe abundant.
- **Texture/Structure** Saddle reefs, ribbon quartz, open-space filling textures commonly destroyed by vein deformation.
- **Alteration** Quartz + siderite and (or) ankerite + albite in veins with halo of carbonate alteration. Chromian mica + dolomite and talc + siderite in areas of ultramafic rocks. Sericite and disseminated arsenopyrite + rutile in granitic rocks.
- **Ore Controls** Veins are persistent along regional high-angle faults, joint sets. Best deposits overall in areas with greenstone. High-grade ore shoots locally at metasediment-serpentine contacts. Disseminated ore bodies where veins cut granitic rocks.
- **Weathering** Abundant quartz chips in soil. Gold may be recovered from soil by panning.
- **Geochemical Signature** Arsenic best pathfinder in general; Ag, Pb, Zn, Cu.

EXAMPLES

- Terra North USAK (Hudson and Millholland, 2002)
- Grass Valley, USCA (Lindgren, 1896)
- Mother Lode, USCA (Knopf, 1929)
- Ballarat Goldfield,
  Victoria, AUVT (Baragwanath, 1953)
- Goldfields of Nova Scotia, CNNS (Malcolm, 1929)

26. DESCRIPTIVE MODEL OF PLACER Au-PGE
Model 39a

by Warren E. Yeend

DESCRIPTION Elemental gold and platinum-group alloys in grains and (rarely) nuggets in gravel, sand, silt, and clay, and their consolidated equivalents, in alluvial, beach, eolian, and (rarely) glacial deposits (see fig. 195).

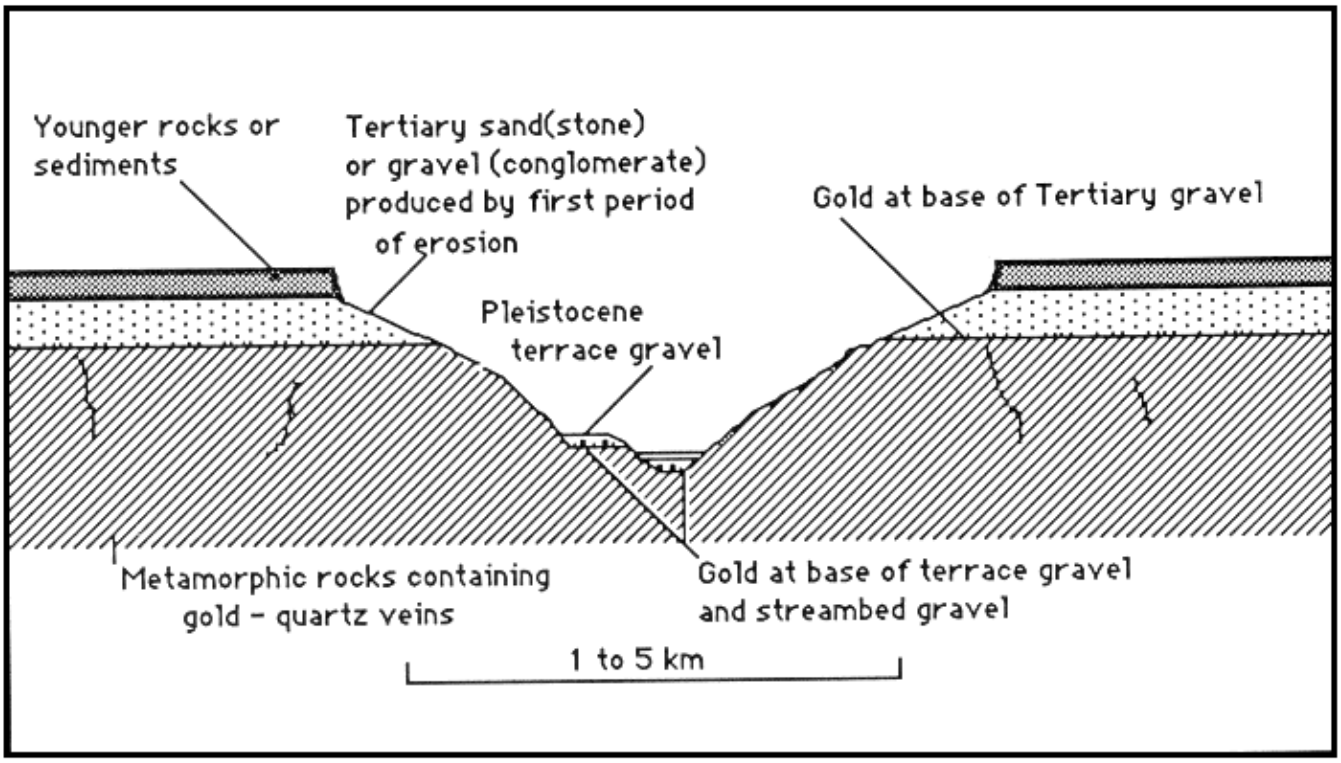


Figure 195. Cartoon cross section showing three stages of heavy mineral concentration typical of placer Au-PGE deposits.

GENERAL REFERENCES Boyle (1979), Wells (1973), Lindgren (1911).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Alluvial gravel and conglomerate with white quartz clasts. Sand and sandstone of secondary importance.
- **Textures** Coarse clastic.
- **Age Range** Cenozoic. Older deposits may have been formed but their preservation is unlikely.
- **Depositional Environment** High-energy alluvial where gradients flatten and river velocities lessen, as at the inside of meanders, below rapids and falls, beneath boulders, and in vegetation mats. Winnowing action of surf caused Au concentrations in raised, present, and submerged beaches.

- **Tectonic Setting(s)** Tertiary conglomerates along major fault zones, shield areas where erosion has proceeded for a long time producing multicycle sediments; high-level terrace gravels.
- **Associated Deposit Types** Black sands (magnetite, ilmenite, chromite); yellow sands (zircon, monazite). Au placers commonly derive from various Au vein-type deposits as well as porphyry copper, Cu skarn, and polymetallic replacement deposits.

DEPOSIT DESCRIPTION

- **Mineralogy** Au, platinum-iron alloys, osmium-iridium alloys; gold commonly with attached quartz, magnetite, or ilmenite.
- **Texture/Structure** Flattened, rounded edges, flaky, flour gold extremely fine grained flakes; very rarely equidimensional nuggets.
- **Ore Controls** Highest Au values at base of gravel deposits in various gold “traps” such as natural riffles in floor of river or stream, fractured bedrock, slate, schist, phyllite, dikes, bedding planes, all structures trending transverse to direction of water flow. Au concentrations also occur within gravel deposits above clay layers that constrain the downward migration of Au particles.
- **Geochemical Signature** Anomalous high amounts of Ag, As, Hg, Sb, Cu, Fe, S, and heavy minerals magnetite, chromite, ilmenite, hematite, pyrite, zircon, garnet, rutile. Au nuggets have decreasing Ag content with distance from source.

EXAMPLES

- Otter Creek USAK (Bundtzen and others, 2004)
- Ganes Creek USAK (Bundtzen and others, 2004)
- Sierra Nevada, USCA (Lindgren, 1911; Yeend, 1974)
- Victoria, AUVT (Knight, 1975)

27. DESCRIPTIVE MODEL OF SHORELINE PLACER Ti
Model 39c

by Eric R. Force

DESCRIPTION Ilmenite and other heavy minerals concentrated by beach processes and enriched by weathering.

GENERAL REFERENCE Force (1976).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Well-sorted medium- to fine-grained sand in dune, beach, and inlet deposits commonly overlying shallow marine deposits.
- **Age Range** Commonly Miocene to Holocene, but may be any age.
- **Depositional Environment** Stable coastal region receiving sediment from deeply weathered metamorphic terranes of sillimanite or higher grade.
- **Tectonic Setting(s)** Margin of craton. Crustal stablity during deposition and preservation of deposits.

DEPOSIT DESCRIPTION

- **Mineralogy** Altered (low Fe) ilmenite ± rutile ± zircon. Trace of monazite, magnetite, and pyroxene; amphibole rare or absent. Quartz greatly exceeds feldspar.
- **Texture/Structure** Elongate “shoestring” ore bodies parallel to coastal dunes and beaches.
- **Ore Controls** High-grade metamorphic source; stable coastline with efficient sorting and winnowing; weathering of beach deposits.
- **Weathering** Leaching of Fe from ilmenite and destruction of labile heavy minerals results in residual enrichment of deposits.
- **Geochemical and Geophysical Signature** High Ti, Zr, REE, Th and U. Gamma radiometric anomalies resulting from monazite content. Induced-polarization anomalies from ilmenite.

EXAMPLES

- Green Cove Springs, USFL (Perkle and others, 1974)
- Trail Ridge, USFL (Perkle and Yoho, 1970)
- Lakehurst, USNJ (Markiewicz, 1969)
- Eneabba, AUWA (Lissiman and Oxenford, 1973)

28. DESCRIPTIVE MODEL OF ALLUVIAL PLACER Sn
Model 39e

by Bruce L. Reed

DESCRIPTION Cassiterite and associated heavy minerals in silt- to cobble-size nuggets concentrated by the hydraulics of running water in modern and fossil streambeds.

GENERAL REFERENCES Hosking (1974), Taylor (1979), Sainsbury and Reed (1973).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Alluvial sand, gravel, and conglomerate indicative of rock types that host lode tin deposits.
- **Textures** Fine to very coarse clastic.
- **Age Range** Commonly late Tertiary to Holocene, but may be any age.
- **Depositional Environment** Generally moderate to high-level alluvial, where stream gradients lie within the critical range for deposition of cassiterite (for instance, where stream velocity is sufficient to result in good gravity separation but not enough so the channel is swept clean). Stream placers may occur as offshore placers where they occupy submerged valleys or strandlines.
- **Tectonic Setting(s)** Alluvial deposits derived from Paleozoic to Cenozoic accreted terranes or stable cratonic foldbelts that contain highly evolved granitoid plutons or their extrusive equivalents (see Model 14b, geochemical signature). Tectonic stability during deposition and preservation of alluvial deposits.
- **Associated Deposit Types** Alluvial gravels may contain by-product ilmenite, zircon, monazite, and, where derived from cassiterite-bearing pegmatites, columbite-tantalite. Economic placers are generally within a few (<8) kilometers of the primary sources. Any type of cassiterite-bearing tin deposit may be a source. The size and grade of the exposed source frequently has little relation to that of the adjacent alluvial deposit.

DEPOSIT DESCRIPTION

- **Mineralogy** Cassiterite; varying amounts of magnetite, ilmenite, zircon, monazite, allanite, xenotime, tourmaline, columbite, garnet, rutile, and topaz may be common heavy resistates.
- **Texture/Structure** Cassiterite becomes progressively coarser as the source is approached; euhedral crystals indicate close proximity to primary source. Where a marine shoreline intersects or transgresses a stream valley containing alluvial cassiterite the shoreline placers normally have a large length-to-width ratio.
- **Ore Controls** Cassiterite tends to concentrate at the base of stream gravels and in traps such as natural riffles, potholes, and bedrock structures transverse to the direction of water flow. The richest placers lie virtually over the primary source. Streams that flow parallel to the margin of a tin-bearing granite are particularly favorable for placer tin accumulation.
- **Geochemical Signature** Anomalously high amounts of Sn, As, B, F, W, Be, W, Cu, Pb, Zn. Panned concentrate samples are the most reliable method for detection of alluvial cassiterite.

EXAMPLES

- Southeast Asian tin fields (Hosking, 1974)(Newell, 1971) (Simatupang and others, 1974) (Westerveld, 1937)

29. DESCRIPTIVE MODEL OF FELSIC-DIKE-HOSTED QUARTZ VEINS WITH Au
Model 99

by Bundtzen and Miller

APPROXIMATE SYNONYM Porphyry Cu-Au Sillitoe (1979); Cox and Singer (1992)

DESCRIPTION Quartz+/- carbonate veinlet networks with Au associated with sulfides related to hypabyssal intrusions in sedimentary terranes.

GEOLOGICAL ENVIRONMENT

- **Rock Types** Rhyolitic to rhyodacitic and commonly porphyritic dike complexes
- **Textures** Fine- to medium-grained equigranular and porphyroaphanitic.
- **Age Range** Late Cretaceous to Early Tertiary
- **Depositional Environment** Veinlet networks deposited within fracture systems in felsic intrusive rocks.
- **Tectonic Setting(s)** Continental margin and island-arc volcanic-plutonic belts.
- **Associated Deposit Types** Porphyry Cu-Au, polymetallic veins, Placer Au.

DEPOSIT DESCRIPTION

- **Mineralogy** Native Au with arsenopyrite, pyrite, and typically younger stibnite. Minor cinnabar and graphite. Crystalline realgar, orpiment, and rare native arsenic. Gold is refractory within the arsenopyrite.
- **Texture/Structure** Veinlet systems fill extensional fractures within igneous rocks in structurally complex areas.
- **Alteration** The main alteration processes include sericitization, carbonatization, and sulfidation. Ankerite, dolomite, and illite present.
- **Ore Controls** Complexly faulted areas: extensional fracture systems formed between major strike –slip faults. Areas of high permeability: intrusive contacts, and fault intersections.
- **Weathering** Minor limonite and Mn-oxide stains.
- **Geochemical Signature** As, Hg, Sb, Cu.

EXAMPLES

- Donlin Creek (Goldfarb and others, 2003; Bundtzen and Miller, 1997)
- Independence (Bundtzen and Miller, 1997)

30. DESCRIPTIVE MODEL OF PLUTONIC-HOSTED Cu – Au POLYMETALLIC STOCKWORK, AND VEIN DEPOSITS
Model 100
by Bundtzen and Miller

APPROXIMATE SYNONYM alkalic porphyry copper-gold model of Lowell and Guilbert (1970), deposit models 20c (porphyry Cu-Au), 18b (Cu skarn), and 22c (polymetallic veins) of Cox and Singer (1992).

DESCRIPTION Granodiorite sills, dikes, and small stocks containing Cu – Au in veins and stockworks.

GENERAL REFERENCES Bundtzen and Miller (1997); Miller and others (2005).

GEOLOGICAL ENVIRONMENT

- **Rock Types** Granite, alaskite, and minor granodiorite.
- **Textures** Intrusive rocks are porphyritic with fine- to medium-grained aplitic
- groundmass.
- **Age Range** Late Cretaceous – early Tertiary (66 to 71 ma)
- **Depositional Environment** Intrude and overlie lithotectonic terranes and Cretaceous basin-fill sequences. Veins and stockworks occur in intrusive rocks or immediately adjacent Kuskokwim Group sedimentary rocks.
- **Tectonic Setting(s)** Intrude and overlie lithotectonic terranes and Cretaceous basin-fill sequences.
- **Associated Deposit Types** Porphyry Cu-Mo; Porphyry Cu-Au; gold placers.

DEPOSIT DESCRIPTION

- **Mineralogy** Arsenopyrite, pyrite,stibnite, complex arsenate-sulfosalts, free gold, minor cinnabar, and rare cassiterite. Gold occurs mostly in lattice structures of pyrite and arsenopyrite and hence refractory.
- **Texture/Structure** Localized in high-angle fault and shear zones.
- **Alteration** Weak argillic, phyllic, silicic, potasic alteration, and dickite
- **Ore Controls** High-angle faults and shear zones
- **Weathering** Minor gossan and bleaching in oxidized zones
- Low.
- **Geochemical Signature** Elevated levels of Au, Ag, As, Sb, and Hg. Locally elevated levels of B, Cu, Pb, Sn, W, and Zn.

EXAMPLES

- Chicken Mountain (Bundtzen and Miller, 1997, 2005)
- Golden Horn (Bundtzen and Miller, 1997)

APPENDIX B

Alphabetical Listing of Mines, Prospects, and Mineral Occurrences

BERING SEA – WESTERN INTERIOR PLANNING AREA

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
ALDER CREEK	20740019	62.6963	-155.7129	S30N34W18	PAST PRODUCER	Placer Au-PGE	Medium	RARE EARTH Zr Ti
ALICE AND BESSIE; PARKS PROSPECT	20820002	61.79458	-157.34982	S20N45W25	PAST PRODUCER	Silica-carbonate Hg	Low	Hg Sb
AMERICAN CREEK	20730095	62.01929	-158.86239	S22N52W05	MINERAL LOCATION	Placer Au-PGE	Low	Au
AMMILINE	20820041	61.79848	-157.3488	S20N45W25	EXP PROSPECT	Silica-carbonate Hg	Low	Hg
ANCHOR	20830025	61.42252	-154.81249	S16N31W34	RAW PROSPECT	Placer Au-PGE	Low	Au
ANVIK RIVER PLACER	20630006	63.46456	-160.29049	K23S08W30	MINERAL LOCATION	Placer Au-PGE	Low	PGM
ANVIL CREEK	20640012	63.12672	-156.50413	K27S12E23	PRODUCER	Placer Au-PGE	Medium	Ag Au Hg
ARNIE	20910038	60.23609	-159.40725	S02N58W29	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Low	Au Ag As
ARNOLD PROSPECT	20810011	61.83192	-161.90014	S20N70W12	EXP PROSPECT	Polymetallic veins	Medium	Ag Pb Cu W Au Mo
BABEL CIRQUE	20830035	61.78267	-154.26892	S20N28W36	MINERAL LOCATION	Polymetallic replacement deposits	Low	Cu Pb Ag Zn
BABYBASKET	20650046	63.0994	-153.82228	K27S26E36	RAW PROSPECT	Cu skarn deposits	Low	Cu Zn Ag Pb
BADNEWS	20740044	62.29918	-153.76665	S26N24W32	RAW PROSPECT	Zn-Pb skarn deposits	Medium	Cu Zn Pb Ag Au
BAROMETER	20820004	61.7715	-157.3392	S19N44W06	PAST PRODUCER	Silica-carbonate Hg	Low	Hg Sb Au As
BEAR CREEK	20640003	63.57049	-156.14821	K22S14E22	PAST PRODUCER	Placer Au-PGE	Medium	Ag Au
BEAR PASS	20650066	63.47041	-154.09133	K23S25E29	MINERAL LOCATION	Southeast Missouri Pb-Zn	Medium	Zn
BEAVER	20650068	63.443	-154.121	K24S25E06	EXP PROSPECT	Southeast Missouri Pb-Zn	Medium	Zn Pb
BEAVER CREEK	20640053	63.55788	-156.13918	K22S14E27	PAST PRODUCER	Placer Au-PGE	Medium	Au Ag

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
BEDROCK CREEK	20640029	63.04492	-156.62041	K28S12E20	PAST PRODUCER	Placer Au-PGE	Low	Au
BEK 29-56	20830004	61.51796	-153.48696	S17N23W32	RAW PROSPECT	Polymetallic veins	Low	Cu
BESSIE-GRANITE CR (TRIB KASIGLUK)	20910012	60.57981	-160.55227	S06N64W29	EXP PROSPECT	Placer Au-PGE	Low	Au
BIG GATE	20650070	63.4374	-154.15833	K24S24E01	OTHER	Southeast Missouri Pb-Zn	Medium	Zn Pb
BIRCH GULCH	20650023	63.20932	-154.76615	K26S21E25	PAST PRODUCER	Placer Au-PGE	Medium	Au Bi
BIRCH-HOLMES GULCH RIDGE	20650029	63.21216	-154.77176	K26S21E25	EXP PROSPECT	Undetermined	Low	U
BISMARK CREEK	20730070	62.42261	-157.02698	S27N42W14	RAW PROSPECT	Sn-polymetallic veins	Medium	Ag Sn As Cd Zn Cu Pb
BLACK CREEK MINE	20730077	62.44421	-157.93823	S27N47W11	PAST PRODUCER	Placer Au-PGE	Low	Au W Cr Ag PGE Pb
BLACK MOUNTAIN	20810010	61.79228	-159.30936	S20N55W30	EXP PROSPECT	Polymetallic veins	Low	Ag Sb Au
BLACK WHALE	20920012	60.84223	-158.89962	S09N54W29	EXP PROSPECT	Silica-carbonate Hg	Low	Hg
BLUE EAGLE 1-125	20820032	60.9535	-158.725	S11N53W28	EXP PROSPECT	Placer Au-PGE	Low	Au
BOBTAIL CREEK	20810015	61.90655	-161.4095	S21N66W07	PAST PRODUCER	Placer Au-PGE	Low	Au Hg
BOGUS CREEK	20810007	61.1927	-160.0214	S13N60W27	EXP PROSPECT	Placer Au-PGE	Low	Au
BOOB CREEK	20640001	63.32991	-157.00432	K25S10E08	PRODUCER	Placer Au-PGE	High	Hg Au Cr PGE Ag Sn
BOOSHU CAMP LODE	20610003	63.45706	-171.82579	K23S68W32	MINERAL LOCATION	Porphyry Cu-Mo	Medium	Cu Mo
BOULDER CREEK	20650010	63.3355	-154.62593	K25S22E11	EXP PROSPECT	Placer Au-PGE	Low	Au
BOWSER CREEK - HEADWATERS	20740116	62.19438	-153.72022	S24N24W05	EXP PROSPECT	Polymetallic veins	Medium	Ag Cu Zn Pb
BOWSER CREEK - MAIN	20740020	62.184	-153.69941	S24N24W09	EXP PROSPECT	Zn-Pb skarn deposits	High	Zn Ag Pb Cu Au

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
BOWSER CREEK - NORTHEAST	20740117	62.19038	-153.69222	S24N24W04	EXP PROSPECT	Zn-Pb skarn deposits	Medium	Ag Au Zn Pb
BRECCIA	20830030	61.41964	-153.58145	S15N24W04	RAW PROSPECT	Polymetallic veins	Medium	Ag Au Cu Bi
BRINK (MOLYBDENUM MOUNTAIN)	20810009	61.80528	-159.25108	S20N55W21	EXP PROSPECT	Porphyry Mo, low-F	Low	Mo
BROKEN SHOVEL	20920032	60.80335	-158.84639	S08N55W12	PAST PRODUCER	Silica-carbonate Hg	Low	Hg
BROKEN SHOVEL PROSPECT	20730057	62.6129	-157.17301	S29N42W09	EXP PROSPECT	Plutonic-hosted Cu-Au polymetallic	High	Pb Cu Ag Sb Au
BUCKSTOCK MOUNTAINS (HILL 2170)	20820053	61.17836	-158.84031	S13N53W31	MINERAL LOCATION	Felsic-dike-hosted qtz veinlets w/Au	Medium	Au
BUCKSTOCK MOUNTAINS (HILL 2280)	20820054	61.1677	-158.7441	S13N53W35	MINERAL LOCATION	Felsic-dike-hosted qtz veinlets w/Au	Low	Au
BUCKSTOCK RIVER TRIBUTARY	20820016	61.21767	-158.73813	S13N53W14	EXP PROSPECT	Placer Au-PGE	Low	Au
BUSTER CREEK	20810017	61.899	-161.446	S21N66W19	PAST PRODUCER	Placer Au-PGE	High	Au
BUTTE CREEK	20640034	63.50638	-156.15797	K23S14E09	PAST PRODUCER	Placer Au-PGE	Low	Au
CAIRN MOUNTAIN	20830024	61.20091	-155.30658	S13N34W24	RAW PROSPECT	Placer Au-PGE	Low	Au
CALIFORNIA CREEK	20640047	61.89153	-156.34476	K28S13E14	MINERAL LOCATION	Placer Au-PGE	Low	Au Ag
CALIFORNIA CREEK	20820014	63.05787	-157.59683	S21N45W19	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Low	Au Ag
CANDLE CREEK	20740003	62.87536	-155.81235	S33N35W17	PAST PRODUCER	Placer Au-PGE	High	Hg Au
CANDLE CREEK HEADWATERS	20740101	62.86236	-155.83635	S32N35W15	RAW PROSPECT	Plutonic-hosted Cu-Au polymetallic	Low	Au Ag Cu Sb Hg
CANDLE HILLS EAST	20740102	62.85436	-155.80135	S32N35W14	RAW PROSPECT	Polymetallic veins	Low	Ag Cu Pb Zn
CANDLE HILLS WEST	20740103	62.86636	-155.86335	S32N35W16	RAW PROSPECT	Polymetallic veins	Low	Cu Ag

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
CANYON CREEK	20650007	63.4434	-154.38433	K24S23E02	MINERAL LOCATION	Placer Au-PGE	Medium	Au
CANYON CREEK	20910006	60.1783	-159.97293	S01N62W11	PAST PRODUCER	Placer Au-PGE	High	Au Ag Hg PGE
CARL CREEK TRIBUTARY	20740106	62.80936	-155.91235	S31N35W06	PAST PRODUCER	Placer Au-PGE	Low	Au Ag
CENTRAL CREEK	20820015	61.88958	-157.94017	S21N47W20	PAST PRODUCER	Placer Au-PGE	Low	Au
CHANUK CREEK	20930029	60.5663	-155.77624	S06N37W33	EXP PROSPECT	Placer Au-PGE	Low	Au
CHEENEETNUK RIVER GOSSAN	20740087	62.07234	-155.1073	S23N32W23	RAW PROSPECT	Polymetallic replacement deposits	Low	Cu Ag
CHEENEETNUK RIVER HILL 2620	20740083	62.03334	-155.23031	S23N33W36	RAW PROSPECT	Polymetallic replacement deposits	Low	Cu Mo Zn
CHEENEETNUK RIVER HILL 2742	20740084	62.06434	-155.20931	S23N32W01	RAW PROSPECT	Polymetallic replacement deposits	Low	Cu Ag
CHEENEETNUK RIVER SOUTH TRIB HILL	20740088	62.09235	-154.86928	S23N31W12	RAW PROSPECT	Polymetallic replacement deposits	Low	Zn Ni
CHEENEETNUK RIVER UNNAMED	20740086	62.06534	-155.1223	S23N32W22	RAW PROSPECT	Polymetallic replacement deposits	Low	Cu Ag
CHEENEETNUK RIVER WEST BANK	20740085	62.05334	-155.1343	S23N32W27	EXP PROSPECT	Polymetallic replacement deposits	Low	Ag Cu Mo
CHEENEETNUK RIVER WHITE MTNS.	20740089	62.17235	-154.93028	S24N31W15	RAW PROSPECT	Polymetallic replacement deposits	Low	Pb Zn Ag Cu
CHICKEN CREEK (lower)	20730002	62.33959	-157.9649	S26N47W15	PAST PRODUCER	Placer Au-PGE	Low	Cr Hg Ag Sb Au RARE EARTH
CHICKEN CREEK DOME	20730025	62.38042	-157.96351	S27N47W34	EXP PROSPECT	Plutonic-hosted Cu-Au polymetallic	Low	Au Sb Zn Ag RARE EARTH Hg Cr
CHICKEN MOUNTAIN	20730026	62.38511	-157.97405	S27N47W34	DEVEL DEPOSIT	Plutonic-hosted Cu-Au polymetallic	High	Hg Sb Au W F Ag
CHIP LOY	20740016	62.16746	-154.38293	S24N28W15	EXP PROSPECT	Synorogenic-synvolcanic Ni-Cu	Medium	Ni Cu Co Ag Au Fe
CINNABAR CHIEF	20820033	61.7493	-157.45237	S19N45W09	PAST PRODUCER	Silica-carbonate Hg	Low	Hg

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
CINNABAR CREEK LODE	20920001	60.79915	-158.85568	S08N55W12	PAST PRODUCER	Silica-carbonate Hg	Low	Hg Sb
CINNABAR CREEK PLACER	20920002	60.79383	-158.86588	S08N54W12	MINERAL LOCATION	Silica-carbonate Hg	Low	Hg
CIRQUE OCCURRENCE	20730049	62.84521	-156.97718	S32N41W21	EXP PROSPECT	Sn-polymetallic veins	Low	Cu Pb Sn Ag Bi Sb
CLOUD PROSPECT	20640049	63.24913	-156.15907	K26S14E10	EXP PROSPECT	Sn-polymetallic veins	Low	Au Sn Ag Hg As Zn Bi Pb Sb
CLOUGH	20740072	62.32538	-153.77122	S26N24W20	EXP PROSPECT	Zn-Pb skarn deposits	Low	Ag Cu Zn Pb
COLORADO CREEK	20640033	63.57355	-156.0121	K22S15E20	PRODUCER	Placer Au-PGE	High	Au Sb
COLORADO GOSSAN	20650048	63.56038	-155.97637	K22S15E28	MINERAL LOCATION	Polymetallic replacement deposits	Low	Au
COLUMBIA CREEK	20910007	60.61172	-160.75299	S06N65W18	EXP PROSPECT	Placer Au-PGE	Low	Au
COPENHAGEN HILL	20650057	63.5144	-154.62834	K23S22E09	RAW PROSPECT	Porphyry Cu-Au	Medium	Cu
CRAIGS CLIFF	20830034	61.723	-154.17	S19N27W21	RAW PROSPECT	Polymetallic veins	Low	Mo
CRASH	20740068	62.35402	-153.80006	S26N24W07	EXP PROSPECT	Polymetallic veins	Medium	Ag Cu Cu Zn
CRESTON CREEK	20650040	63.60411	-155.9721	K22S15E04	MINERAL LOCATION	Placer Au-PGE	Low	Au Ag
CRIPPLE CREEK	20640031	63.56338	-156.09376	K22S14E23	PRODUCER	Placer Au-PGE	High	Au
CRIPPLE CREEK	20910008	60.73588	-159.56883	S08N59W36	PAST PRODUCER	Placer Au-PGE	Low	Au Ag
CROOKED CREEK	20730013	62.02208	-158.25796	S22N49W03	PAST PRODUCER	Placer Au-PGE	Low	Au Ag Hg Sn Sb
CROOKED CREEK	20650014	63.10744	-154.85232	K27S21E34	PAST PRODUCER	Placer Au-PGE	Medium	Au Ag
CRYSTAL GULCH	20650025	63.23668	-154.78036	K26S21E13	PAST PRODUCER	Placer Au-PGE	Medium	Au Bi Ag

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
DALL	20740070	62.32906	-153.81132	S26N24W19	EXP PROSPECT	Polymetallic replacement deposits	Medium	Ag Cu Zn
DEADWOOD CREEK	20730035	62.70432	-157.24735	S30N42W07	EXP PROSPECT	Placer Au-PGE	Medium	Au
DECOURCY MOUNTAIN MINE	20730019	62.06319	-158.46213	S23N50W21	PAST PRODUCER	Silica-carbonate Hg	High	Sb Hg
DEEP CREEK	20640007	63.40964	-156.976	K24S10E17	PAST PRODUCER	Placer Au-PGE	Medium	Au
DISAPPOINTMENT CREEK	20810021	61.869	-161.889	S21N69W35	PAST PRODUCER	Placer Au-PGE	Low	Au PGE
DODGE CREEK	20640039	63.14009	-156.56822	K27S12E22	PAST PRODUCER	Placer Au-PGE	Medium	Au
DOMINION CREEK	20640028	63.33132	-156.37459	K25S13E10	PAST PRODUCER	Placer Au-PGE	Medium	Au
DOMINION CREEK	20910004	60.96038	-159.40784	S10N58W12	EXP PROSPECT	Placer Au-PGE	Medium	Au
DONLIN CREEK	20730007	62.07769	-158.21843	S23N49W14	PRODUCER	Placer Au-PGE	High	Au Ag Sb Sn Hg
DONLIN CREEK - LEWIS GULCH	20730014	62.04973	-158.22988	S23N49W27	PRODUCER	Placer Au-PGE	High	Au Ag
DONLIN CREEK - QUARTZ GULCH	20730081	62.08118	-158.18363	S23N23E13	PAST PRODUCER	Placer Au-PGE	Medium	Au Ag Sb Hg Sb
DONLIN CREEK - QUEEN GULCH	20730015	62.06014	-158.22185	S23N49W26	PAST PRODUCER	Placer Au-PGE	Low	Au Ag
DONLIN CREEK - RUBY GULCH	20730016	62.06514	-158.21629	S23N49W23	PRODUCER	Placer Au-PGE	High	Au Ag
DONLIN CREEK - SNOW GULCH	20730052	62.07625	-158.19824	S23N49W14	PAST PRODUCER	Placer Au-PGE	Low	Au Ag Hg Sb W
DONLIN PROJECT	20730051	62.04185	-158.21309	S23N49W35	DEVEL DEPOSIT	Felsic-dike-hosted qtz veinlets w/Au	High	Au Ag As Sb
DONLIN PROJECT - DOME AREA	20730083	62.07188	-158.1554	S23N48W19	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Medium	Au Ag Sb As
DONLIN PROJECT - SNOW AREA	20730048	62.05917	-158.19142	S23N49W25	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Medium	Au Ag Sb As
EAGLE CREEK	20650012	63.12697	-154.89367	K27S21E29	PAST PRODUCER	Placer Au-PGE	Medium	Au Ag RARE EARTH Th

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
EAGLE CREEK GULCH	20650044	63.14938	-154.88232	K27S21E17	PAST PRODUCER	Placer Au-PGE	Low	Ag Au Th W U
EAGLE CREEK PLACER	20910003	60.8845	-159.532	S09N58W11	RAW PROSPECT	Placer Au-PGE	Low	Au
EAST FORK PROSPECT	20730056	62.97789	-156.38954	S33N38W01	RAW PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Medium	Au
EAST WINDY FORK	20740115	62.22338	-153.82922	S25N25W25	EXP PROSPECT	Sedimentary exhalative Zn-Pb	Low	Zn
EGNATY CREEK	20820001	61.86447	-157.87188	S21N47W34	EXP PROSPECT	Silica-carbonate Hg	Low	Hg
EIGHTMILE CREEK	20820017	61.7868	-157.60099	S20N46W34	PAST PRODUCER	Placer Au-PGE	Low	Au Ag
ELDORADO BASIN LODE	20640054	63.53598	-156.00837	K22S15E32	MINERAL LOCATION	Polymetallic veins	Medium	Au
ELDORADO CREEK	20640022	63.41047	-156.87683	K24S10E14	UNKNOWN	Placer Au-PGE	Low	Au
ELEPHANT CREEK	20810003	61.86645	-161.87252	S21N69W35	PAST PRODUCER	Placer Au-PGE	Low	Au W
ELLIE'S GOLD	20740124	62.10038	-153.46322	S23N23W10	EXP PROSPECT	Placer Au-PGE	Low	Au
ENCIO GULCH	20650027	63.22324	-154.74726	K26S22E19	PAST PRODUCER	Placer Au-PGE	Medium	Au Ag U
ESPERANTO CREEK	20640027	63.42603	-156.7635	K24S11E09	PAST PRODUCER	Placer Au-PGE	High	Au
ESPERANTO CREEK LODE	20640026	63.42076	-156.76433	K24S11E09	PAST PRODUCER	Low-sulfide Au-quartz veins	Low	Au
ESTER CREEK	20640030	63.03763	-156.57711	K28S12E28	PRODUCER	Placer Au-PGE	High	Au
ESTER CREEK LODE	20640048	63.04928	-156.54787	K28S12E22	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Low	Au
EUDIALYTE	20740107	62.06336	-154.08623	S23N26W20	EXP PROSPECT	Thorium-rare-earth veins	Low	RARE EARTH Zr Th U
EUREKA CREEK	20910011	60.9764	-159.55894	S10N58W02	PAST PRODUCER	Placer Au-PGE	High	Au
FAIRVIEW	20820022	61.76431	-157.36739	S19N45W02	EXP PROSPECT	Silica-carbonate Hg	Low	Hg Sb Au

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
FISHER	20910014	60.82176	-159.72977	S09N59W34	MINERAL LOCATION	Simple Sb deposits	Low	Sb Au
FISHER CREEK	20910016	60.81999	-159.54167	S09N58W34	EXP PROSPECT	Placer Au-PGE	Low	Au
FLAT CREEK	20730008	62.40209	-158.00518	S27N47W28	PAST PRODUCER	Placer Au-PGE	Medium	Au Cr Ag Hg U Sn Zr
FLAT SKARN	20920034	60.9186	-156.71484	S10N42W34	RAW PROSPECT	Zn-Pb skarn deposits	Low	Pb Zn Cu
FLUORITE CREEK GOSSAN	20740097	62.14702	-154.27328	S24N27W20	RAW PROSPECT	Polymetallic veins	Low	Au Ag Cu Zn Pb F
FORTYSEVEN CREEK LODE	20820010	61.04703	-158.2001	S11N50W16	RAW PROSPECT	Polymetallic veins	Medium	Au W Sb W Ag W
FORTYSEVEN CREEK PLACER	20820009	61.04889	-158.16802	S11N50W16	PAST PRODUCER	Placer Au-PGE	High	Au W
FOURTH OF JULY CREEK	20730034	62.67053	-157.1222	S30N42W22	PAST PRODUCER	Placer Au-PGE	Medium	Cr Au
FREDERICK	20920003	60.93263	-156.89396	S10N43W27	EXP PROSPECT	Undetermined	Low	Hg
FRENCH JOE MOUNTAIN PROSPECT	20730064	62.99253	-156.34437	S34N37W32	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Low	Au
FROZEN CREEK LODE	20650059	63.5314	-154.51534	K23S22E06	EXP PROSPECT	Porphyry Cu-Au	Medium	Cu Au
FULLER AND WILLIS; WILLIS	20820003	61.81214	-157.37494	S20N45W24	PAST PRODUCER	Silica-carbonate Hg	Low	Hg Sb As
FULLER CREEK	20820013	61.75625	-157.4221	S19N45W10	PAST PRODUCER	Placer Au-PGE	Low	Au Hg Ag As
GAGARYAH	20830015	61.82454	-154.47486	S20N29W14	RAW PROSPECT	Sedimentary exhalative Zn-Pb	Medium	Ba
GAGARYAH RIVER	20830022	61.6668	-155.3042	S20N29W14	EXP PROSPECT	Placer Au-PGE	Low	Au Hg
GANES CREEK (LOWER)	20640050	63.08937	-156.43152	S28S13E05	PAST PRODUCER	Placer Au-PGE	High	Fe Ti Ag Au
GANES CREEK (UPPER)	20730042	62.97503	-156.51836	S33N38W05	PRODUCER	Placer Au-PGE	High	Au Fe
GANES CREEK LODE	20730065	62.85534	-156.95535	S32N41W15	RAW PROSPECT	Polymetallic veins	Low	Ag Cu Pb

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
GEMUK MOUNTAIN	20920008	60.58875	-159.01162	S06N55W19	EXP PROSPECT	Plutonic-hosted Cu-Au polymetallic	High	Au Sb Hg
GEORGE RIVER	20730021	62.33819	-157.18712	S26N43W14	PAST PRODUCER	Placer Au-PGE	Low	Au
GEORGETOWN; HARVISON	20820007	61.95993	-157.7274	S22N46W33	EXP PROSPECT	Polymetallic veins	Medium	Hg Au Sb As
GETMUNA	20820046	61.76229	-158.49337	S19N51W03	MINERAL LOCATION	Polymetallic veins	Medium	Au Ag
GETMUNA CREEK (EAST HEAD)	20820048	61.77379	-158.48158	S20N51W35	EXP PROSPECT	Polymetallic veins	Low	Zn Ag W
GIRL CREEK	20820029	61.22313	-158.46344	S13N51W17	UNKNOWN	Placer Au-PGE	Low	Au Ag
GLACIER GULCH	20730044	62.95236	-156.53036	S33N38W17	INTERMITTENT PRODUCER	Placer Au-PGE	Low	Au
GLEN GULCH	20730074	62.44598	-157.93379	S28N47W24	EXP PROSPECT	Polymetallic veins	Low	Au Ag Hg Sb
GOLD CREEK/ WILLOW CREEK BENCH	20730031	62.36375	-158.07879	S26N47W07	PAST PRODUCER	Placer Au-PGE	Medium	Au Cr Ag Hg U Sn W Zr
GOLD LAKE	20910039	60.28	-159.44	S02N59W12	MINERAL LOCATION	Felsic-dike-hosted qtz veinlets w/Au	Low	Au Ag As Pb Sb
GOLD RUN CREEK	20640042	63.13772	-156.55295	K27S12E22	UNKNOWN	Placer Au-PGE	Low	Au
GOLD RUN CREEK	20820028	61.40762	-158.48152	S15N51W07	UNKNOWN	Placer Au-PGE	Low	Ag Au
GOLDEN BUTTE	20910015	60.18285	-159.98508	S01N62W11	PAST PRODUCER	Felsic-dike-hosted qtz veinlets w/Au	Low	Au Ag PGE
GOLDEN GATE FALLS	20910027	60.50238	-160.17955	S05N62W21	RAW PROSPECT	Placer Au-PGE	Low	Au Cu Sn
GOLDEN GROUND PROSPECT	20730071	62.48815	-157.91172	C28N47W25	EXP PROSPECT	Polymetallic veins	Low	Au Ag Pb Sb Zn Cu W
GOLDEN HORN MINE	20730027	62.44666	-157.9227	S27N47W12	PAST PRODUCER	Plutonic-hosted Cu-Au polymetallic	High	Au Hg Zn Ag Pb W Sb
GOSS GULCH PROSPECT	20730054	62.98536	-156.36736	S33N37W06	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Medium	Au
GRAHAM CREEK	20640051	63.60958	-156.13028	K22S14E03	EXP PROSPECT	Placer Au-PGE	Low	Au

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
GRANDVIEW (PURKEYPILE)	20750014	62.89166	-152.21612	S32N16W02	EXP PROSPECT	Sn-polymetallic veins	Medium	Zn Au Ag Cu W Pb
GRANITE CREEK LODE	20730098	62.35915	-156.93692	S26N41W07	EXP PROSPECT	Polymetallic veins	Low	Cu As Au
GRANITE CREEK MINE	20730005	62.46459	-157.90323	S27N47W01	PAST PRODUCER	Placer Au-PGE	Low	Cr Au Ag
GRANITE PUP	20730068	62.35119	-156.9452	S26N42W12	PAST PRODUCER	Plutonic-hosted Cu-Au polymetallic	Medium	Au Ag Hg Sn Sb
GRANITE-WILLOW CREEKS	20730022	62.34375	-157.05101	S26N42W15	PAST PRODUCER	Placer Au-PGE	High	Au
GREENSTONE RIDGE COPPER	20910037	60.48801	-160.19828	S05N62E29	MINERAL LOCATION	Undetermined	Low	Cu As Ni
GREISEN	20820049	61.76939	-158.45898	S19N51W01	MINERAL LOCATION	Sn-polymetallic veins	Medium	Ag Pb Zn
HAPPY CREEK	20810020	61.6939	-161.85743	S21N69W25	UNKNOWN	Placer Au-PGE	Low	Au
HAPPY CREEK	20730001	62.38049	-158.03081	S27N47W32	PAST PRODUCER	Placer Au-PGE	Medium	Sn U Au Ag Hg W Sb Cr
HARD SCRAMBLE	20740047	62.32488	-153.78072	S26N24W20	EXP PROSPECT	Zn-Pb skarn deposits	Medium	Pb Cu Zn Ag
HARTMAN RIVER - SOUTH TRIBUTARY	20830002	61.59602	-153.56891	S17N24W02	RAW PROSPECT	Polymetallic veins	Low	Cu Au Ag
HARTMAN RIVER HEADWATERS	20830019	61.72455	-153.68564	S19N24W01	EXP PROSPECT	Polymetallic veins	Low	Mo Au W Ag Cu Sb
HEADWALL	20810033	61.662	-159.115	S18N54W08	EXP PROSPECT	Polymetallic veins	Low	Au Sb Sn
HELNAC	20720007	62.31737	-161.29858	S26N65W27	EXP PROSPECT	Epithermal quartz-alunite Au	Low	Au
HIDDEN CREEK PLACER	20650021	63.21439	-154.74932	K26S22E19	PAST PRODUCER	Placer Au-PGE	Medium	Au Bi W Ag
HILL 1466 (S. OF TAYLOR MOUNTAINS)	20920037	60.85929	-157.38229	S09N46E23	RAW PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Low	Au Ag Hg
HILL 5550	20740110	62.38838	-153.96222	S27N25W32	EXP PROSPECT	Noril"sk Cu-Ni-PGE	Low	Fe Cu Ni Bi Cr

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
HILL 914 (HOHOLITNA RIVER)	20920033	60.887	-156.416	S09N40W08	RAW PROSPECT	Southeast Missouri Pb-Zn	Low	Zn As
HILL TOP NO. 1	20730036	62.62654	-157.48292	S29N44W02	EXP PROSPECT	Simple Sb deposits	Medium	Sb Hg
HILLSIDE	20650069	63.4394	-154.12832	K24S25E06	EXP PROSPECT	Southeast Missouri Pb-Zn	Medium	Zn Pb
HIPPIE CREEK	20740011	62.26739	-153.67115	S25N24W11	EXP PROSPECT	Polymetallic veins	Medium	Pb Zn Ag
HIPPIE CREEK SOUTH FORK	20740012	62.21438	-153.71722	S25N24W34	RAW PROSPECT	Zn-Pb skarn deposits	Low	Ag Pb
HOLMES GULCH	20650024	63.21057	-154.78285	K26S21E25	PAST PRODUCER	Placer Au-PGE	Medium	Au Bi
HOLOKUK RIVER PLACER	20820020	61.32012	-158.27734	S14N50W08	EXP PROSPECT	Placer Au-PGE	Low	Au
HOPE	20910032	60.5077	-160.75031	S05N65W19	EXP PROSPECT	Placer Au-PGE	Low	Sb Au
HORN MOUNTAINS PLACER	20820031	61.73078	-158.57255	S19N51W20	MINERAL LOCATION	Placer Au-PGE	Low	W Au
IDAHO BENCH	20730076	62.38822	-157.98516	S27N47W34	PAST PRODUCER	Placer Au-PGE	Medium	Au Ag Hg
INDEPENDENCE MINE	20730063	62.9468	-156.4762	S33N38W15	PAST PRODUCER	Felsic-dike-hosted qtz veinlets w/Au	Medium	Au Ag
INNOKO RIVER	20640006	63.13358	-156.49107	K27S12E24	UNKNOWN	Placer Au-PGE	Medium	Au
INNOKO RIVER (LOWER)	20640036	63.161	-156.619	K27S12E08	PRODUCER	Placer Au-PGE	High	Au
IRON CREEK	20640021	63.40386	-156.85279	K24S10E13	PAST PRODUCER	Placer Au-PGE	Medium	Au
JIMMY LAKE	20830010	61.73338	-153.20012	S19N22W13	MINERAL LOCATION	Polymetallic veins	Medium	Cu Au Mo
JOFFRE CREEK	20640055	63.40436	-156.80768	K24S11E18	PAST PRODUCER	Placer Au-PGE	Medium	Au
JONES CREEK	20650009	63.31967	-154.71899	K25S22E17	EXP PROSPECT	Placer Au-PGE	Medium	Au

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
JULI/JUL	20730079	62.22736	-157.41406	S25N44W27	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Low	Ag Sn As Sb Bi Cd
JULIAN CREEK	20730010	62.20819	-157.37601	S25N44W35	PAST PRODUCER	Placer Au-PGE	High	Au Sn Hg RARE EARTH Cr Ag Sb Ba
JUMBO PEAK	20650031	63.24661	-154.7176	K26S22E08	PAST PRODUCER	Undetermined	Low	Bi Au Ag Cu
KAKO CREEK	20810014	61.96593	-161.38015	S22N66W28	PAST PRODUCER	Placer Au-PGE	Low	Au
KAKO PROSPECT	20810038	61.90521	-161.46964	S21N67W13	EXP PROSPECT	Polymetallic replacement deposits	Medium	Au As
KATY-O	20650071	62.93421	-154.24233	K23S24E33	EXP PROSPECT	Southeast Missouri Pb-Zn	Low	Zn
KATZ PROSPECT	20730043	62.93421	-156.51294	S33N38W20	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Medium	Sb Au
KANGIK RIVER K LODE	20610002	63.56906	-171.72279	K22S68W23	MINERAL LOCATION	Volcanic-hosted Cu-As-Sb	Low	Cu
KAY CREEK	20820037	61.29608	-158.72225	S14N53W23	EXP PROSPECT	Disseminated Sb deposits	Low	Sb
KC BARITE	20830041	61.71911	-154.82945	S19N31W24	RAW PROSPECT	Sedimentary exhalative Zn-Pb	Low	Ba Zn
KIKNIK CREEK	20920010	60.8539	-157.54983	S09N47W24	EXP PROSPECT	Placer Au-PGE	Medium	Au
KISA	20910036	60.35537	-159.30225	S03N58W14	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	High	Au Ag Sb As
KOLMAKOF MINE	20820012	61.59627	-158.96157	S17N53W06	PAST PRODUCER	Silica-carbonate Hg	Low	Hg
KRISTEN CREEK	20830038	61.07932	-154.06228	S12N27W33	RAW PROSPECT	Placer Au-PGE	Low	Au
LAST CHANCE GULCH	20730059	62.96036	-156.52336	S33N38W08	PAST PRODUCER	Placer Au-PGE	Low	Au
LITTLE BIRD	20740066	62.3599	-153.8002	S26N24W06	EXP PROSPECT	Zn-Pb skarn deposits	Medium	Zn Cu Ag
LITTLE CREEK	20640010	63.06676	-156.48146	K28S12E13	PRODUCER	Placer Au-PGE	High	Ag W Au

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
LITTLE CREEK	20730009	62.02485	-158.69407	S22N51W06	UNKNOWN	Placer Au-PGE	Medium	Ag Au Hg
LITTLE ELDORADO	20730085	62.17	-157.972	S24N47W18	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Low	Zn Ag Au Hg As
LITTLE KASIGLUK RIVER	20910013	60.53925	-160.66894	S05N65W10	EXP PROSPECT	Placer Au-PGE	Low	Au
LITTLE TAYLOR MOUNTAINS	20920005	60.8479	-157.1936	S09N45W25	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Low	Au Cu
LITTLE UNDERHILL CREEK	20830014	61.3938	-154.08971	S14N27W06	RAW PROSPECT	Thorium-rare-earth veins	Low	U Sn Zn RARE EARTH Ag U
LONE	20740079	62.50937	-154.72026	S28N29W18	RAW PROSPECT	Cu skarn deposits	Low	Cu Fe Ag
LOUISE	20810035	61.66528	-159.12036	S18N54W08	RAW PROSPECT	Polymetallic veins	Low	Au Sn Sb
LUCKY DAY	20920031	60.74932	-158.85043	S08N55W25	PAST PRODUCER	Silica-carbonate Hg	Low	Hg Sb
LYNN-MARIE	20650064	63.4804	-154.16933	K23S25E20	MINERAL LOCATION	Southeast Missouri Pb-Zn	Medium	Zn
MACKIE CREEK	20730046	62.98936	-156.49436	S34N38W33	PAST PRODUCER	Placer Au-PGE	Medium	Au
MADISON CREEK	20640025	63.40737	-156.79428	K24S11E17	PAST PRODUCER	Placer Au-PGE	Medium	Au
MALAMUTE GULCH	20730028	62.4582	-157.9174	S27N47W01	EXP PROSPECT	Placer Au-PGE	Low	RARE EARTH Hg Sn Au Cr
MALAMUTE PUP	20730006	62.45903	-157.91351	S27N47W01	PAST PRODUCER	Placer Au-PGE	Low	Ag Cr RARE EARTH Sn U Au Hg
MARVEL CREEK	20910001	60.9013	-159.61979	S10N58W32	PRODUCER	Placer Au-PGE	High	Au Ag
MARY MARGARET	20740092	62.16379	-154.87395	S24N30W13	EXP PROSPECT	Hot-spring Hg	Low	Hg Sb
MASTADON CREEK	20640020	63.35519	-156.91544	K25S10E02	EXP PROSPECT	Placer Au-PGE	Low	Au
MATTHEWS AND BLACKBURN	20650041	63.20939	-154.72232	K26S22E29	EXP PROSPECT	Cu skarn deposits	Low	Au Cu

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
MAYBE CREEK	20730072	62.70453	-157.17495	S30N42W09	EXP PROSPECT	Placer Au-PGE	Low	Au
MAYBE CREEK LODE	20730101	62.691	-157.153	S30N42W16	RAW PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Low	Au
MCLEOD PROSPECT	20630005	63.272	-159.288	K25S03W32	EXP PROSPECT	Porphyry Cu-Mo	Medium	Mo
MEDFRA ROAD 8-9 MILE	20650032	63.22439	-154.75232	K26S22E19	EXP PROSPECT	Undetermined	Low	U
MERCURY	20820038	61.76491	-157.32627	S19N44E06	EXP PROSPECT	Silica-carbonate Hg	Low	Hg Sb
MICH	20730090	62.1574	-157.69264	S24N46W22	RAW PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Low	Au
MICHIGAN CREEK	20730012	62.23708	-157.33129	S25N43W19	EXP PROSPECT	Placer Au-PGE	Low	Au
MIDDLE FORK KUSKOKWIM SILL	20740111	62.33238	-153.95122	S26N25W01	EXP PROSPECT	Noril"sk Cu-Ni-PGE	Low	Cu Zn
MILLIE CREEK	20920016	60.86983	-157.38652	S10N45W14	PAST PRODUCER	Placer Au-PGE	Low	Au
MINNIE GULCH	20730075	62.44893	-157.92836	S27N47W11	EXP PROSPECT	Plutonic-hosted Cu-Au polymetallic	Low	Au Hg
MISSION (KONECHNEY) PROSPECT	20810005	61.65283	-159.1122	S18N54W17	EXP PROSPECT	Polymetallic veins	Medium	Sb Au Cu Ag Pb U W
MOGHOWEYIK RIVER (UPPER)	20610008	63.44907	-171.61277	K23S67W33	MINERAL LOCATION	Porphyry Cu-Mo	Medium	Mo Cu
MOGHOWEYIK RIVER LODE	20610004	63.46573	-171.79445	K23S68W26	RAW PROSPECT	Porphyry Cu-Mo	Medium	Mo
MONTANA CREEK	20650052	63.58238	-155.98237	K22S15E16	EXP PROSPECT	Placer Au-PGE	High	Au
MONTANA SADDLE	20650049	63.55638	-155.96437	K22S15E27	EXP PROSPECT	Porphyry Cu-Au	Low	Au
MONTEZUMA CREEK	20810016	61.90168	-161.41618	S21N66W20	PAST PRODUCER	Placer Au-PGE	Low	Au
MOORE CREEK	20730004	62.59623	-157.16394	S29N42W21	PRODUCER	Placer Au-PGE	High	Hg Ag Cr Au
MOOSE JAW	20650050	63.54338	-156.00037	K22S15E32	EXP PROSPECT	Simple Sb deposits	Medium	Sb Au

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
MOSQUITO MOUNTAIN	20730096	62.0409	-158.9322	S23N53W13	MINERAL LOCATION	Felsic-dike-hosted qtz veinlets w/Au	Low	Ag Hg Sb
MOUNT HURST	20640009	63.23186	-156.93667	K26S10E15	MINERAL LOCATION	Podiform chromite	Medium	Cr PGE
MOUNT JOAQUIN	20730038	62.84658	-156.22736	S32N37W21	EXP PROSPECT	Polymetallic veins	Low	Hg Sb
MOUNTAIN TOP MINE	20820027	61.39544	-157.9656	S15N49W18	PAST PRODUCER	Silica-carbonate Hg	High	Hg Au
MUNTHER CREEK	20730069	62.31018	-156.91331	S26N41W29	EXP PROSPECT	Placer Au-PGE	Medium	Au
MURRAY GULCH	20820011	61.56805	-158.58722	S17N51W18	PAST PRODUCER	Placer Au-PGE	High	Ag Au
MYSTERY MOUNTAINS EAST	20650058	63.5234	-154.56234	K23S22E02	RAW PROSPECT	Porphyry Cu-Au	Low	Cu
MYSTERY MOUNTAINS WEST	20650056	63.5134	-154.65834	K23S22E08	RAW PROSPECT	Polymetallic veins	Low	Pb Zn
NEAR FLAT AIRSTRIP	20730078	62.45325	-157.99028	S27N47W04	EXP PROSPECT	Undetermined	Low	Hg
NECONS RIVER	20830031	61.02612	-154.01348	S11N27W23	RAW PROSPECT	Placer Au-PGE	Low	Au
NEILSON PROSPECT	20730073	62.47709	-157.90934	S28N47W36	EXP PROSPECT	Polymetallic veins	Low	Au Ag As
NEIROD - EAST	20650051	63.53538	-155.99737	K22S16E33	MINERAL LOCATION	Porphyry Cu-Au	Low	Au
NEPTUNE	20740076	62.27938	-153.64222	S25N24W01	EXP PROSPECT	Polymetallic veins	Low	Pb Zn
NIXON FORK MINE	20650022	63.23761	-154.76721	K26S21E24	PRODUCER	Cu skarn deposits	High	Au Ag Cu Bi
NO. 1 DISCOVERY	20820034	61.78958	-157.33571	S20N44W30	EXP PROSPECT	Silica-carbonate Hg	Low	Hg
NORTH TERRA COTTA TALUS	20740125	62.102	-153.394	S23N23W12	EXP PROSPECT	Polymetallic veins	Low	As Au W Sb
NORTHERN CRIPPLE MOUNTAINS	20910040	60.69445	-159.64559	S07N59W16	MINERAL LOCATION	Felsic-dike-hosted qtz veinlets w/Au	Low	Mo As Au

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
NUNATAK	20830029	61.40614	-153.62476	K15N24W08	EXP PROSPECT	Polymetallic veins	Low	Ag Au Cu Co Zn Ni Pb
NYAC LODE - SADDLE MOUNTAIN	20810037	61.09965	-159.77865	S12N59W29	EXP PROSPECT	Plutonic-hosted Cu-Au polymetallic	Medium	Au
NYAC LODE - VABM BONANZA	20810036	61.07203	-159.84307	S11N60W01	EXP PROSPECT	Plutonic-hosted Cu-Au polymetallic	High	Au Cu Bi
NYAC LODE - WALLACE	20810027	61.05349	-159.93031	S11N60W09	EXP PROSPECT	Low-sulfide Au-quartz veins	High	Au Bi Te
NYAC PLACER	20810002	61.00482	-159.94396	S11N60W33	PRODUCER	Placer Au-PGE	High	Au Ag PGE
NYAC PLACER - BEAR CREEK	20810028	61.05554	-159.77429	S11N59W08	PAST PRODUCER	Placer Au-PGE	Medium	Au Ag PGE Hg
NYAC PLACER - CALIFORNIA CREEK	20810025	61.05149	-159.92503	S11N60W35	PAST PRODUCER	Plutonic-hosted Cu-Au polymetallic	Low	Au Ag Te Bi
NYAC PLACER - GRANITE CREEK	20910019	60.98278	-160.09238	S10N61W03	PAST PRODUCER	Placer Au-PGE	Low	Au Ag
NYAC PLACER - MARY LOU GULCH	20910023	60.99349	-160.10303	S11N61W33	PAST PRODUCER	Placer Au-PGE	Low	Au
NYAC PLACER - SHAMROCK CREEK	20810030	61.01919	-159.85404	S11N60W23	PRODUCER	Placer Au-PGE	High	Au
NYAC PLACER - SPRUCE CREEK	20810029	61.0685	-159.782	S11N59W05	PAST PRODUCER	Placer Au-PGE	Low	Ag Au
NYAC PLACER - TINY GULCH	20810024	61.00482	-159.89813	S11N60W34	PAST PRODUCER	Placer Au-PGE	Low	Au Hg
NYAC PLACER - UPPER TULUKSAK RIVER	20910024	60.98482	-159.99257	S10N60W06	PAST PRODUCER	Placer Au-PGE	Medium	Ag Au PGE
OGRIZ-SLATE CREEK	20730030	62.41792	-157.92323	S27N47W24	PAST PRODUCER	Placer Au-PGE	Low	Ag Hg Au
OKOK RIVER LODE	20610010	63.33007	-171.37375	K25S67W14	MINERAL LOCATION	Polymetallic veins	Low	Cu Pb Ag Zn
ONLY	20830032	61.09482	-154.52435	S12N30E36	RAW PROSPECT	Placer Au-PGE	Low	Au
OPHIR CREEK	20640037	63.1237	-156.5311	K27S12E26	PRODUCER	Placer Au-PGE	Medium	Ag Au

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
OPHIR CREEK	20810004	61.21938	-159.84454	S13N59W05	RAW PROSPECT	Placer Au-PGE	High	Au
OSKAWALIK RIVER	20820036	61.53735	-157.6718	S17N46W30	UNKNOWN	Placer Au-PGE	Low	Ag Au
OSKAWALIK RIVER LODE	20820052	61.695	-157.751	S19N47W35	RAW PROSPECT	Polymetallic replacement deposits	High	As Au
OTTER CREEK	20730003	62.45153	-157.93174	S27N47W02	PAST PRODUCER	Placer Au-PGE	High	Sn Cr Hg Ag Au Sb Pb
OWHAT (COBALT CREEK)	20810001	61.66764	-159.10489	S18N54W08	EXP PROSPECT	Polymetallic veins	Low	Au Pb Ag Zn Cu Sn
OZZNA CREEK	20740032	62.30882	-153.90694	S26N25W32	RAW PROSPECT	Polymetallic veins	Low	Zn Pb
OZZNA CREEK LODE	20740114	62.29306	-153.94524	S26N25W32	EXP PROSPECT	Porphyry Cu-Mo	Medium	Au Ag Cu Zn Pb
PASS FORK STIBNITE	20830001	61.64745	-153.58084	S18N24W14	RAW PROSPECT	Simple Sb deposits	Low	Sb
PEGGY BARBARA	20740091	62.17235	-154.86728	S24N30W18	RAW PROSPECT	Hot-spring Hg	Low	Hg Sb
POINT SKARN	20820042	61.0138	-156.0322	S11N38W28	EXP PROSPECT	Cu skarn deposits	Low	Cu As U W
POOVOOKPUK MOUNTAIN	20610009	63.44814	-171.53554	K23S67W36	MINERAL LOCATION	Porphyry Cu-Mo	Medium	Mo Ag Cu
PORK CHOP	20650035	63.5154	-154.59434	K23S22E10	EXP PROSPECT	Porphyry Cu-Au	Medium	Cu Sn Au U W Zn Cd Ag Cu
PORPHYRY KNOB	20640052	63.53838	-156.02437	K22S15E32	EXP PROSPECT	Plutonic-hosted Cu-Au polymetallic	Medium	Au Ag
POST LAKE	20740118	62.12038	-153.52722	S24N23W23	EXP PROSPECT	Polymetallic veins	Low	As Co Ni Cu
POST RIVER PLUTON	20740119	62.08237	-153.66722	S23N24W01	EXP PROSPECT	Polymetallic veins	Low	Ag Cu W Sn
POST RIVER WEST FORK NORTH	20740121	62.02837	-153.82622	S22N25W03	EXP PROSPECT	Sedimentary exhalative Zn-Pb	Low	Ag Cu Zn
POTOSI CREEK	20730060	62.97436	-156.51336	S33N38W05	PAST PRODUCER	Placer Au-PGE	Low	Au

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
PRINCE CREEK	20730102	62.35471	-157.914	S26N47W02	PRODUCER	Placer Au-PGE	Medium	Ag
PRINCE CREEK (LOWER)	20730024	62.33681	-157.90518	S26N47W13	PRODUCER	Placer Au-PGE	High	Hg Au Ag
PRINCE CREEK (UPPER)	20730023	62.36931	-157.94296	S26N47W02	PAST PRODUCER	Placer Au-PGE	High	Hg Au
PUPINSKI	20650047	63.22105	-154.72454	K26S22E20	PAST PRODUCER	Sn-polymetallic veins	Low	Ag Sn Cu W
PYRRHOTITE	20740074	62.28638	-153.78022	S25N24W05	EXP PROSPECT	Polymetallic replacement deposits	Low	Fe Cu Ni Co
QUARTZ CREEK	20810019	61.86794	-161.66635	S21N68W36	EXP PROSPECT	Placer Au-PGE	Low	Au
RAT FORK-BASE	20740112	62.31838	-153.87222	S26N26W01	EXP PROSPECT	Zn-Pb skarn deposits	Medium	Cu Pb Ag Zn Cd Co Fe
RAT FORK-HEADWALL	20740113	62.31838	-153.89122	S26N25W27	EXP PROSPECT	Zn-Pb skarn deposits	Medium	Ag Cu Zn Pb
RED DEVIL	20820005	61.75915	-157.31493	S19N44W06	PAST PRODUCER	Silica-carbonate Hg	High	Hg Sb Au As
RED MOUNTAIN	20820044	61.57905	-157.27737	S17N44W09	EXP PROSPECT	Plutonic-hosted Cu-Au polymetallic	Medium	Au Ag
RED SHALE	20740078	62.51536	-154.77827	S28N39W14	RAW PROSPECT	Sedimentary exhalative Zn-Pb	Low	Pb Zn Cu
REDSKIN	20920007	60.73466	-158.84617	S08N55W36	EXP PROSPECT	Silica-carbonate Hg	Low	Sb Hg
REEF RIDGE	20650072	63.3834	-154.36632	K24S23E26	EXP PROSPECT	Southeast Missouri Pb-Zn	High	Zn
REGER PYRRHOTITE	20740096	62.15836	-154.40123	S24N28W22	RAW PROSPECT	Noril"sk Cu-Ni-PGE	Low	Cu Ni Fe
RETURN CREEK	20730020	62.05625	-158.46019	S23N50W28	EXP PROSPECT	Placer Au-PGE	Low	Hg
RETURN CREEK LODE	20730097	62.0513	-158.50841	S23N50W30	EXP PROSPECT	Silica-carbonate Hg	Low	Hg Sb
RHYOLITE PROSPECT (JUNINGGULRA MTN)	20820008	61.93903	-158.41104	S22N50W03	EXP PROSPECT	Silica-carbonate Hg	Low	Hg Sb

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
ROBERTS PGM	20740056	62.1939	-154.4455	S24N28W05	RAW PROSPECT	Noril"sk Cu-Ni-PGE	High	Cu Ni PGE PGE Ag Cr Au Bi Co
ROBIN CREEK	20910002	60.9975	-159.55551	S11N58W34	EXP PROSPECT	Placer Au-PGE	Low	Au
ROCK GLACIER	20740098	62.35338	-154.13022	S26N26W08	RAW PROSPECT	Cu skarn deposits	Low	Cu Fe
ROUND	20740104	62.89037	-155.66734	S32N43W04	RAW PROSPECT	Polymetallic veins	Low	Ag Cu
ROUNDABOUT MOUNTAIN SOUTHEAST	20740105	62.88737	-155.59034	S32N34W02	RAW PROSPECT	Polymetallic veins	Low	Ag Cu Pb Ni
ROXIE	20920011	60.82137	-158.90625	S09N54W32	EXP PROSPECT	Silica-carbonate Hg	Low	Hg
RUBY CREEK (LOWER)	20650002	63.23343	-154.78644	K26S21E14	PAST PRODUCER	Placer Au-PGE	Medium	Ag Au Sn W Bi U
RUSSIAN MOUNTAINS, NORTHERN	20810031	61.69828	-159.19836	S19N55W35	MINERAL LOCATION	Polymetallic veins	High	Cu Ag Pb U Sb
RUSSIAN MOUNTAINS, SOUTHERN	20810034	61.63664	-159.10195	S18N54W20	MINERAL LOCATION	Polymetallic veins	Medium	Zn Sb As
RUSSIAN MOUNTAINS, WESTERN	20810032	61.66928	-159.09536	S18N54W09	EXP PROSPECT	Polymetallic veins	Low	Au Sn
RUSTY CIRQUE	20830033	61.91603	-153.9189	S21N25W18	MINERAL LOCATION	Porphyry Cu-Mo	Medium	Ag Au Mo Pb As
SADDLE	20820047	61.75309	-158.48687	S19N51W11	MINERAL LOCATION	Sn-polymetallic veins	Medium	Ag Au
SATURN	20740075	62.28938	-153.66222	S26N24W35	EXP PROSPECT	Zn-Pb skarn deposits	Low	Zn
SCHAEFER PROSPECT	20920038	60.78927	-158.85227	S08N55W13	EXP PROSPECT	Silica-carbonate Hg	Low	Hg
SHEEP CREEK 1	20740069	62.34152	-153.7997	S26N24W18	EXP PROSPECT	Sedimentary exhalative Zn-Pb	Low	Zn Pb Ag
SHEEP CREEK SOUTH	20740073	62.31702	-153.79707	S26N24W30	EXP PROSPECT	Polymetallic replacement deposits	High	Zn
SHEEP CREEK TRIB A	20740031	62.30882	-153.90694	S26N25W28	EXP PROSPECT	Polymetallic veins	Low	Pb

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
SHEEP CREEK TRIB D	20740035	62.3341	-153.80999	S26N24W19	EXP PROSPECT	Polymetallic veins	Low	Ag
SHEEP CREEK WEST	20740036	62.33712	-153.82002	S26N25W13	EXP PROSPECT	Polymetallic veins	Low	Cu Pb Zn Ag
SHEEP CREEK, RAT FORK 1	20740034	62.31466	-153.88499	S26N25W27	EXP PROSPECT	Polymetallic veins	Low	Ag Pb Zn Cu
SHEEP DIVIDE	20740067	62.36038	-153.88122	S26N25W10	EXP PROSPECT	Polymetallic veins	Low	Cu
SHELLABARGER PASS	20750015	62.55242	-152.78922	S29N19W35	MINERAL LOCATION	Besshi massive sulfide	Medium	Au Cu Ag Zn
SIX (LAST CHANCE) GULCH	20730040	62.96325	-156.51014	S33N38W08	PAST PRODUCER	Placer Au-PGE	Low	Au
SLATE CREEK DISCOVERY	20730029	62.41737	-157.90462	S27N47W24	PAST PRODUCER	Placer Au-PGE	Low	Au Hg Ag
SMITH LAKE	20740071	62.32762	-153.74238	S26N24W21	DEVEL DEPOSIT	Polymetallic veins	Medium	Pb Cu Zn Ag
SNOWCAP MOUNTAIN EAST	20830005	61.48903	-153.46752	S16N23W07	RAW PROSPECT	Polymetallic veins	Low	Au Mo Cu Zn
SODA CREEK LODE	20650073	63.3474	-154.42032	K25S23E02	OTHER	Southeast Missouri Pb-Zn	Medium	Zn
SPARREVOHN	20830023	61.12431	-155.64138	S12N36W15	RAW PROSPECT	Placer Au-PGE	Low	Au Hg
SPAULDING CREEK	20730041	62.94536	-156.54036	S33N38W17	PAST PRODUCER	Placer Au-PGE	Medium	Au
SPAULDING CREEK LODE PROSPECT	20730062	62.93336	-156.51636	S33N38W20	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Low	Au Cr
SPOT 1-84	20820018	61.31596	-157.42733	S14N45W07	EXP PROSPECT	Undetermined	Low	Au
SPRING RIDGE	20650067	63.4654	-154.13233	K23S23E25	MINERAL LOCATION	Southeast Missouri Pb-Zn	Medium	Zn
SPRUCE AND LITTLE CREEK RIDGE	20640043	63.05979	-156.53876	K28S12E15	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Low	Au
SPRUCE CREEK	20640002	63.09216	-156.52876	K28S12E02	PAST PRODUCER	Placer Au-PGE	Medium	Ag Au
STARSHIP	20650065	63.48241	-154.07833	K23S25E20	MINERAL LOCATION	Southeast Missouri Pb-Zn	Medium	Zn

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
STEVENS CREEK LODE	20920018	60.94929	-157.3523	S10N45W13	MINERAL LOCATION	W veins	Low	W
STONE	20650013	63.14988	-154.87384	K27S21E16	PAST PRODUCER	Cu skarn deposits	Medium	Au Ag
STONEY VEIN	20840044	61.9094	-152.92223	S21N20W15	MINERAL LOCATION	Polymetallic veins	Medium	Ag Au Pb Cu
STONY RIVER EAST	20830037	61.2977	-153.64004	S16N25W02	RAW PROSPECT	Polymetallic veins	Low	Cu
STRAIGHT CREEK SPRINGS	20740095	62.16936	-154.39023	S24N28W15	RAW PROSPECT	Undetermined	Low	Cu Ni Zn Mo
STUYAHOK MINE (FLAT CREEK)	20720001	62.06039	-160.96122	S23N64W26	PAST PRODUCER	Placer Au-PGE	High	Hg Au
STUYAHOK PROSPECT	20720009	62.05621	-160.96904	S23N64W26	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Medium	Au
STUYAK CREEK	20810018	61.88026	-161.31337	S21N66W25	UNKNOWN	Placer Au-PGE	Low	Au
STYX RIVER LODE	20830007	61.53847	-153.1599	S17N21W30	MINERAL LOCATION	Polymetallic veins	Low	Zn Pb Mo Ag
SUE CREEK LODE	20820050	61.70099	-158.54617	S19N51W28	EXP PROSPECT	Polymetallic veins	Low	Sb W Zn
SWIFT RIVER NORTHEAST	20830011	61.55211	-154.02727	S17N26W20	RAW PROSPECT	Polymetallic veins	Low	Zn Cu Pb
SWIFT RIVER-PEAK 5848	20830026	61.54633	-154.22477	S17N27E20	EXP PROSPECT	Thorium-rare-earth veins	Low	RARE EARTH
SWIFT RIVER-SOUTHEAST	20830027	61.45453	-154.11117	S16N27W27	RAW PROSPECT	Thorium-rare-earth veins	Low	RARE EARTH
SYENITE PORPHYRY PROSPECT	20730099	62.92679	-157.08023		RAW PROSPECT	Plutonic-hosted Cu-Au polymetallic	Low	Au
TAKOTNA MOUNTAIN -EAST FLANK	20740100	62.94537	-155.98635	S33N35W18	RAW PROSPECT	Plutonic-hosted Cu-Au polymetallic	Low	Ag Cu Pb
TAMARACK CREEK	20640038	63.09242	-156.52014	K28S12E02	PAST PRODUCER	Placer Au-PGE	Low	Au
TATALINA MOUNTAIN PROSPECT	20730058	62.75223	-156.0708	S31N36W29	EXP PROSPECT	Polymetallic veins	Medium	Ag Cu V

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
TATALINA/CARL CREEK PLACER	20730061	62.75436	-156.08736	S31N36W19	EXP PROSPECT	Placer Au-PGE	Low	Au
TAYLOR CREEK (LOWER)	20920004	60.9436	-157.1996	S10N45W23	EXP PROSPECT	Placer Au-PGE	Medium	Au
TAYLOR CREEK (UPPER)	20920029	60.8719	-157.35331	S09N46W13	PAST PRODUCER	Placer Au-PGE	High	Au Ag
TAYLOR MOUNTAINS SOUTH LODE	20920035	60.90611	-157.37978	S09N46W02	RAW PROSPECT	Polymetallic veins	Low	Au As
TAYLOR MOUNTAINS WEST PLACER	20920030	60.87213	-157.43694	S09N46W16	PRODUCER	Placer Au-PGE	Medium	Au
TELAQUANA LOCALITY 38	20930031	60.95934	-153.51226	S10N24W15	RAW PROSPECT	Porphyry Cu	Low	Cu
TELAQUANA PASS	20930028	60.92535	-153.44426	S10N24W25	MINERAL LOCATION	Porphyry Mo, low-F	Low	Mo
TELAQUANA RIVER	20930027	60.93306	-153.55432	S10N24W28	MINERAL LOCATION	Porphyry Mo, low-F	Low	Mo
TELEPHONE HILL (TELE) PROSPECT	20730055	62.95521	-156.43175	S33N38W14	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Medium	Au
TERRA COTTA-HILL 5981	20740126	62.06238	-153.44823	S23N23W23	EXP PROSPECT	Creede epithermal veins	Low	As Au Zn
TERRA COTTA MOUNTAINS	20830016	61.94077	-153.50843	S21N23W04	EXP PROSPECT	Polymetallic veins	Low	Ag Au Cu Sb Pb
TERRA COTTA -POST RIVER TRIB.	20740099	62.01738	-153.46623	S22N23W10	EXP PROSPECT	Polymetallic veins	Low	As Pb Zn
TERRA COTTA SADDLE	20740130	62.0099	-153.44163	S22N23W11	EXP PROSPECT	Polymetallic veins	Low	As Sb
TERRA COTTA SECTION 12	20740129	62.01338	-153.41123	S22N23W12	EXP PROSPECT	Polymetallic veins	Low	As Au W
TERRA COTTA-SECTION 30	20740127	62.05238	-153.39123	S23N22W30	EXP PROSPECT	Alluvial placer Sn	Low	Sn
TERRA COTTA-SECTION 36	20740128	62.04338	-153.41323	S23N23E36	EXP PROSPECT	Creede epithermal veins	Low	As Au W
TERRA NORTH	20830020	61.77068	-153.70764	S19N24W01	PRODUCER	Low-sulfide Au-quartz veins	High	Au

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
TERRA SOUTH	20830021	61.74188	-153.67682	S19N24W17	EXP PROSPECT	Low-sulfide Au-quartz veins	Medium	Au
TERRA-FISH CREEK	20830018	61.78513	-153.7075	S19N24W08	EXP PROSPECT	Low-sulfide Au-quartz veins	High	Au Ag W Cu Sb Mo Pb As
THREE CUB	20830017	61.76526	-153.63644	S19N24W04	RAW PROSPECT	Polymetallic veins	Medium	Au Cu Ag Pb Zn Sb W
TIN CREEK #1	20740022	62.40687	-153.65686	S27N24W25	EXP PROSPECT	Zn-Pb skarn deposits	Medium	Cu Ag Zn
TIN CREEK #2	20740062	62.43339	-153.67422	S27N24W14	EXP PROSPECT	Zn-Pb skarn deposits	Medium	Ag Cu Zn Pb
TIN CREEK NORTH	20740061	62.45439	-153.69622	S27N24W03	EXP PROSPECT	Cu skarn deposits	Low	Pb Cu Zn Ag
TIN CREEK SOUTH	20740065	62.37906	-153.65628	S26N24W01	EXP PROSPECT	Zn-Pb skarn deposits	Low	Pb Cu Zn Ag
TIN CREEK TRIBUTARY	20740023	62.463	-153.66611	S27N24W02	EXP PROSPECT	Polymetallic veins	Medium	Cu Zn
TIN MIDWAY	20740063	62.42263	-153.66998	S27N24W24	EXP PROSPECT	Zn-Pb skarn deposits	High	Pb Cu Zn Ag
TOLSTOI CREEK	20730066	62.98134	-156.99635	S33N41W02	RAW PROSPECT	Placer Au-PGE	Low	Au
TOLSTOI LODE	20730050	62.91534	-156.99035	S33N41W26	RAW PROSPECT	Sn-polymetallic veins	Medium	Cu Zn As Sb Sn Ag
TOM GRAY (ALLMAN)	20720005	62.3018	-161.47451	S26N65W35	EXP PROSPECT	Placer Au-PGE	Low	Au
TOM GRAY CREEK	20720006	62.24482	-161.42211	S25N66W24	EXP PROSPECT	Placer Au-PGE	Low	Au
TRIBUTARY BELOW ROBERTS PGM	20740094	62.20936	-154.45123	S25N28W34	RAW PROSPECT	Sedimentary exhalative Zn-Pb	Low	Ag Cu Pb Fe Zn Mo Ni V
TWO GENEVIEVES	20820026	61.81319	-157.31904	S20N44W19	EXP PROSPECT	Silica-carbonate Hg	Low	Hg
UNALALKLEET RIVER	20630011	63.93829	-160.26147	K18S08W08	MINERAL LOCATION	Placer Au-PGE	Low	Au
UNNAMED (SOUTHEAST OF JIMMY LAKE)	20830043	61.69478	-153.19181	S19N22W36	MINERAL LOCATION	Olympic Dam Cu-U-Au	Medium	Th U

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
UNNAMED (TATINA RIVER TRIB)	20740135	62.38841	-153.06023	S27N20W01	MINERAL LOCATION	Polymetallic veins	Low	Cu Zn Pb
UNNAMED LODE (JONES RIVER)	20740134	62.4454	-153.24323	S27N21W07	MINERAL LOCATION	Polymetallic veins	Low	Cu
UNNAMED OCCURRENCE	20610014	63.52908	-171.04275	K23S64W04	EXP PROSPECT	Zn-Pb skarn deposits	Low	Pb Zn
UNNAMED OCCURRENCE	20830006	61.56806	-153.32232	S17N22W17	RAW PROSPECT	Polymetallic veins	Medium	Cu Ag
UPPER CHICKEN CREEK	20730082	62.37599	-157.97793	S26N47W03	PAST PRODUCER	Placer Au-PGE	Medium	Au Bi Ag Cd Sb Cu Hg Pb
UPPER SALMON RIVER	20910017	60.796	-159.5425	S08N59W12	EXP PROSPECT	Placer Au-PGE	Medium	Au
UPPER TATLAWISKSUK RIVER	20740082	62.233	-155.592	S25N34W28	RAW PROSPECT	Polymetallic veins	Low	Ag Cu
URSUS	20650060	63.4694	-154.55233	K23S22E23	MINERAL LOCATION	Polymetallic veins	Medium	Ag Pb
VABM CONE	20910029	60.6119	-159.2804	S06N57W16	RAW PROSPECT	Epithermal quartz-alunite Au	Low	Au Ag Fe Sb Hg
VABM TIPPY	20920024	60.5008	-158.74554	S05N54W27	RAW PROSPECT	Polymetallic veins	Low	Cu
VABM UPSELAT	20740080	62.39934	-155.93035	S27N36W27	RAW PROSPECT	Polymetallic veins	Low	Ag Au
VELESKA SOUTH	20740037	62.348	-153.64482	S26N24W13	EXP PROSPECT	Polymetallic veins	Low	Ag Cu Pb Zn
VERMILLION	20820039	61.76761	-157.33177	S19N44W06	EXP PROSPECT	Silica-carbonate Hg	Low	Hg
VICTOR GULCH	20640019	63.12302	-156.49588	K27S12E25	PAST PRODUCER	Placer Au-PGE	Medium	Hg Au
VINASALE	20740077	62.70936	-155.69234	S30N34W08	EXP PROSPECT	Plutonic-hosted Cu-Au polymetallic	High	Au Ag As Bi Zn Mo Pb Sb
VITA	20640046	62.99986	-156.42706	K29S13E05	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Low	Au
VON FRANK MOUNTAIN - SOUTH	20650036	63.5144	-154.33534	K23S23E12	EXP PROSPECT	Porphyry Cu-Au	Medium	Cu Au Mo

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
WEST FORK POST RIVER	20740005	62.01436	-153.88556	S22N25W09	RAW PROSPECT	Polymetallic veins	Low	Zn Cu
WEST FORK POST RIVER HEADWATERS	20740123	62.01236	-153.92823	S22N25W07	RAW PROSPECT	Sedimentary exhalative Zn-Pb	Low	Ag Zn
WEST SIDE SELATNA HILLS	20740081	62.28034	-155.64233	S25N34W06	RAW PROSPECT	Polymetallic veins	Low	Cu Ag Pb Zn
WEST SNOWCAP MTN.	20830003	61.46357	-153.70288	S16N25W23	RAW PROSPECT	Polymetallic veins	Low	Ag Cu Pb Zn
WHALEN MINE	20650042	63.2231	-154.76622	K26S22E24	PAST PRODUCER	Cu skarn deposits	High	Ag Cu Au Th Bi U W
WHIRLWIND CREEK	20650006	63.4444	-154.38233	K24S23E02	MINERAL LOCATION	Placer Au-PGE	Low	Au
WHIRLWIND RIDGE LODE	20650061	63.5034	-154.23333	K23S24E09	OTHER	Polymetallic veins	Low	Ag Pb
WHISKEY CREEK	20810013	61.89619	-161.74487	S21N68W21	EXP PROSPECT	Placer Au-PGE	Low	Au Ag
WHITE MOUNTAIN MINE	20740001	62.18313	-154.84975	S24N30W07	PAST PRODUCER	Silica-carbonate Hg	Low	Hg Sb
WHITE MOUNTAIN SUMMIT	20740090	62.18435	-154.89728	S24N30W11	RAW PROSPECT	Polymetallic veins	Low	Cu Hg Ag
WHITE WING VALLEY (EAST HEAD)	20820051	61.73299	-158.47047	S19N51W14	EXP PROSPECT	Polymetallic veins	Low	Ag Au
WHITEWATER CREEK	20920036	60.8797	-157.5033	S09N47W07	RAW PROSPECT	Placer Au-PGE	Low	Au
WHITEWATER TOURMALINE	20920039	60.92451	-157.44685	S10N46W28	MINERAL LOCATION	Undetermined	Low	GEMSTONE
WILLOW CREEK	20730032	62.37598	-158.07185	S26N47W06	PAST PRODUCER	Placer Au-PGE	High	Au
WILLOW CREEK	20810012	61.807	-161.908	S20N70W24	PAST PRODUCER	Placer Au-PGE	High	Au PGE Ag
WILSON CREEK	20810026	61.87534	-161.89257	S21N69W26	PAST PRODUCER	Placer Au-PGE	Low	PGE Au
WIN	20650037	63.20049	-155.88347	K26S16E30	EXP PROSPECT	Sn-polymetallic veins	High	Zn Sb Ag Au Cu Sn

continued

Name	Mils Id	Latitude	Longitude	MTRS	Current Status	Deposit Type	Potential	Commodities
WINDY FORK CLIFF	20740109	62.04536	-154.07023	S23N26W32	EXP PROSPECT	Thorium-rare-earth veins	Low	Th U
WINDY FORK PLACER	20740108	62.06936	-154.06222	S23N26W21	EXP PROSPECT	Alluvial placer Sn	Medium	RARE EARTH Zr Ti
WINDY FORK PLUTON - NORTH	20740131	62.03881	-154.05889	S23N26W33	RAW PROSPECT	Thorium-rare-earth veins	Low	RARE EARTH U Ti Zn Zr Cu
WINDY FORK SOUTHEAST	20740120	62.12937	-153.92822	S24N25W31	EXP PROSPECT	Sedimentary exhalative Zn-Pb	Low	Ag Zn
WINDY FORK TRIB -TRIMOKISH HILLSIDE	20740006	62.2027	-154.1725	S24N27W02	EXP PROSPECT	Thorium-rare-earth veins	Low	RARE EARTH Zr Ti
WOLF CREEK MOUNTAIN	20720004	62.36646	-161.40733	S26N65W06	MINERAL LOCATION	Epithermal quartz-alunite Au	Low	As Sb Hg
WYOMING CREEK LODE	20650003	63.57439	-155.93431	K22S15E22	EXP PROSPECT	Simple Sb deposits	Low	Sb Hg
WYRICK LODE	20730067	62.35394	-156.98186	S26N42W12	EXP PROSPECT	Simple Sb deposits	Medium	Sb Au Ag Pb Hg
YANKEE CREEK (LOWER)	20640014	63.00846	-156.36756	K29S13E03	PAST PRODUCER	Placer Au-PGE	High	Au Cr
YANKEE CREEK (UPPER)	20730039	62.97058	-156.40434	S33N38W01	PRODUCER	Placer Au-PGE	High	Au
YELLOW JACKET LODE	20810039	61.22314	-159.79855	S13N59W14	EXP PROSPECT	Felsic-dike-hosted qtz veinlets w/Au	Low	Au
YUSHUR	20730086	62.22021	-158.41605	S25N49W32	MINERAL LOCATION	Silica-carbonate Hg	Low	Hg W Ba As Sb

APPENDIX C

Explanation of Mineral Potential Scores

BERING SEA – WESTERN INTERIOR PLANNING AREA

Explanation of Mineral Potential Scores	
MRTS [Meridian, Township, Range, and Section]	This is the Legal Land Description according to the Public Land System. It is listed in order by Meridian, Township, Range and Section. The Bering Sea-Western Interior Planning Area contains areas of the Kateel River and Seward Meridians. The list is first sorted alphabetically and then numerically.
Total Score	This is the sum of the Mineral Potential Score as described in Section IV part 2 of this report (Application of potential ratings) and **Figure 31**.
Placer-Producing Area	This is the score associated with the intersection of a single section of land and the area of known placer mine production.
Sum of AMIS Site Scores	This is the sum of the mineral potential scores of all the AMIS mineral occurrences that intersect an individual section of land.
Mineral Terrane Area	This is the score associated with intersection of a section of land with one of the Mineral Terranes outlined in *Mineral Terranes of Alaska* published by the U.S. Bureau of Mines (1995).
2003 State Claim	When a section of land intersected a State mining claim or State prospecting site active in May 2003, it received a score of 5.
2008 State Prospecting Site	When a section of land intersected a State prospecting site active in May 2008, it received a score of 5. *Note: In 2003, state prospecting sites were saved in the same computer files as mining claims.*
2003 Federal Claim	When a section of land intersected a Federal mining claim active in May 2003, it received a score of 5.
2008 Federal Claim	When a section of land intersected a Federal mining claim active in November 2008, it received a score of 5.
2008 State Claim	When a section of land intersected a State mining claim active in November 2008, it received a score of 5.
Land Status	When a section of land intersected State-selected parcels and Native Corporation-selected or patented parcels, it received a score of 1; all other lands received no score.
Mineral Survey	A section of land that intersected mineral surveyed lands, as noted on BLM Master Title Plats, received a score of 10.
Mineral Patent:	A section of land that intersected patented mining claims, as noted on BLM Master Title Plats, received a score of 10.

[1] Alaska Statehood Act, Public Law 85-508, 72 Stat. 339, July 7, 1958
[2] Alaska Native Claims Settlement Act (ANCSA), Public Law 92-203, 43 U.S.C. §1601 et seq., December 18, 1971.
[3] Alaska National Interest Lands Conservation Act (ANILCA), Public Law 96-487, 94 Stat. 2371, December 2, 1980.