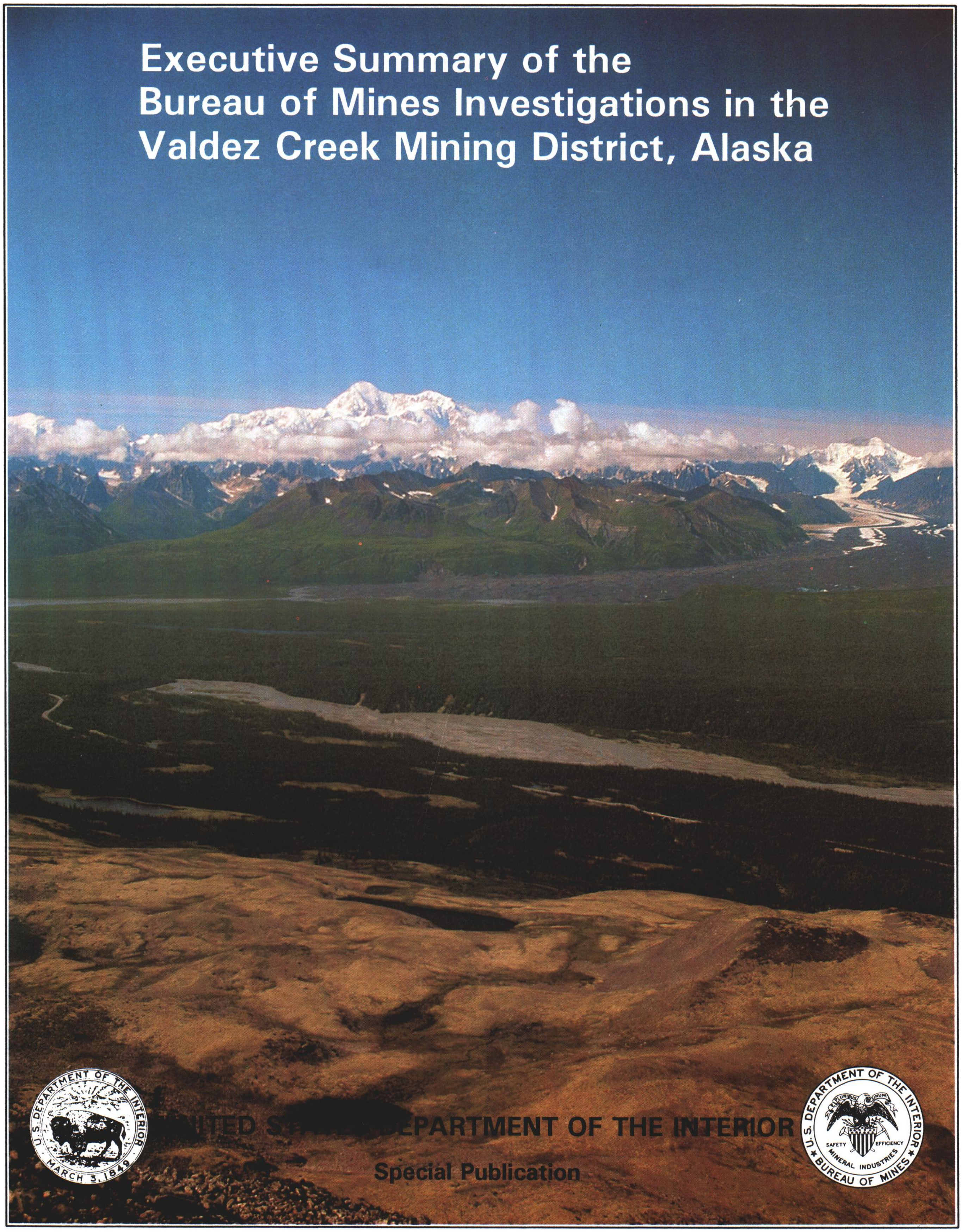
Executive Summary of the Bureau of Mines Investigations in the Valdez Creek Mining District, Alaska



UNITED STATES DEPARTMENT OF THE INTERIOR

Special Publication

COVER - View of Denali and the Chulitna River Valley from the top of Indian Mountain.

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By Michael D. Balen and others

UNITED STATES DEPARTMENT OF THE INTERIOR
Manuel Lujan, Jr., Secretary

BUREAU OF MINES
T S Ary, Director

Special Publication

FIGURE 1. - Bureau geologist collects a rock sample near the terminus of the Maclaren Glacier.

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

Symbol	Definition
%	percent
°F	degree Fahrenheit
ft	feet, foot
lb	pound
mi^2	square mile
m.s.l.	mean sea level
oz	troy ounce
oz/st	troy ounce per short ton
oz/yd^3	troy ounce per cubic yard
ppb	parts per billion
ppm	parts per million
st	short ton
yd^3	cubic yard

EXECUTIVE SUMMARY
of the
BUREAU OF MINES INVESTIGATIONS
in the
VALDEZ CREEK MINING DISTRICT, ALASKA

By Michael D. Balen[1] and others

INTRODUCTION

During the years 1987 through 1989, the Bureau of Mines Alaska Field Operations Center (Bureau) in cooperation with the Western Field Operations Center and the Alaska Division of Geological and Geophysical Surveys (ADGGS), conducted mining, geological, and geochemical investigations in the 5.7 million-acre Valdez Creek Mining District (VCMD). This investigation was conducted as part of the Bureau's continuing Mineral Land Assessment (MLA) mining district studies program.

The Bureau's MLA program is designed to provide reliable and comprehensive mineral resource information that supports mineral resource policy and land use decisions made by Congress and Federal land management agencies. The information also provides the basis for decisions that would expand the domestic supply of important mineral resources, primarily strategic and critical minerals. Much of the MLA work is done jointly with cooperating State or U.S. geological surveys.

Section 1010 of ANILCA[2] authorizes the Secretary of the Department of the Interior to assess the oil, gas, and other mineral potential on all public lands in the State of Alaska in order to expand the data base with respect to the mineral potential of such lands.

Sixty-seven mining districts in Alaska have been defined by Ransome and Kerns (1)[3]. After consultation with State and Federal land managers, mining districts selected for investigation are prioritized by the Bureau on the basis of availability of data, need for additional data, national need for contained commodities, and physical access.

The Bureau's investigative work for each district takes an average of 4 years to complete. The first year is spent in

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[2] *Alaska National Interest Lands Conservation Act.*
[3] *Underlined numbers in parentheses refer to citations that appear in references at the end of this report.*

literature search and data compilation, and initial field reconnaissance of the mining district. During the second and third years, field work to acquire all data necessary to establish the mineral data base on which the evaluation is based is conducted. The fourth year is devoted to compilation of all data, completion of complementary studies from data acquired in the first three years, and preparation of the final report. The final product is published as an executive summary and special publication. During the course of the project, open file reports (OFR) are published yearly which describe the work completed to date and the significant data collected.

The objectives of the VCMD investigation were to (1) evaluate the mineral resources of the VCMD, (2) perform theoretical mining feasibility studies, (3) study the application of modern beneficiation technologies on known deposits, and (4) perform a probabilistic mineral resource and economic assessment of the mining district.

During the course of the VCMD investigation, Bureau field personnel discovered 19 previously unreported mineral occurrences within the district. Reconnaissance placer sampling resulted in the identification of 10 previously unreported gold placer occurrences, some of which contain subsidiary placer platinum group metals (PGM) or tin, or both. Reconnaissance lode sampling resulted in the identification of 2 gold-silver occurrences, 3 PGM occurrences that contain subsidiary chromium, nickel and/or cobalt, 3 copper occurrences that contain subsidiary molybdenum or zinc, and 1 zinc occurrence.

This document (1) discusses pertinent recent and historical information about the VCMD, (2) summarizes the findings of Bureau work that has been performed in the VCMD to date, and (3) can be used as a principal reference to information on government geological research and mineral resource evaluation in the VCMD.

LOCATION

Located in the south-central portion of Alaska, the VCMD is geographically defined by the portion of the Susitna River drainage basin upstream from the Talkeetna River confluence (fig. 2). Bounded on the north by the crest of the Alaska Range, on the west by the Mt. McKinley massif, on the south by the Talkeetna Mountain Range, and on the east by the Lake Louise Plateau (2), the VCMD encompasses a vast, diverse landscape.

LAND STATUS

The VCMD comprises Federal, State, and private land holdings. Figure 2 shows a generalized land status map for the district. Current land status for specific areas can most accurately be determined by reviewing the Master Title Plats at the Bureau of Land Management (BLM) Public Lands Office in Anchorage, Alaska. Federal lands are administered by the BLM and the National Park Service (NPS); State lands are administered by the Department of Natural Resources (DNR), Division of Land and Water Management.

ACCESS

Portions of the VCMD are accessible from the Parks, Denali, and Glenn Highways, which are the major roads within the district. Poorly maintained mining roads and hunting trails provide limited access to some back-country areas for 4-wheel-drive or off-road vehicles. The most practical method of access to most of the VCMD is

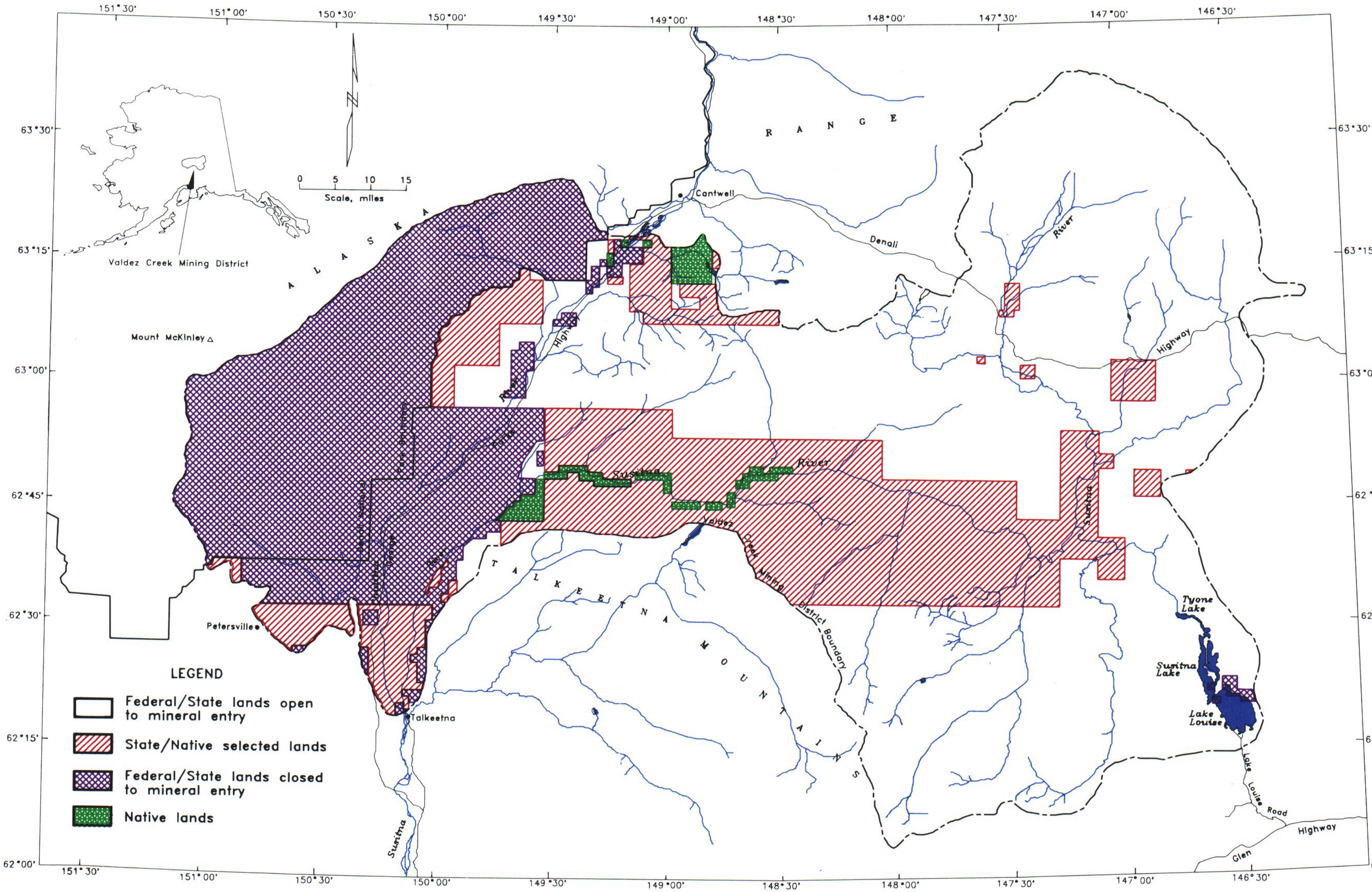

FIGURE 2. - Land status map for the Valdez Creek Mining District, Alaska.

FIGURE 3. - The Black River looking towards the eastern Talkeetna Mountains.

by helicopter or small fixed-wing aircraft. Access by shallow-draft boat is possible on some of the larger rivers such as the Susitna, Chulitna, and Maclaren Rivers. The Alaska Railroad parallels the Parks Highway in the western portion of the district.

PHYSIOGRAPHY

The physical geography of the VCMD comprises a wide variety of features. Periglacial landforms predominate throughout the region. Rugged mountains with elevations as high as the 20,320-ft Mt. McKinley massif host the snow fields that inaugurate the descent of thick glaciers into "U"-shaped valleys. Some glaciers, such as the Ruth, stretch as far as 30 miles from their highest cirques. Approximately 63% (5,598 mi^2) of the land surface within the VCMD is higher than 3,000 ft above mean sea level (m.s.l.), and 6% (536 mi^2) lies higher than 6,000 ft above m.s.l. Treeline throughout the VCMD ranges from 2,500 to 3,000 ft above m.s.l.

The entire district lies within the boreal forest belt that surrounds the globe in the high latitudes of the Northern Hemisphere. Vegetation communities present in the district are classified as members of the taiga biome. Wetlands are vegetated with sedge grasses, tamarack, and stunted black spruce. Low-elevation valley bottoms are vegetated with cottonwood, birch, and white spruce. With increasing elevation, the mixed forest gives way to white spruce and aspen forests. An undergrowth of willow, alder, and sphagnum moss is ubiquitous below treeline. Above treeline, the forest gives way to shrubland and tundra. Figures 3 and 4 show typical views of the VCMD landscape.

Nearly all Alaskan species of wildlife can be found within the VCMD. Moose, caribou, grizzly and black bear are the most visible animals; they range throughout the region. Beaver, muskrat, geese, and ducks populate the wetlands in valley bottoms and lower elevations. Dall sheep and ptarmigan inhabit the high peaks of the Talkeetna Mountains and the Alaska Range. Fox, coyote, wolf, porcupine, marten, mink, lynx, rabbit, grouse, wolverine, and several species of raptor are also VCMD residents.

Cool, rainy summers and cold, snowy winters are the norm throughout most of the district. Average midwinter temperatures range from -10°F to +10°F, and average midsummer temperatures range between +40°F and +60°F. Temperatures as low as -64°F, and wind chill temperatures below -100°F, have been recorded in the district. At the opposite end of the scale, summertime temperature extremes have exceeded +96°F. Seasonal snowfall in the VCMD has exceeded 21 ft in portions of the Chulitna River valley (3).

The VCMD is sparsely populated; most residents live along the major highways. Talkeetna is the largest settlement near the VCMD and has a population of 269. Cantwell, with 150 residents, is the second largest population center near the VCMD. The Valdez Creek Mining Company camp has a population of about 130 persons when the Denali Mine is in operation, and represents the largest settlement actually within the district. Other relatively significant population centers in the VCMD are located at Lake Louise, where less than 100 people live year round, at Busch Creek, where 3 to

FIGURE 4. - View up the Susitna River looking towards the Alaska Range, Clearwater Mountains area.

10 miners work during the summer, and in the Valdez Creek drainage above the Valdez Creek Mine, where 5 to 20 people work placer and lode mines during the summer.

EXPLORATION AND MINING HISTORY

Russian exploration dominates the early historical record of exploitation of the natural resources in Alaska. However, the Russians had little to do with exploration in the VCMD except for a Russian American Company explorer named Rufus Serebrenikoff. Serebrenikoff led one of the last Russian exploration teams into the Alaskan interior in 1847-1848. Penetrating the wilderness further than any previous explorers, Serebrenikoff's expedition traveled into the Copper River basin, possibly reaching the southeastern portion of the VCMD. The expedition ended when the explorers met their untimely deaths at the hands of the Natives. The loss of the Serebrenikoff party dampened the enthusiasm of the Russian American Company for exploration of interior Alaska, and was one of the contributing factors to the Treaty of Cession in 1867, which transferred sovereignty over Alaska to the United States.

After the 1867 treaty, Russian interest in Alaska slowly diminished concurrent with an increase in interest by the United States. The earliest documented U.S. exploration in the VCMD was accomplished by W. G. Jack, who explored for gold in the upper Susitna River headwaters in 1897 (4). Jack reportedly discovered gold at a creek called "Galina" by the local Natives, but lacking excavation equipment, he returned to the Cook Inlet area later that year. Word soon spread of the gold strike on Galina Creek, which was renamed Swollen Creek reportedly in honor of the mosquito population that thrived there (5).

The first documented mineral discovery in the district occurred on August 15, 1903, when a party led by Peter Monahan rediscovered placer gold in the gravel deposits on Swollen Creek (Monahan is given credit by most accounts for the Valdez Creek gold discovery, even though Jack apparently made the discovery several years earlier). Monahan renamed the creek Valdez Creek after the town of Valdez (6). The Valdez Creek placer gold strike sparked an influx of prospectors to the area during the succeeding years. The result of that small gold rush was the discovery of several lode gold deposits, including both the Timberline and Black Creek lodes, around 1906 (6). Figures 5, 6, and 7 show scenes of early mining activity on Valdez Creek.

In 1907, the first significant mineral discovery west of Broad Pass was made by John Coffee on Bryn Mawr Creek (7). Coffee attempted to mine placer gold on the creek, but was unsuccessful due to the low grade of the deposit. Bryn Mawr Creek drains the area around an arsenical gold-silver-copper-lead deposit now known as the Golden Zone Mine. The deposit was discovered in 1912 as a result of interest in the gold placers on Bryn Mawr Creek. The Golden Zone was developed into a mine shortly after its discovery and by 1917, 221 ft of underground workings had been completed. The mine went into production in 1941 and produced gold, silver, copper, and lead during the years 1941 and 1942. World War II forced the shutdown of the mine in 1942. The latest attempt at development, which began at the Golden Zone Mine in 1980 and continued through 1988, involved surface drilling, trenching, and underground development work.

In 1913, a placer gold deposit was

FIGURE 5. - The original adit on the Tammany paleochannel, circa 1915. View of the present location of the Denali placer mine (photo courtesy of U.S. Geological Survey).

discovered on Albert Creek, a tributary to the Nelchina River. The discovery stimulated a gold rush into the Nelchina and Oshetna River drainages in 1914. Prospectors found no other significant concentrations of gold and most gold seekers soon departed the country for more promising areas (8-9).

Lode copper deposits in the Clearwater Mountains and the Maclaren River area were discovered in 1918. Although several copper deposits have undergone significant development work, notably the Denali Copper prospect, Zackly, and the Kathleen Margaret, only the Kathleen Margaret has

FIGURE 6. - Gold sluicing operation on Valdez Creek, circa 1915 (photo courtesy of the U.S. Geological Survey).

recorded very minor production.

In 1922, a ruby silver prospect was discovered on Portage Creek, 3 miles above its confluence with the Susitna River (10). The prospect was slowly developed over many years to the point of production, until World War II forced suspension of development activity. The workings have since caved, and the mill building has collapsed.

Coal was discovered in the Costello Creek drainage around 1911. The Dunkle Coal Mine, located just east of the Golden Zone Mine, was eventually developed and produced 64,000 tons of coal between 1940 and 1954. The mine supplied coal to local mining operations and to consumers along the Alaska Railroad.

In 1984, placer gold prospecting and mining activity on Valdez Creek and its tributaries increased with the startup of the large-scale open pit Denali Mine operated by the Valdez Creek Mining Company (VCMC). Placer gold production from the

FIGURE 7. - Placer mining on Valdez Creek, circa 1920 (photo courtesy of the Anchorage Museum of History and Art).

Denali Mine over the past 5 years has been several times greater than the total previous production for the entire VCMD.

Minor lode gold mining occurred on Black Creek at the Black Creek Lode and on Timberline Creek (tributaries to Valdez Creek) in 1984. Development work has continued at the Black Creek Lode since 1984 through 1990.

ACKNOWLEDGMENTS

The VCMD study was made possible by the effort and expertise contributed by many people. Anchorage Field Operations Center personnel Steve Fechner, Denise Herzog, Mark Meyer, Nathan Rathbun, Chris Roe, and Dennis Southworth added the benefit of their knowledge and the strength of their backs to the project. Western Field Operations Center personnel Peter Gabby, Steve Iverson, Rick Johnson, Andy Leszcykowski, Terry Newman, Steve Schmauch, and Spencee Willett assisted with the field investigations during the first year of the study and deserve many thanks. Recognition for a professional contribution to the project also goes to field assistants Laurie Dilley, Vic Fisher, Gerald Harris, and Dan O'Haire.

The author gratefully acknowledges the expertise contributed to the VCMD project by ADGGS geologists Tom Bundtzen, Laurel Burns, Ellen Harris, Gerald Harris, Jeff Kline, Shirly Liss, Rainer Newberry, Chris Nye, Gar Pessel, Dick Reger, Thomas Smith, Diana Solie, and Milt Wiltse, who conducted geologic mapping and geochemical sampling in the VCMD and assisted with their wide-ranging knowledge of geology and mineral deposits.

The author also wishes to thank local geologists, prospectors, and miners, including Gerald Anderson, Lyle Beecroft, Joe Britton, Frank Celizic, John Dewan, Robert Dupere, Bill Elim, Lee Estes, John Galey, Jr., John Holmgren, John Jacobsen, Stan and Harry Kindblade, Howard and Ed Lightfoot, Paul Lindberg, Joe Malatesta, Leo Mark Anthony, Claude Morris, Daryl Pelke, Henry Peters, A. L. Renshaw, Jr., Earl Sikes, Bill Strauss, Jake Tansey, Danny Thomas, Kevin Thompson, Bob Titchemal, and Angel Vidal for sharing their specialized knowledge of the mining history, geology, and mineralization associated with the occurrences with which they are familiar. The staff of the Valdez Creek Mining Co. provided the Bureau access to their operation on Valdez Creek. Wallace Toupe of Nerco

Minerals Inc. conducted a tour of, and provided geological information about, the Zackly Prospect. Chuck Hawley of Golden Zone Developments, Ltd. provided access to the Golden Zone Mine.

RECENT MINERAL DEVELOPMENT ACTIVITY

Several localities within the VCMD have experienced exploration and mineral development activity in the recent past. The most notable projects are the placer gold mining operation at the Denali Mine (fig. 8), the Denali Copper copper-gold prospect, the Su Claims gold-copper-molybdenum quartz monzonite porphyry, the Golden Zone arsenical gold-silver-copper-lead breccia pipe, the Zackly copper-gold-silver skarn, the Kathleen Margaret copper-gold lode, the Tsusena Creek silver-tin lode prospect, the Coal Creek Tin tin-silver prospect, the Busch Creek gold-PGM placer, and the Tyone Creek-Yacko Creek area gold-PGM placer occurrences (fig. 9).

VALDEZ CREEK AREA

The Valdez Creek area encompasses those properties located within the drainage basin of Valdez Creek. Historically, the area has been and currently is the most active locality for mining and exploration in the VCMD. The area is known for the largest gold producer in the VCMD and one of the largest placer mines in Alaska: the Denali Mine. Located in the lower reaches of Valdez Creek, the mine has produced 243,908 oz of gold, and has moved over 20 million yd^3 of overburden to expose the gold-rich pay gravel. Exploration for placer gold at the Denali Mine has identified resources of 627,000 oz of gold including measured reserves of 316,000 oz (11). After an approximately 1 year suspension of operations due to low gold prices in 1989, exploration has resumed and is planned to continue ahead of the open pit mining operation to further define reserves and provide data for the control of open pit development. The 5-year plan for the mine calls for diversion of Valdez Creek (which is necessary to continue mining the

FIGURE 8. - Denali Mine gold placer open-pit mining operation on Valdez Creek, 1989.

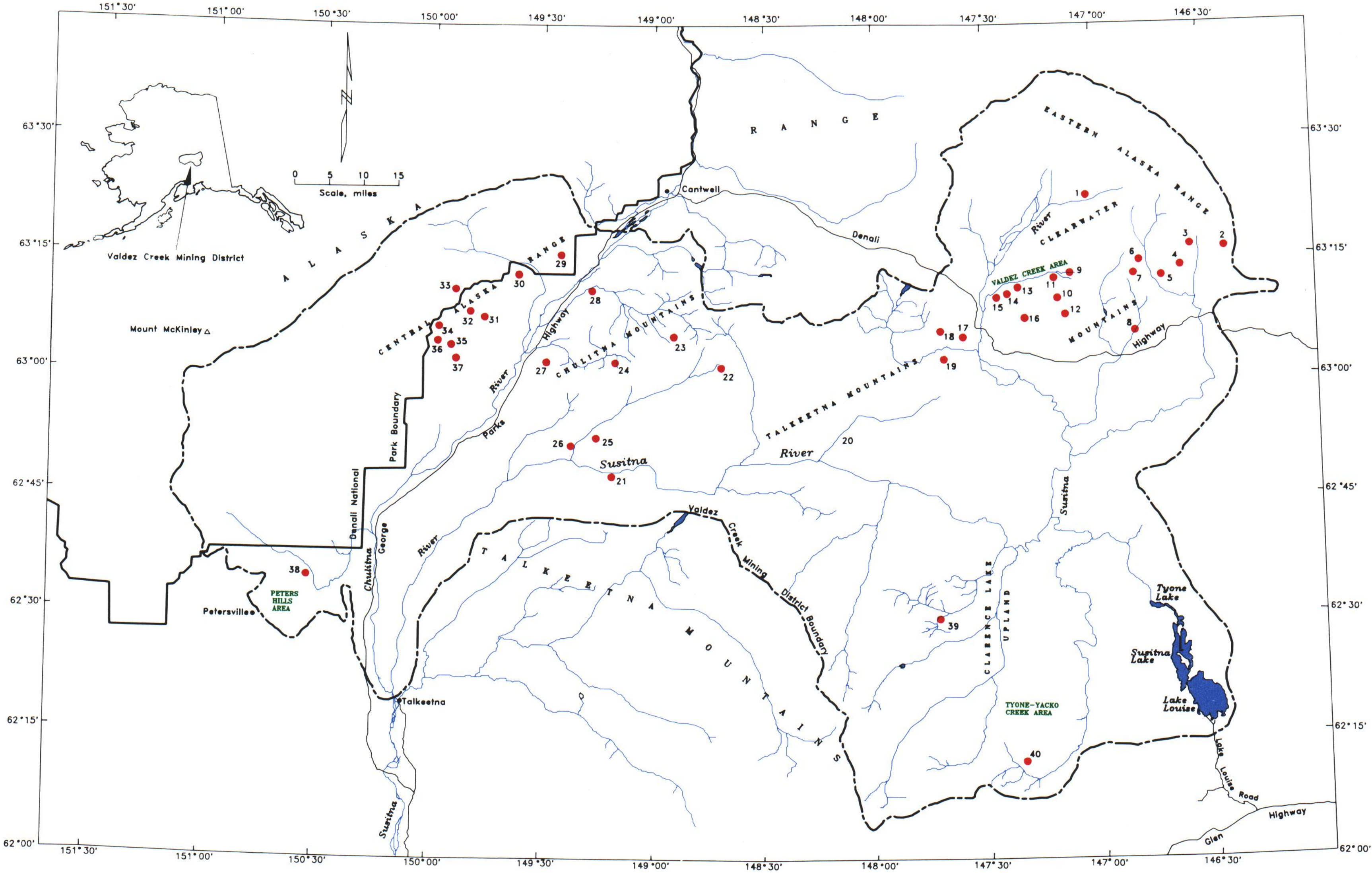

FIGURE 9. - Mineral property location map for selected mineral deposits in the Valdez Creek Mining District, Alaska.

Key for figure 9 - names of mineral properties discussed in this report

EASTERN ALASKA RANGE

1. East Fork Susitna River placer gold occurrence.
2. Eureka Glacier lode PGM occurrence.
3. Kathleen Margaret lode copper-gold prospect.
4. Viking lode copper-gold occurrence.
5. Zackly lode copper-gold-silver prospect.

CLEARWATER MOUNTAINS

6. Gossan lode gold occurrence.
7. Mex Claims lode gold occurrence.
8. Little Clearwater Creek placer gold prospect.
9. Grogg Creek gold placer prospect and Upper Valdez Creek gold placer occurrence.
10. Eldorado Creek lode PGM occurrence and gold placer prospect.
11. Gold/Lucky Hill lode gold prospect and Black Creek lode gold prospect.
12. Denali Copper lode copper prospect.
13. White Creek - Lucky Gulch - Rusty Creek gold placer mines and prospects.
14. Timberline Creek lode gold prospects.
15. Denali Mine placer gold mine.
16. Windy Creek gold placer prospect.

TALKEETNA MOUNTAINS

17. Su Claims lode gold prospect.
18. Gold Creek East lode gold prospect.
19. Peak 5532 lode PGM occurrence.
20. Watana Creek placer gold occurrence.
21. Devils Canyon lode gold-copper-zinc-PGM occurrence.

CHULITNA MOUNTAINS

22. Tsusena Creek lode tin-silver prospect.
23. Green Spike lode copper-silver occurrence.
24. Honolulu Creek placer gold occurrence.
25. Treasure Creek lode molybdenum prospect.
26. Mint Mine lode silver prospect.
27. Honolulu lode tin-silver prospect.
28. East Fork Chulitna River placer gold occurrence.

CENTRAL ALASKA RANGE

29. Colorado Creek area lode gold-silver occurrences and prospects.
30. Golden Zone Mine.
31. Christy Creek Chromite occurrence.
32. Ready Cash lode tin-silver prospect.
33. Ohio Creek lode tin prospect.
34. McCallie Glacier lode gold occurrence.
35. Shotgun Creek lode PGM occurrence.
36. Partin Creek lode gold occurrence.
37. Coal Creek Tin prospect.

PETERS HILLS AREA

38. Peters Hills area placer gold mines, prospects, and occurrences.

TYONE CREEK - YACKO CREEK AREA

39. Busch Creek gold-PGM-placer mine.
40. Tyone Creek - Yacko Creek area gold-PGM-placer mines, prospects, and occurrences.

deposit) and for full capacity production. Figure 8 shows the open-pit mining operation at Denali Mine as it was in 1989.

Other important placer gold producers or exploration projects in the area exist on White Creek, Lucky Gulch, Eldorado Creek, Grogg Creek, Rusty Creek, upper Valdez Creek, and Windy Creek (fig. 9).

The Gold Hill-Lucky Hill area, also known as the Rainbow Hill property, is located upstream of the Denali Mine and has been identified as a possible source for the placer gold that exists in the Valdez Creek drainage. The property is currently being explored for economic lode gold resources.

Minor lode gold mining occurred at the Black Creek Lode on Black Creek near the headwaters of Valdez Creek, in 1984. Bureau personnel observed development work and small scale lode mining there in 1987 through 1989. The mine has recorded production of small quantities of gold. Mine operators commenced the development of a new adit in 1990.

DENALI COPPER

The historical record of the Denali Copper prospect includes references to the many early prospectors who set foot on the deposit, or saw signs of copper mineralization from the air or nearby mountains (12). However, the deposit was not well known until 1964 when the occurrence was first reported in literature published by the State of Alaska, Department of Natural Resources (13). Between 1964 and 1971, the occurrence was subjected to a concerted attempt at development through surface trenching, diamond drilling, and an underground exploration program (12). The exploration efforts indicated that the Denali Copper prospect is a series of at least six stratiform, volcanogenic, massive sulfide copper deposits of the Kuroko or Besshi type (14). The property has essentially had little development work performed since 1971, and only maintenance level work is currently being conducted. Most of the surface facilities were destroyed by a large avalanche during the winter of 1989.

SU CLAIMS

The Su Claims overlie a mineralized quartz monzonite stock that cuts hornfelsed and propylitized siltstone and argillite. The prospect is located in the Butte Creek region of the Central Talkeetna Mountains. The Su Claims have drill holes scattered across the property, which were drilled during the period between 1975-1990. The latest exploration activity on the prospect involved a drilling, geophysical, and surface geochemical investigation. Drill results from one hole show a 10-ft thick mineralized intercept containing up to 0.39 oz/st gold. Trenching has exposed a 230-ft thick interval containing 410 ppb gold.

GOLDEN ZONE

The Golden Zone Mine (fig. 10), located 12 air miles southwest of Cantwell, is an arsenical gold-silver-copper-lead-bearing intrusive breccia pipe that produced more than 1,500 oz of gold, 8,600 oz of silver, 21 st of copper, and 3,000 lb of lead during the years 1941-1942 (15). World War II forced the closure of the mine by Executive order in 1942. Exploration over the years following the end of the war involved sporadic episodes of trenching, geophysics, and drilling by both private organizations and by the Bureau. During the years 1949-1952, the Bureau was involved in drilling and metallurgical testing of the ore (16). Additional drilling and underground

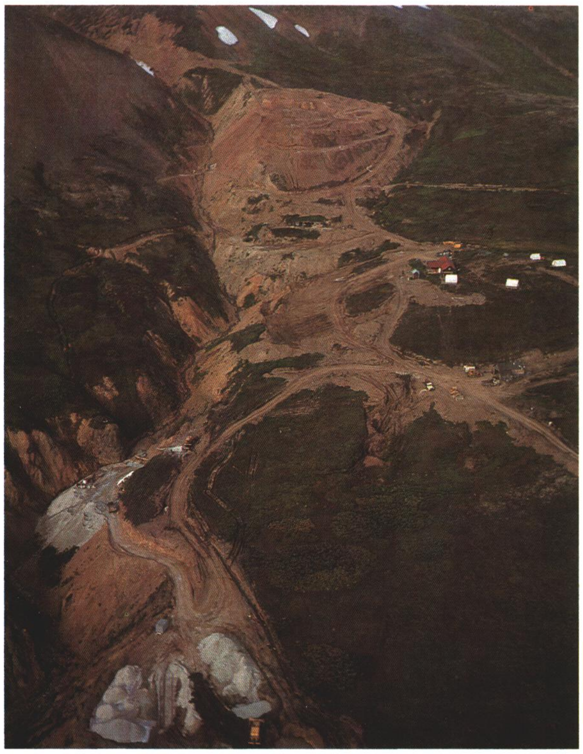

FIGURE 10. - Aerial view of the Golden Zone Mine, 1988.

development occurred on the property between 1980-1989.

The development of the Golden Zone to its full potential has suffered because the ore in the deposit is a complex sulfide with high concentrations of arsenic. This combination of factors causes very low metal recoveries using conventional vat leach and flotation milling processes.

ZACKLY

The Zackly copper-gold-silver skarn deposit has been subjected to intensive exploration between its 1979 discovery and 1987 (17). The deposit, located in the Eastern Alaska Range, was originally located as a copper prospect, however, subsequent drilling has shown that there are considerable precious metal concentrations in the ore. Development and exploration activity at the deposit has been minimal over the past few years.

KATHLEEN MARGARET

The Kathleen Margaret prospect is a basalt hosted copper-gold quartz vein located west of the terminus of the Maclaren Glacier. The prospect was discovered in 1952 (18-19), and underwent development work that included trenching, drilling, and underground excavation during the years 1953-1959. Small amounts of copper, gold, and silver were recovered from the deposit during this period. Exploration (trenching) occurred again in 1965, and also in 1988. The property is currently idle, and the portal to the underground workings has caved.

The Bureau conducted beneficiation testing of the ore in the 1950's, and reported that the ore was readily amenable to standard flotation beneficiation methods for copper ores (16).

TSUSENA CREEK PROSPECT

The Tsusena Creek prospect was discovered in 1973 after a reconnaissance geological exploration team collected samples from a tributary to Tsusena Creek that contained anomalous silver concentrations (20). The occurrence was staked by Resource Associates of Alaska in 1979 when silver prices rose and the mineral resource potential of the area became more clearly understood. Detailed geologic mapping and geophysical exploration occurred on the property during 1980 and 1981. Four mineralized areas exhibiting sulfide-bearing veins and shear zones were discovered as a result of the work. The Tsusena Creek property is currently idle, and Resource Associates have dropped their claims on the prospect.

COAL CREEK TIN PROSPECT

The Coal Creek Tin prospect is a tin-bearing sheeted greisen vein system associated with aplite granite (21). Mineralization consists of tin-silver-copper-zinc-bearing greisen veins. The prospect was drilled in 1983, and the results indicate a 5 million ton deposit grading 0.2% tin (22). The prospect is currently idle.

BUSCH CREEK

Prior to 1977, small scale placer gold mining had occurred intermittently on Busch Creek since the early 1900's. In 1977, a medium sized mining operation began that, when in operation, produced up to 1,000 bank cubic yards of pay gravel per day (fig. 11). Mine operators recovered a total of approximately 150 oz of gold prior to 1989 when the operation ceased mining activity. The property is currently idle. Placer platinum and gold were first documented on Busch Creek by the U.S. Geological Survey in 1978 (23).

YACKO CREEK - TYONE CREEK AREA

Placer gold was discovered in the Yacko-Tyone Creek area around 1914 (8). Since that time, there has been considerable, but sporadic exploration and mining activity in the area. Small scale placer mining has taken place on Tyone Creek, Daisy Creek, and Yacko Creek resulting in approximately 10,000 oz of gold production. Both Tyone Creek and Yacko Creek currently have active mining claims staked over nearly their entire length. All mining activity on both creeks has recently ceased.

FIGURE 11.- Mining operation on Busch Creek showing the jig plant gold recovery system.

REGIONAL GEOLOGY[4]

The VCMD lies generally south of the east-west trending Denali Fault and is cut by the Talkeetna Fault system trending northeast-southwest through the center of the district (fig. 12). These major structural features roughly separate distinct geologic regions, or tectonostratigraphic terranes, interpreted to have evolved under different geologic conditions. To the north, rock units north or within splays of the Denali Fault represent Paleozoic through earliest Mesozoic oceanic sediments of the Dillinger Terrane (24), Aurora Peak Terrane (25), and North American craton or Yukon Tanana Terrane (24). The region immediately south of the Denali Fault lies within the Kahiltna Terrane (24), and is composed of Jura-Cretaceous marine clastic sedimentary rocks intruded by upper Mesozoic and Cenozoic granitic plutons. Sediments of the Kahiltna Terrane are thought to represent a flysch basin formed as the land mass south of the Talkeetna Fault system, termed the Talkeetna Superterrane (26), converged with the North American Continent in Mesozoic time. Stratigraphy of the Talkeetna Superterrane represents several volcanic arcs, which range from pre-Permian through Jurassic in age; the Talkeetna Superterrane includes Wrangellia Terrane (24) to the north and Peninsular Terrane (24) to the south. Wrangellia and Peninsular Terranes may at one time have been discrete land masses. Since the accretion of the Talkeetna Superterrane to North America and the closing of the intervening flysch basin in Mesozoic time, Tertiary volcanism and shallowly emplaced intrusives have affected the region. Other evidence of young tectonism in the region is found in the displacement of the Denali Fault system, where more than 240 miles of right-lateral movement is possible (27), mostly from late Mesozoic through Cenozoic time, and in the continental fluvial deposits of Tertiary age found, in some places, perched well above present streams. Glacial drift from at least five glaciations, ranging in age from pre-Illinoian (more than 1.7 million years ago) to Holocene (less than 9,500 years ago), cap the bedrock geology (28).

DEPOSIT TYPES

The mineral deposits that occur within the VCMD were described and classified into a scheme that resulted from the probabilistic mineral assessment of the VCMD (29). The classification system is based on the geology, standard chemical analyses, thin section studies, major/minor oxide rock analyses, lead and sulfur isotope studies, trace element studies, and microprobe analyses of key ore and alteration minerals from samples collected at the mineral occurrence. Where there was insufficient field, petrographic, trace element, and/or isotopic data to arrive at a definitive classification for a mineral occurrence, a mathematical discriminant analysis was employed based on the geochemistry of samples collected from the occurrence. Table 1 shows the 14 unique types of mineral deposits that were identified by the discriminant analysis classification procedure.

BUREAU INVESTIGATION

The VCMD investigation was initiated by collecting available historical data

[4] *By K. H. Clautice, Geologist, Alaska Division of Geological and Geophysical Surveys, Fairbanks, Alaska.*

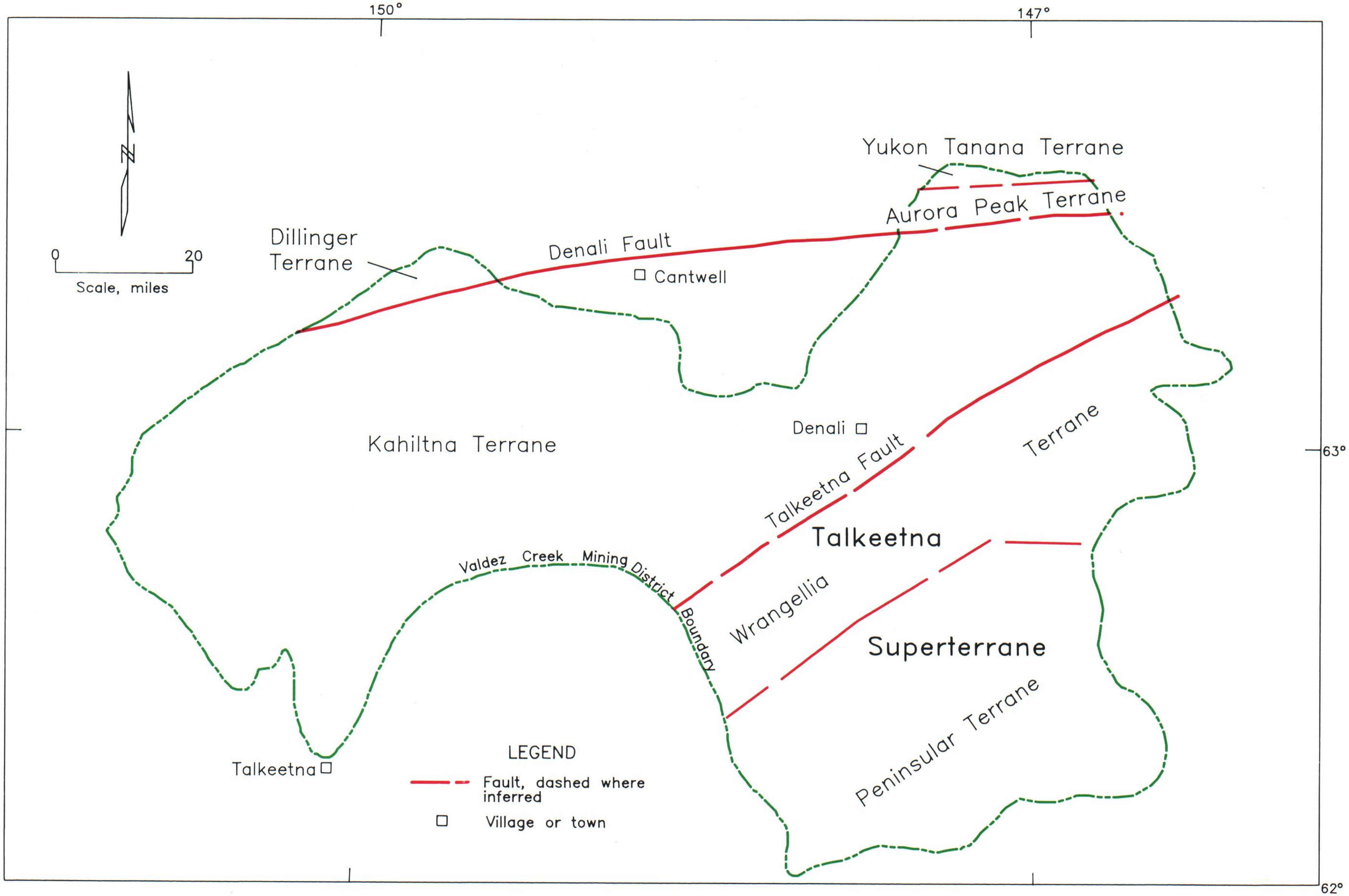

FIGURE 12. - Generalized geologic terrane map for the Valdez Creek Mining District, Alaska.

Deposit type	Description
Plutonic related vein and replacement gold deposits.	Vein and replacement deposits are spatially associated with granitic rocks. Ore mineralogy features arsenopyrite, pyrite, pyrrhotite, and stibnite.
Tin-silver-base metal polymetallic veins.	Polymetallic veins spatially associated with the tops of highly evolved "tin granites". Ore mineralogy features cassiterite, arsenopyrite, sphalerite, galena, pyrite, and chalcopyrite.
Tin greisen deposits.	Stockwork and disseminated vein aggregate ores associated with the tops of highly evolved "tin granites". Ore mineralogy features cassiterite, stannite, arsenopyrite, sphalerite, galena, pyrite, and chalcopyrite.
Copper-gold skarns.	Skarn deposits are hosted in carbonate-rich rocks near the contact with plutonic granitic rocks. Ore minerals include bornite, pyrite, magnetite, chalcopyrite and pyrrhotite.
Porphyry copper ± gold deposits.	Deposits are hosted above, and/or in the tops of granitic bodies that exhibit porphyry textures. Some deposits are associated with porphyry dikes. Ore mineralogy includes pyrite, chalcopyrite, bornite, and magnetite.
Porphyry molybdenum deposits.	Deposits are hosted above, and/or in the tops of granitic bodies that exhibit porphyry textures. Ore minerals include molybdenite, pyrite, chalcopyrite, and scheelite.
Kuroko type volcanogenic massive sulfide deposits.	Deposits are hosted at the interface region between submarine volcanic and sedimentary rocks. Ore mineralogy includes pyrite, pyrrhotite, sphalerite, chalcopyrite, galena, and barite.
Metamorphic gold vein deposits.	Vein deposits are hosted in alkalic plutons that have been metamorphosed to greenschist/amphibolite grade. Ore mineralogy includes pyrite, chalcopyrite, sphalerite, gold tellurides, and rare tetrahedrite, galena, and arsenopyrite.
Carlin-type gold deposits.	Carlin-type deposits occur in silty to sandy thin-bedded carbonaceous siltstone or carbonate rock. High-angle faults have been identified as conduits for hydrothermal fluids. Intermediate composition plutonic rocks are spatially associated and may represent a fluid source. Ore mineralogy includes native gold, pyrite, cinnabar, stibnite, realgar, orpiment, and scheelite.
Basalt hosted copper deposits.	Deposits occur in copper-rich, rift-related basalt. Deposits are thought to form during low-grade metamorphism. Most occurrences are associated with overlying copper-bearing sedimentary rocks. Ore mineralogy includes chalcopyrite and silver-bearing bornite.
Basalt-associated, sediment-hosted copper deposits.	Deposits occur in association with copper-rich, rift-related basalt. Deposits are thought to form during low-grade metamorphism. Most occurrences are hosted in overlying copper-bearing sedimentary rocks. Ore mineralogy includes chalcocite or pyrite and chalcopyrite, depending on the type of host rock.
Podiform chromite deposits.	Deposits are hosted in ophiolite complexes. Ore mineralogy includes chromite, magnetite, and awurite. Platinum, osmium, and iridium may also be present.
Mafic-ultramafic-hosted platinum-group-metal sulfide deposits.	Magmatic sulfide deposits are associated with mafic-ultramafic sills and dikes. Ore mineralogy includes pyrrhotite, pentlandite, chalcopyrite, and nickel, platinum and palladium sulfide minerals.
Placer gold ± platinum	Due to the geomorphic variables present in the VCMD, placer deposits can occur in almost any geologic setting. Typically, deposits form in a rough spatial association with the lode sources of the metals present in the deposit. Ore mineralogy includes native gold and platinum-group metals.

TABLE 1. - VCMD deposit types and descriptions.

concerning the exploration and mining history, geology, and mineral occurrences associated with the district. This information was organized into a data base that was used throughout the project. Through the use of the data base, Bureau personnel were able to locate and field check the existence of reported mineral occurrences.

Field work performed by the Bureau encompassed district-wide reconnaissance geochemical rock and placer sampling and the detailed examination of 176 of the 218 previously known mineral occurrences in the district. Of the 42 occurrences not visited, 13 were located inside Denali National Park and Preserve, 11 were located but could not be investigated safely due to rugged terrain, and 18 could not be located on the ground. The Bureau collected and analyzed 1,632 rock and 781 placer samples, and had 7 bulk samples tested for beneficiation characteristics.

Bureau field personnel were responsible for discovering 19 previously unreported mineral occurrences within the VCMD during the course of the investigation. Reconnaissance placer sampling resulted in the identification of 10 previously unreported gold placer occurrences, some of which contain subsidiary placer platinum group metals (PGM) or tin, or both. Reconnaissance lode sampling resulted in the identification of 2 gold-silver occurrences, 3 PGM occurrences that contain subsidiary chromium, nickel and/or cobalt, 3 copper occurrences that contain subsidiary molybdenum or zinc, and 1 zinc occurrence.

Bureau personnel have written 8 of the 24 documents that have been published as a result of the VCMD investigation. Table 2 summarizes the names of these documents. Included is a comprehensive compilation of the geochemical sampling results (32), and a detailed discussion of the Bureau's investigation of each mineral occurrence, prospect, mine, and previously unreported occurrence in the district (33).

The ADGGS conducted geologic mapping and geochemical sampling of selected areas in the VCMD and produced several new geologic and geochemical reports concerning portions of the mining district, including the first-ever published geologic map of the entire district (28, 37-49). The Bureau and the ADGGS participated jointly in conducting a probabilistic mineral resource and economic assessment of the mining district in 1990 (29).

Title	Publication	
	Date	Type
Results of 1987 Bureau of Mines Investigations in the Valdez Creek Mining District, Alaska (30)	1988	OFR
Results of 1988 Bureau of Mines Investigations in the Valdez Creek Mining District, Alaska (31)	1989	OFR
Geochemical Sampling Results From Bureau of Mines Investigations in the Valdez Creek Mining District, Alaska (32)	1990	OFR
Mineral Investigations in the Valdez Creek Mining District, South-Central Alaska (Final Report) (33)	1991	OFR
Industrial Minerals of the Valdez Creek Mining District, Alaska (34)	1990	OFR
Gold- and PGM-Bearing Conglomerate of the Valdez Creek Mining District, Alaska (35)	1990	OFR
The Feasibility of Mining in the Valdez Creek Mining District, Alaska (36)	1990	OFR

TABLE 2. - Publications by Bureau authors resulting from the VCMD investigation.

SAMPLING

The Bureau collected two basic types of samples: (1) rock samples, and (2) placer samples. Rock samples consisted of fresh, altered, or mineralized material and were collected from outcrop, rubble crop, underground workings, or float. Placer samples were collected from river bars, flood plains, alluvial fans, colluvial fans, or alluvial benches. Two basic types of procedures were employed when collecting either rock or placer samples: (1) reconnaissance sampling, and (2) sampling previously known mineral occurrences. Reconnaissance sampling procedures involved collection of placer or rock samples, or both, from those regions in the VCMD where little or no historical information existed about mineral occurrences. Sampling previously known mineral occurrences involved geologic mapping of the occurrences and the collection of rock or placer samples, or both, depending on the type of mineral occurrence. A complete compilation of results of the geochemical analysis of samples collected by the Bureau in the VCMD is available in an OFR (32).

Bureau personnel also collected 7 bulk mineralogical samples from select mineral occurrences in the district. These samples were analyzed at the Bureau of Mines Salt Lake Research Center in Salt Lake City, Utah. Results of the analysis of the bulk mineralogical samples are published in the final report (33).

CLARENCE LAKE UPLAND

The Clarence Lake Upland is a sub-physiographic province within and along the eastern edge of the Talkeetna Mountains physiographic province (fig. 13). Within the Clarence Lake Upland region, there are several significant gold- and PGM-placer deposits in the Tyone Creek-Yacko Creek area, and on Busch Creek (fig. 9).

The Bureau conducted site-specific evaluations of the Tyone Creek-Yacko Creek area to investigate the occurrence of gold

FIGURE 13. - Bureau geologist collecting a sample near the headwaters of the Black River, Talkeetna Mountains physiographic province.

and PGM in the placers (35). The investigation focused on sampling the Jurassic and Tertiary conglomerate rock units found throughout the area to test the theory that these rocks are the source of precious metals in the local placer occurrences. Bureau stream placer sampling in the Tyone Creek-Yacko Creek area recovered as much as 0.0212 oz/yd^3 gold. Samples that contained the highest placer gold grades were collected from mining cuts on Upper Red Fox Creek, a tributary to Tyone Creek. PGM grains existed in samples collected from several creeks in the area, however, the quantity recovered was too small to estimate a PGM ore grade. Stream drainages that contain PGM- and gold-bearing gravel correlate well with drainages that have eroded Jurassic and Tertiary conglomerate rock units.

Samples collected from the Jurassic conglomerate rock unit in the Tyone Creek-Yacko Creek area contained as much as 0.0001 oz/yd^3 gold, but contained no visible PGM. Trace concentrations of PGM were detected in the analysis of the heavy mineral concentrate portion of the samples.

The Tyone Creek-Yacko Creek area Tertiary conglomerate rock unit generally contained more gold and PGM than its Jurassic counterpart. Gold was recovered in quantities as high as 0.0027 oz/yd^3 and platinum grains were visible in some samples. Analysis of the heavy mineral portion of the samples resulted in the detection of as much as 280 ppb platinum and 6 ppb palladium.

The Bureau investigated the gold-PGM placer deposit at Busch Creek in 1987 and 1988 and confirmed the existence of the reported placer platinum (30-31). Samples collected at the Busch Creek gold-PGM placer mine contained as much as 0.012 oz/yd^3 gold. Placer sample concentrates contained as much as 120 ppb palladium and 1,060 ppb platinum. The Bureau investigation also noted that the deposit contains abundant amounts of magnetite. The large amounts of magnetite impeded the efficiency of both the Bureau's sampling equipment and the gold recovery system employed by the mine operators by overloading concentrate collection points. The Bureau's sampling procedure was easily modified to account for the large quantity of magnetite. However, the mining operation suffered because of the difficulty experienced in extracting small particle size gold from the large volumes of concentrate that were recovered from the deposit.

In the Granite Creek headwaters, the Bureau investigated the occurrence of hydrothermal mineralization that occurs along a narrow, steeply dipping gouge zone at the fault contact between intrusive and volcanic rocks. Samples collected from the 3.5 ft wide by 350 ft long zone contained up to 0.87% zinc and 0.87% copper. Select pieces of float contained up to 1.5 oz/st silver, 5.8% copper and 2.4% zinc.

PETERS HILLS

The Peters Hills area is located in the western most region of the VCMD, south of Mt. McKinley and west of Talkeetna (fig. 9). The Bureau collected placer samples from creeks and from conglomerate bedrock outcrops to evaluate the gold-PGM-placer resources and to investigate the reportedly auriferous Sterling Formation conglomerate unit that exists throughout the area (35). Samples collected from the alluvial gravel in the Peters Hills area contained as much as 0.014 oz/yd^3 gold. The highest grade placer gold was recovered from samples collected from small areas in the creeks where mining had not taken place. Visible PGM was not recovered from any of the samples collected in the Peters Hills area. PGM was detected however, in some sample concentrates at levels up to 800 ppb platinum. In 1919, platinum grains were reportedly observed in samples collected from two creeks in the area, namely Canyon Creek and Poorman Creek (50).

Samples collected from the Sterling Formation contained as much as 0.007 oz/yd^3 gold. The Bureau has concluded that the Sterling Formation is clearly a source of the placer gold in the local drainages, and has inferred that there are 21,000,000 yd^3 of subeconomic gold-bearing conglomerate in the area (35).

CENTRAL ALASKA RANGE

The southern portion of the Central Alaska Range physiographic province incorporates the northwest third of the VCMD, and is one of the most geologically diverse and mineralogically significant areas in the district. The area encompasses the Chulitna trend (51), which has a strong northeasterly trending grain demonstrated by the orientation of sedimentary rock layers, faults, and elongated intrusive bodies. Sedimentary rock units in the area include argillite, greywacke, red beds, limestone, and chert. Portions of the sedimentary rock package are interlayered with volcanic rocks. The sedimentary rocks have been intruded in many areas by plutonic rocks ranging in composition from ultramafic to felsic (51). A total of 46 mineral occurrences are known in the Central Alaska Range area (fig. 9).

Epigenetic mineral occurrences associated mainly with plutonic rocks are found throughout the entire area. The mineral occurrences in the Colorado Creek and the Long Creek localities have been shown to be associated with small diorite porphyry stocks or small quartz porphyry plugs, and are known for vein, breccia, stockwork, and disseminated deposits that can contain gold, or copper and silver in addition to zinc, molybdenum, tin, cadmium, or bismuth (51). The mineralized areas of the Colorado Creek locality were not evaluated by the Bureau during the VCMD investigation because of access restrictions into Denali National Park and Preserve. Occurrences of note in the Long Creek vicinity are the Golden Zone arsenical gold-silver-copper-lead bearing breccia pipe deposit, the Lookout Mountain silver-lead-zinc quartz porphyry, and the Copper King massive sulfide copper-silver replacement deposit. The Golden Zone was not evaluated in great detail during the VCMD investigation because of the large volume of previously written information that exists about the deposit. Several samples, however, were collected from rock faces exposed during development work that took place in 1988. The highest grade samples contained greater than 0.29 oz/st gold, and as much as 1.67 oz/st silver, 0.21% copper, 0.04% lead, and 0.01% zinc.

Cyanide amenability tests were conducted by the Bureau's Salt Lake Research Center on a bulk sample of ore from the Golden Zone Mine. Test results show that 22% of the gold is encapsulated in particles smaller than -325 mesh, indicating that special techniques will have to be employed to liberate the gold.

Mining feasibility studies have been conducted for a "generic" deposit modeled after the Golden Zone deposit. The feasibility studies have shown that the "generic" deposit is sub-economic due mainly to the difficulty in recovering metals from refractory ore. The mining operation model that was applied to the deposit model

FIGURE 14. - Bureau geologist at the discovery outcrop of the McCallie Glacier occurrence.

exceeded a 15% rate of return when the value of the metal recovered from the ore exceeded \$262/st of ore (36, 52).

A tin-silver-base metal polymetallic vein occurrence known as the Ready Cash, and a tin greisen known as the Ohio Creek Tin occurrence are mineral deposits of significance in the Ohio Creek drainage. The Ready Cash is a system of sheeted sulfide veins as wide as 9 ft and of undetermined length. Bureau samples contained concentrations as high as 0.205 oz/st gold, 54.9 oz/st silver, 0.39% tin, 1.8% copper, 4.11% lead, and 9.19% zinc. The Ohio Creek Tin occurrence was not visited by the Bureau during this study because of access restrictions into Denali National Park and Preserve, however, the Bureau has previously investigated the occurrence (53).

The Partin Creek polymetallic sulfide vein occurrence is associated with plutonic rocks, and is known mainly as a gold prospect. The Bureau collected samples at the prospect that contained as much as 1.602 oz/st gold, 21.9 oz/st silver, and 1.7% copper.

A discovery made by the Bureau known as the McCallie Glacier occurrence (fig. 14) is located at the head of McCallie Creek. The occurrence consists of disseminated sulfides and stockwork veinlets hosted in silicified metavolcanic rocks. The area affected by sulfide mineralization is as much as 100 ft wide, and of undetermined length. Bureau samples collected from the occurrence contained as much as 0.878 oz/st gold, 4.41 oz/st silver, 1.79% lead, 1.2% zinc, and 4.03% antimony.

Magmatic mineral occurrences associated with the ultramafic and mafic rocks in the Central Alaska Range exist in a northeasterly

FIGURE 15. - Bureau geologist examining the ultramafic occurrence in the Butte Creek drainage.

trending belt that lies on the outer flanks of the southern edge of the central Alaska Range. The occurrences consist of small pods of sulfide minerals intimately associated with serpentenites. Mineralization can include chromite- and nickel-bearing minerals as well as copper, arsenic, gold, and trace amounts of platinum. Bureau samples collected from the Shotgun Creek Lode contained the highest levels of copper (4.79%), nickel (2,178 ppm), platinum (30 ppb), and palladium (16 ppb) that were detected in magmatic mineral occurrences associated with mafic and ultramafic rocks in the area. The Christy Creek Chromite occurrence located at the head of Christy Creek contained ultramafic rocks with chromium concentrations exceeding 1.0%.

TALKEETNA MOUNTAINS

The VCMD includes within its boundary, the northern half of the Talkeetna Mountain physiographic province. Mineral occurrences of significance in this area include the PGM-chromium-nickel-copper ultramafic magmatic-sulfide occurrence in the Butte Creek drainage (fig. 15), the Su Claims gold-molybdenum-copper porphyry, the Gold Creek East gold-silver occurrence, and the Devils Canyon occurrence (fig. 9).

The occurrence known as Peak 5532 was discovered by the Bureau and exists in a belt of ultramafic rocks that trend for 7.5 miles in a northeasterly direction through the mountains south of Butte Creek. Samples collected at the Peak 5532 occurrence contained as much as 0.41% chromium, 0.15% copper, 0.11% nickel, 28 ppb palladium, and 140 ppb platinum.

Porphyry mineralization at the Su Claims prospect is associated with a quartz monzonite stock that has intruded and altered siltstone and sandstone. Alteration products include hornfelsed and propylitized sedimentary host rocks. The deposit appears to be concentrically zoned, and has associated gold-bearing veins and shear zones (33). Concentrations as high as 265 ppb gold, 282 ppm copper, and 60 ppm molybdenum were detected in samples collected from the property.

The Gold Creek East lode gold occurrence exists 2.5 miles east of the Su Claims. Samples collected from a silicified fault zone contained as much as 0.25 oz/st gold, 0.57% copper, and 71 ppm molybdenum.

The Bureau collected 5 placer samples from stream gravel and 3 rock samples from outcrop or float in a series of tributaries that flow north into the Susitna River at Devils Canyon. Three placer samples were anomalous in silver, arsenic, gold, platinum, and/or tin, and 2 rock samples were anomalous in silver, arsenic, gold, copper, molybdenum, lead, and/or zinc. Table 3 summarizes the highest magnitude anomalies with respect to the sample type.

Bureau samples collected from two locations in the Watana Creek drainage were found to contain anomalous levels of placer gold. Placer gold values as high as 0.002 oz/yd^3 were recovered in a sample collected at the mouth of Delusion Creek, a tributary to Watana Creek. The lower portion of Delusion Creek drains through a Tertiary conglomerate rock unit (42), which could represent the lode source for the placer gold. Values as high as 0.002 oz/yd^3 were recovered in a sample collected several miles upstream on Watana Creek where the creek also erodes through the same Tertiary conglomerate unit.

CHULITNA MOUNTAINS

The Chulitna Mountains are a part of the northern Talkeetna Mountains and comprise an area in the VCMD where few known mineral occurrences exist. Consequently, the Bureau spent a significant amount of time collecting reconnaissance samples from the area in an effort to locate new, and evaluate the few known occurrences. As a result of the Bureau's reconnaissance effort, several new occurrences were discovered. The new occurrences of significance are the Green Spike copper-zinc-silver-tin-molybdenum

Sample Type	Anomalous geochemical analyses									
	Ag (ppm)	As (ppm)	Au (ppb)	Au oz/yd^3	Cu (ppm)	Mo (ppm)	Pb (ppm)	Pt (ppb)	Sn (ppm)	Zn (ppm)
Placer	120	155	830	0.002	N/A	N/A	N/A	860	180	N/A
Rock	13.5	180	N/A	N/A	2,882	11	264	N/A	N/A	2,121

TABLE 3. - Summary of results from samples collected at the Devils Canyon occurrence. Note. - Only the highest anomalous values are listed. N/A = not anomalous.

granite porphyry, the Honolulu Creek gold placer, and the East Fork Chulitna River gold placer (fig. 9).

The Green Spike occurrence is a granite porphyry that outcrops prominently in the headwaters of the East Fork Chulitna River. Samples collected there contained as much as 0.48% copper, 819 ppm zinc, 0.39 oz/st silver, 13 ppm tin, and 25 ppm molybdenum.

The Bureau collected placer samples over the entire length of Honolulu Creek, and discovered several areas that contain high concentrations of placer gold. The highest grade sample contained 0.010 oz/yd^3 gold and was collected near the headwaters.

Several placer samples collected from the lower portion of the East Fork Chulitna River contained anomalous gold. The highest grade sample contained 0.003 oz/yd^3 gold.

Previously known mineral occurrences of significance in the Chulitna Mountains are the Tsusena Creek lode tin-silver prospect, the Honolulu lode tin silver prospect, the Mint Mine lode silver prospect, and the Treasure Creek lode molybdenum prospect (fig. 9).

The Bureau visited the Tsusena Creek tin-silver vein and mineralized shear-zone prospect and collected 48 samples from the occurrence. The highest grade samples contained as much as 26.5 oz/st silver, 0.55% tin, 1.21% lead, 5.45% zinc, and 0.66% copper.

The Honolulu prospect exists in a tributary drainage to Honolulu Creek. Outcrops in the tributary valley bottom exhibit highly altered granitic rock and sulfide-rich quartz veinlets. One sample collected across a 60 ft exposure of altered granite contained 1.09 oz/st silver, 0.032 oz/st gold, 1.55% copper, and 250 ppm tin. The highest grade samples contained as much as 141.7 oz/st silver, 0.05 oz/st gold, 6.33% lead, 6.04% zinc, 1.55% copper, and 795 ppm tin.

The main mineralized zone at the Mint Mine consists of a quartz-filled shear zone exhibiting minor sulfides and intense footwall alteration. The highest grade samples collected from the vein contained as much as 56.6 oz/st silver and 0.09 oz/st gold. One sample averaged 28.0 oz/st silver across 3 ft of vein exposure.

The Treasure Creek molybdenum prospect exists near the Mint Mine, approximately 2 miles upstream. The prospect consists of highly altered granite porphyry stock containing massive molybdenite in at least one exposed vein. The highest grade samples collected from the occurrence contained greater than 1.0% molybdenum and as much as 1.7 oz/st silver, 0.02 oz/st gold, 2.56% zinc, 0.42% tungsten, and 17 ppm tin.

CLEARWATER MOUNTAINS[5]

The Clearwater Mountains area extends northeasterly from the Susitna River at the Valdez Creek confluence to the headwaters of the West Fork Maclaren River (figs. 9 and 16). The area contains many significant types of mineral occurrences. The area is also known for the Denali Mine, which is in the Valdez Creek drainage and is the largest gold producer in the VCMD. The Valdez Creek drainage also contains the largest known gold resources in the VCMD. The majority of production in Valdez Creek comes from buried interglacial bedrock channels in the lower portion of Valdez Creek. Sampling by both private industry and the Bureau indicates potential for placer

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[5] *By Joseph M. Kurtak, Physical Scientist, Alaska Field Operations Center, Anchorage, Alaska.*

FIGURE 16. - View up the Maclaren River valley from the Denali highway at the Maclaren River crossing.

gold deposits in ice-marginal and medial moraine deposits in the upper part of the Valdez Creek drainage. Placer samples collected on benches along Valdez Creek upstream from White Creek contained as much as 0.017 oz/yd^3 gold. Placer samples from bench gravel along White Creek contained as much as 0.007 oz/yd^3 gold and in Grogg Creek up to O.004 oz/yd^3 gold. Drilling by private industry along lower White Creek indicates potential for deeply buried placer deposits.

In the Gold Hill-Lucky Hill vicinity between upper Valdez Creek and White Creek, placer samples collected from soils and colluvium contained as much as 0.03 oz/yd^3 gold. A soil geochemical survey done on Gold Hill and Lucky Hill in 1988 by private industry led to the discovery of lode gold in 1989. Subsequent drilling has intersected zones of quartz-carbonate veining as wide as 15 ft containing as much as 0.811 oz/st gold. Potential exists in the area for further discoveries of quartz-carbonate vein stockwork-type mineralization.

A contact between altered quartz diorite and argillite can be traced for 1 mile across Timberline Creek, a tributary to Valdez Creek. Samples of the diorite contain as much as 410 ppb gold, and quartz breccia float found nearby contains as much as 0.13 oz/st gold. Potential exists in the area for vein and stockwork-type mineralization similar to that found in the Lucky Hill-Gold Hill area. Some shallow drilling has been done along the contact, but the results were inconclusive.

In the Eldorado Creek drainage, a tributary to upper Valdez Creek, float samples of alkali gabbro contained as much as 45 ppb platinum and 92 ppb palladium. An alkali gabbro body at the head of the drainage is probably the source of the float.

The Bureau collected rock samples and a bulk metallurgical sample from the Denali Copper prospect, at the head of Windy Creek. The highest grade samples contained as much as 0.39 oz/st silver, 0.11 oz/st gold, 12.5% copper, and 94 ppm molybdenum. Metallurgical testing has shown that approximately 50% of the metals in the ore can be recovered using standard sulfide flotation techniques. The low metal recovery rates experienced during milling of the ore is the most detrimental variable affecting the likelihood for development and subsequent mining of the deposit. A mining feasibility study conducted for a "generic" deposit modeled after the Denali Copper prospect has shown that a mining operation would be subeconomic due to (1) the metal recovery problems associated with the large quantity of sulfides in the ore, (2) the actual grade of the modeled deposit, and (3) the requirements for ore extraction given the deposit structure and known engineering characteristics. The best case mining scenario that was applied to the deposit model yielded a 15% rate of return when the value of the metal recovered from the ore exceeded $65/st of ore (36).

At the Mex Claims and the Gossan occurrence near the headwaters of Little Clearwater Creek, polymetallic veins are anomalous in antimony, gold, tungsten, mercury, and arsenic. Metasediments in the area are also anomalous in mercury, arsenic, silver, and gold. Samples of altered metasediments contain as much as 0.79 oz/st silver and 50 ppb gold. The area has potential for low-grade silver and gold deposits, but detailed geochemical sampling and drilling are necessary to determine if such deposits exist. Placer samples collected along lower Little Clearwater Creek contained as much as 0.015 oz/yd^3 gold and were anomalous in tungsten and mercury.

EASTERN ALASKA RANGE

The Eastern Alaska Range physiographic province encompasses the northeastern portion of the VCMD. The areal extent of the VCMD within the province includes the West Fork and the Middle Fork of the Maclaren River, the Susitna Glaciers and contributing icefields, and the Maclaren Glacier and contributing icefields. Mineral occurrences of significance within this region are the Zackly copper-gold-silver skarn, the Kathleen Margaret basalt hosted copper-gold vein, the Viking basalt hosted copper-gold-magnetite veins, the Eureka Glacier ultramafic associated PGM-chrome-nickel occurrence, and the East Fork Susitna River placer gold occurrence (fig. 9).

The Bureau performed a minimal investigation at the Zackly copper-gold-silver skarn mainly because of the existence of previous data and the record of extensive exploration performed by private industry on the prospect. Bureau work on the prospect included the collection of a bulk sample for metallurgical testing purposes, and the collection of several samples from a high grade zone of mineralization. The highest grade samples contained as much as 0.18 oz/st gold, 2.44 oz/st silver, and 7.1% copper.

The metallurgical test evaluated the amenability of the ore to standard gold-copper-sulfide ore processing. Fine-grain gold and complex sulfide structures caused recovery rates below 50% for gold and copper under test conditions. Test results show that metal recoveries increase when the ore is ground to sizes smaller than -325 mesh. (33).

A mining feasibility study conducted by

the Bureau for a geologically and metallurgically analogous "generic" deposit has shown that the "generic" deposit is currently subeconomic, primarily due to the relatively low amounts of metal that can be recovered from the ore, and secondarily due to the type of mining methods that must be employed to extract the ore. The mining scenario that was applied to the "generic" deposit model yielded a 15% rate of return when the value of the metal recovered from the ore exceeded $258/st of ore (36).

The Kathleen Margaret prospect consists of a sulfide-rich quartz vein that is exposed on the surface and in underground workings. The Bureau collected samples from several trenches, and from a 10-ft-wide exposure of sulfide-rich quartz vein in the main zone of mineralization. The highest grade samples contained as much as 2.07 oz/st silver, 0.119 oz/st gold, 38.4% copper, 0.43% antimony, and 0.19% zinc.

A short distance south from the Kathleen Margaret is the Viking copper-gold-magnetite vein occurrence. Mineralization occurs in lenticular veins oriented in echelon across an undetermined thickness of host metabasalt rocks. Bureau samples collected from the veins contained as much as 14.4 oz/st silver, 1.258 oz/st gold, 3.17% copper, and 0.01% gallium.

On the far eastern boundary of the VCMD is the Eureka Glacier ultramafic associated PGM-chrome-nickel occurrence. The occurrence mainly consists of narrow zones of intermittently exposed rubblecrop that extends across several hundred acres of high mountainous terrain. Bureau samples collected from the occurrence contained as much as 0.38% chromium, 0.36% nickel, 0.011 oz/st palladium, and 0.017 oz/st platinum.

Bureau geologists discovered gold-placer occurrences in two adjacent tributaries to the north side of the East Fork Susitna River. The highest grade samples that were collected from the occurrence contained as much as 0.01 oz/yd^3 gold and 58 ppm cobalt. The cobalt sulfide mineral linnaeite was identified in one sample.

INDUSTRIAL MINERALS[6]

Present within the VCMD are potential economic sources of argillite, limestone, intrusive rock, basalt, perlite, zeolite, and gravel. At least six potentially economic limestone deposits are known to exist within the VCMD. Adjacent to the Parks Highway and marginal to the VCMD, a limestone deposit is currently being mined as a source of agricultural lime. Deposits of argillite, granitic rock, and basalt of commercial grade are known to exist within the VCMD, and some of these were exploited during the construction of the Alaska Railroad and the Parks and Denali Highways.

A perlite occurrence near Yacko Creek was evaluated by the Bureau in 1989. Analyses have shown that the occurrence is not of commercial grade (34).

Large zeolite deposits of potentially commercial grade exist in the Talkeetna Formation, which is located in the Horn Mountains of the upper Matanuska Valley. Commercial extraction of the resource in the near term is unlikely due to the remote location of the occurrences and the distance from the area to potential markets.

There are large deposits of glacially-derived gravel within the VCMD. High silt content and distance to construction sites render much of this material subeconomic.

[6] *By D. D. Southworth, Physical Science Technician, Alaska Field Operations Center, Anchorage, Alaska.*

MINING FEASIBILITY STUDIES

Mining feasibility investigations were conducted for eight mineral deposit models (Table 4) (36). The models were based on real and hypothetical deposits that occur in the VCMD. Sixty-six mine models were developed for application to the mineral deposit models and capital and operating costs were calculated for each mine model. From the cost data for each mine model, a capital investment schedule (CIS) was developed to show the timing of capital investment into the mining model. A cash flow analysis was performed for the CIS data for each mine model, and the discounted cash flow rate of return on investment (DCFROR) versus the recoverable metal value[7] (RMV) distribution was evaluated.

The goal of the feasibility study was to determine the monetary value per metric ton of minable ore that would cause the simulated cash flow of each of the mine models to achieve certain predefined rates of return for the invested capital.

The result of the cash flow analysis is a graphical representation of the economic performance of the mine model, expressed in terms of expected DCFROR. All of the results are estimated to be within ± 25% of real costs.

The cash flow analysis for each mine model covered a range of RMV's that caused the DCFROR result of the cash flow analysis to exceed an arbitrary 15% DCFROR economic threshold. The 15% DCFROR threshold was chosen to represent the level of return on investment that would be considered an acceptable minimum for economic viability of a mine model.

Given the "generic" nature of the mining feasibility study, and the number of variables involved in performing an economic analysis for a mineral property, it is difficult to arrive at any concrete summation of what is or is not feasible. Factors that behave as

Deposit model	Mine model(s) (extraction method depends upon mining rate)
Metamorphic gold vein deposits	Overhand or cut-and-fill
Copper-gold skarn deposits	Overhand, cut-and-fill, or longhole-sublevel
Plutonic related vein and replacement gold deposits	Shrinkage, overhand, or longhole-sublevel
Basalt hosted copper deposits	Longhole-sublevel or vertical crater retreat
Carlin-type gold deposits	Open pit
Plutonic related tin greisen deposits	Open pit
Gold, silver, copper breccia pipe deposit	Open pit and cut-and-fill
Deep placer gold deposit	Open pit

TABLE 4. - Mineral deposit models and associated mine models used in the mining feasibility study of the Valdez Creek Mining District, Alaska.

[7] *The recoverable metal value is the gross monetary value of the metal recovered from the mineral deposit, less shipping costs, and less smelter royalty.*

dominant functions in the equation for economic viability are ore grade, deposit size, deposit structure, and ore mineralogy. A mineral deposit becomes more economically viable when ore grade is high, deposit size is large, deposit structure is favorable for the application of low cost ore extraction techniques, and the ore is amenable to current metals extraction technology. Generally and from the engineering point of view, small, high-grade, easily accessible vein-type lode gold deposits are likely to be economic at the present time, based on the mining feasibility study. Large tonnage, low grade, sediment-hosted disseminated precious metal deposits are also likely to be economic if open pit mining methods can be used for mining, and if the ore yields to current milling technology. It may be evident from this discussion that there are innumerable variables that effect the economic viability of an ore deposit. Given the proper qualifiers and conditions, it is possible to describe nearly any mining scenario that could be economic.

A likely application of the mining feasibility study is to compare the results of the economic analysis of a model to a real mineral prospect that possesses geological and structural characteristics that are similar to the model. The results of the mining feasibility analysis of these mine models could be used in a preliminary manner to evaluate the mining potential of real mineral deposits that are similar to the deposit models.

PROBABILISTIC MINERAL ASSESSMENT[8]

Mineral resources in the VCMD were assessed using a modified version of a computer simulation model (ROCKVAL) developed jointly by the Bureau and the ADGGS (29, 54). The assessment was accomplished as part of a cooperative agreement between the ADGGS and the Bureau. An assessment committee was composed of geologists and engineers from the Bureau, ADGGS, and the University of Alaska, Fairbanks (UAF). The committee members were participants in the collection and analysis of samples during the field investigation portion of the VCMD study, and are intimately familiar with the district.

The computer simulation made extensive use of "generic" deposit-based models for initial estimations of deposit parameters. The number of mineral deposits and their associated grades and tonnages were estimated by using generic probability distributions for particular deposit types, based on compilations derived from world-wide literature. Specific knowledge about the occurrence of deposits within the VCMD was used to modify these parameters, where appropriate, by the assessment committee. The results of the assessment represent a mineral resource endowment for the VCMD. The assessment results can be used to derive an estimate of the economic value of the mineral resources in the study area, using an appropriate economic model.

The results of the ROCKVAL analysis can be described in several ways. Table 5 gives the total estimated endowment for each major element present in major concentration at three probability levels. This data indicated that gold is the element of greatest significance (at present-day metal values), accounting for approximately one-half of the present-day gross metal value in the district. At high probability fractiles (high levels of certainty), the elements copper (Cu), tin

[8] *By Rainer Newberry, Professor of Geology, University of Alaska, Fairbanks, Alaska.*

Element (units)	Probability fractile		
	95th	50th	5th
Gold (10^6 oz)	4.4	15	86
Silver (10^6 oz)	44	100	320
Copper (10^5 st)	8	21	37
Zinc (10^5 st)	3	5	8
Tin (10^4 st)	2	6	41
Molybdenum (10^3 st)	1	16	160
Platinum (10^4 oz)	1	3	23
Palladium (10^4 oz)	0	0	24
Nickel (10^5 st)	0	1	34
Chromium (10^5 st)	0	5	180

TABLE 5. - Estimated total endowment for the most significant metals in the VCMD.

(Sn), and zinc (Zn) also make an appreciable contribution to the district endowments' gross metal value.

In order to show and compare the contributions of the various deposit types to the overall metal endowment of the VCMD, contained metals are presented on a deposit type by deposit type basis, with each metal converted to 1 million ounce gold equivalents (using summer 1990 metal prices) in Table 6. This tabulation provides a measure of the relative value of each deposit type, highly simplified because the elements in many cases are not present in high enough concentrations or appropriate mineralogy for presently economic extraction and beneficiation. The results shown in Table 5 are arranged in descending order of gold-equivalent endowment at the 95% probability level. The areas judged favorable for the various deposit types are shown on figures 17-20.

The estimated endowment as presented in Tables 4 and 5 is biased towards those deposit types with the greatest amount of drilled reserves or other strong indications of existence. Placer gold deposits are the pre-eminent source (≈40%) of the metal value of the endowment at the 95% probability level not only because it represents the single deposit type for which there has been appreciable mining, but also because placer resource estimates can be semiconfidently made based on limited surface sampling and comparison with known production. The order of endowment contribution following placer gold mostly reflects the published amounts of metal determined thus far from drilling and underground sampling at the major known deposits in the VCMD. These are: (1) Coal Creek tin-silver-zinc greisen; (2) Denali Copper sediment hosted copper-silver; (3) Golden Zone plutonic related gold; and (4) Zackly copper-gold-silver skarn.

Also present in Table 6 is the estimated metal endowment for the different deposit types for the 50% and 5% probability levels. The sometimes large disparities between the 95% probability level and the lower probability levels reflects the speculative nature of the endowment estimations at the lower probability levels. Placer gold is still the pre-eminent contribution to the endowment at the 50% probability level (≈23%), but as there is a distinctly limited amount of gold-bearing gravel present, and an almost unlimited amount of unexposed and buried rock below the surface, there is a low probability for a large contribution to the endowment caused by several other deposit types.

The bulk of the present-day gross metal value of the endowment (except placer gold) lies in plutonic-related deposits, including skarns, vein-replacement gold, plutonic tin-silver-zinc, various porphyry-type deposits, and ultramafic-hosted deposits. This partly reflects the large amount and variety of plutonic rocks in the district and the variety of plutonic-related deposits known to exist,

Deposit type/contained metal (units)	Probability fractile		
	95th	50th	5th
Placer gold deposits	**3.2**	**7.8**	**19.0**
Gold (10^6 oz)	3.2	7.8	19.0
platinum (10^6 oz)	0.01	0.03	0.06
Tin-silver deposits	**1.9**	**4.2**	**15**
Tin ($4X10^4$ st)	0.45	1.5	10.3
Silver (10^8 oz)	0.11	0.3	2.1
Zinc ($2X10^5$ st)	1.3	2.4	2.8
Sediment hosted copper deposits	**1.3**	**5.4**	**14**
Copper ($2X10^5$ st)	1.2	5	13
Silver (10^8 oz)	0.046	0.14	0.3
Gold (10^6 oz)	0.06	0.3	0.7
Plutonic related gold deposits	**0.5**	**3.6**	**21**
Gold (10^6 oz)	0.5	3.3	20
Silver (10^8 oz)	0	0.3	1.4
Metamorphic gold deposits	**0.5**	**3.6**	**34**
Gold (10^6 oz)	0.51	3.6	34
Silver (10^8 oz)	0	0	0.1
Copper-gold-skarn deposits	**0.4**	**0.8**	**16**
Gold (10^6 oz)	0.24	0.5	10
Silver (10^8 oz)	0.01	0.02	1
Copper ($2X10^5$ st)	0.17	0.027	4.6
Porphyry molybdenum deposits/ molybdenum ($5X10^4$ st)	**0.2**	**3.2**	**31**
Podiform chromite deposits - chromite (10^5 st)	**0**	**0.54**	**18**
Porphyry copper deposits	**0**	**0.2**	**11**
Copper ($2X10^5$ st)	0	0.2	9.3
Gold (10^6 oz)	0	0	0.9
Silver (10^8 oz)	0	0	0.3
Molybdenum ($5X10^4$ st)	0	0.04	0.8
Basalt related copper deposits	**0**	**0.03**	**1.1**
Copper ($2X10^5$ st)	0	0.025	1
Silver (10^8 oz)	0	0.002	0.1
Carbonate hosted gold deposits	**0**	**0.1**	**4**
Gold (10^6 oz)	0	0.1	3.7
Silver (10^8 oz)	0	0.003	.24
PGM sulfide deposits	**0**	**0.03**	**1**
Platinum (10^6 oz)	0	0	0.17
Palladium ($3X10^6$ oz)	0	0	0.08
Copper ($2X10^5$ st)	0	0	0.11
Nickel ($5X10^4$ st)	0	0.03	.7
Volcanogenic massive sulfide deposits	**0**	**0**	**0.6**
Copper ($2X10^5$ st)	0	0	0.2
Zinc ($2X10^5$ st)	0	0	0.4
TOTAL ALL DEPOSIT TYPES	**8**	**29**	**185**

TABLE 6. - Estimated summary endowment for the VCMD, by deposit type, expressed as 10^6 oz gold equivalents.

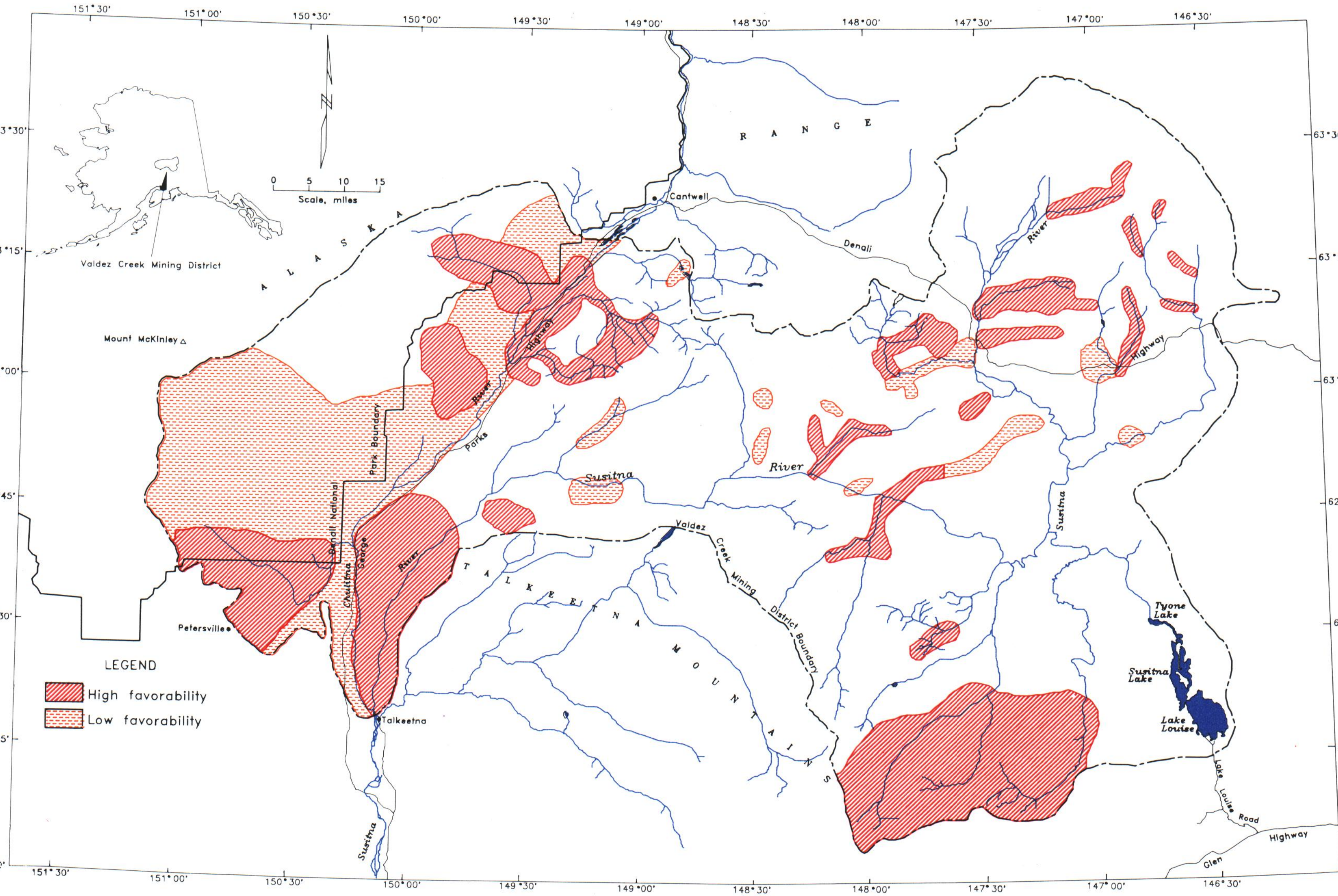

FIGURE 17. - Regions favorable for the occurrence of placer gold.

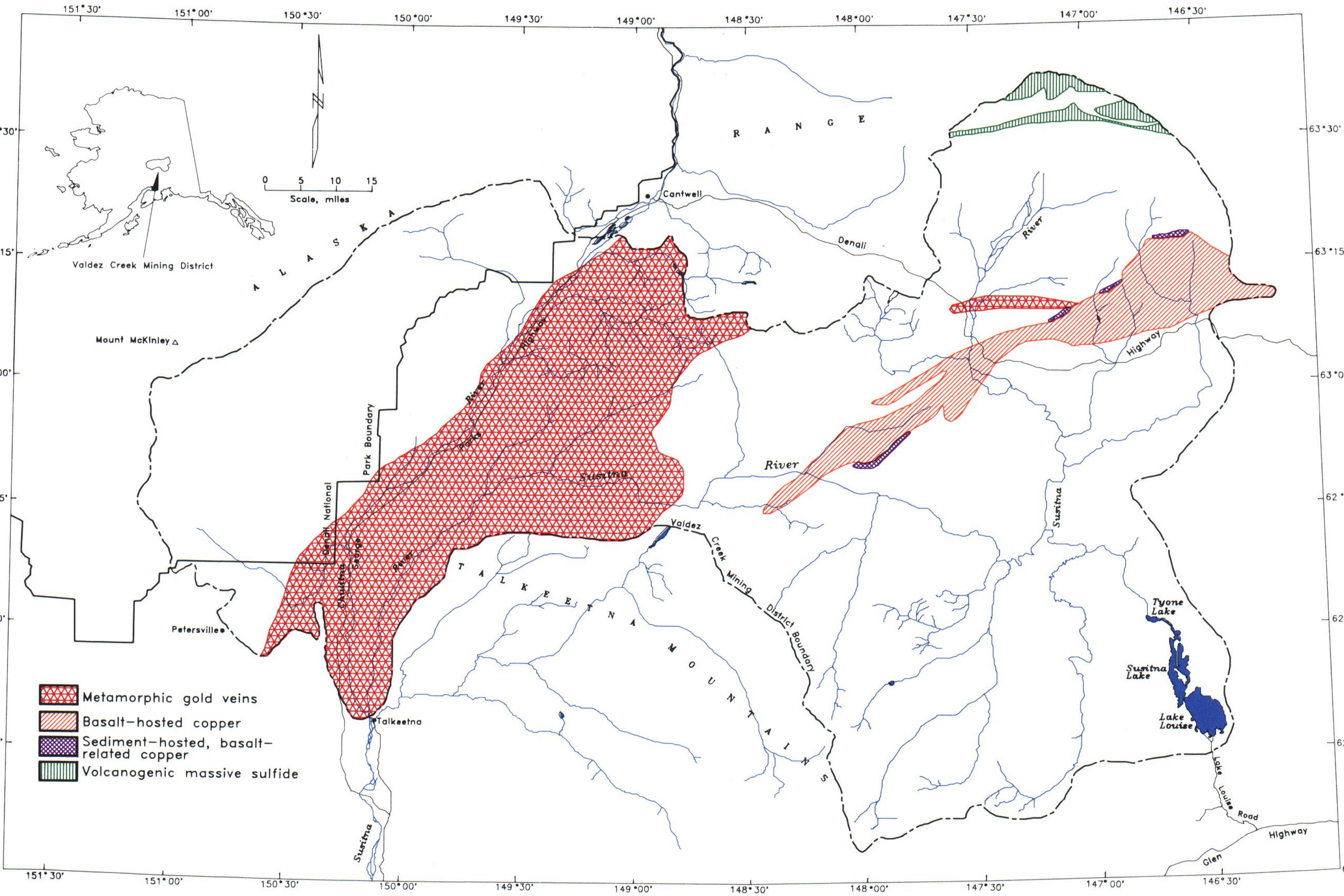

FIGURE 18. - Regions favorable for the occurrence of metamorphic gold veins, basalt-hosted copper, sediment-hosted and basalt-related copper, and volcanogenic massive sulfides.

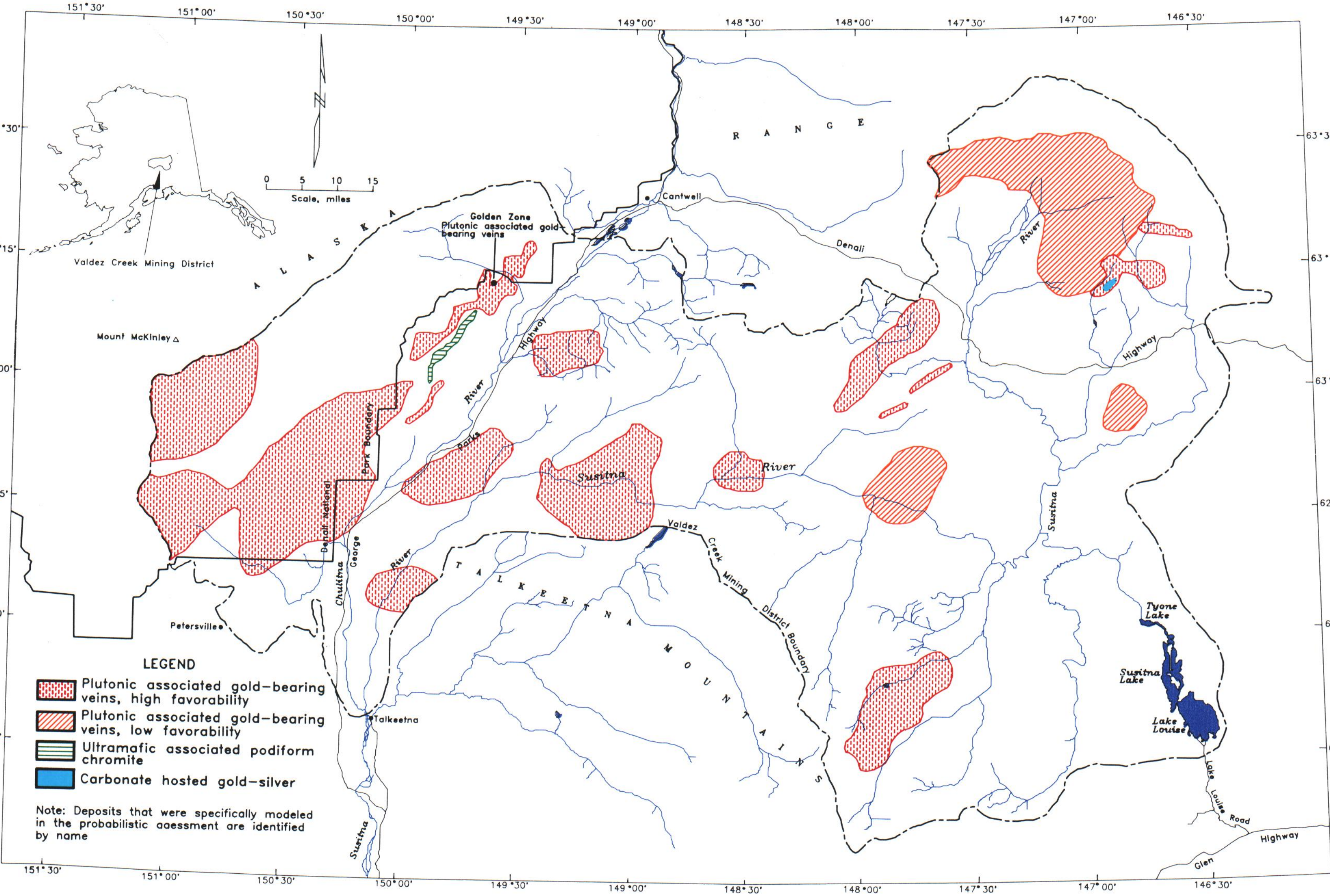

FIGURE 19. - Regions favorable for the occurrence of plutonic associated gold-bearing veins, ultramafic associated podiform chromite, and carbonate-hosted gold-silver.

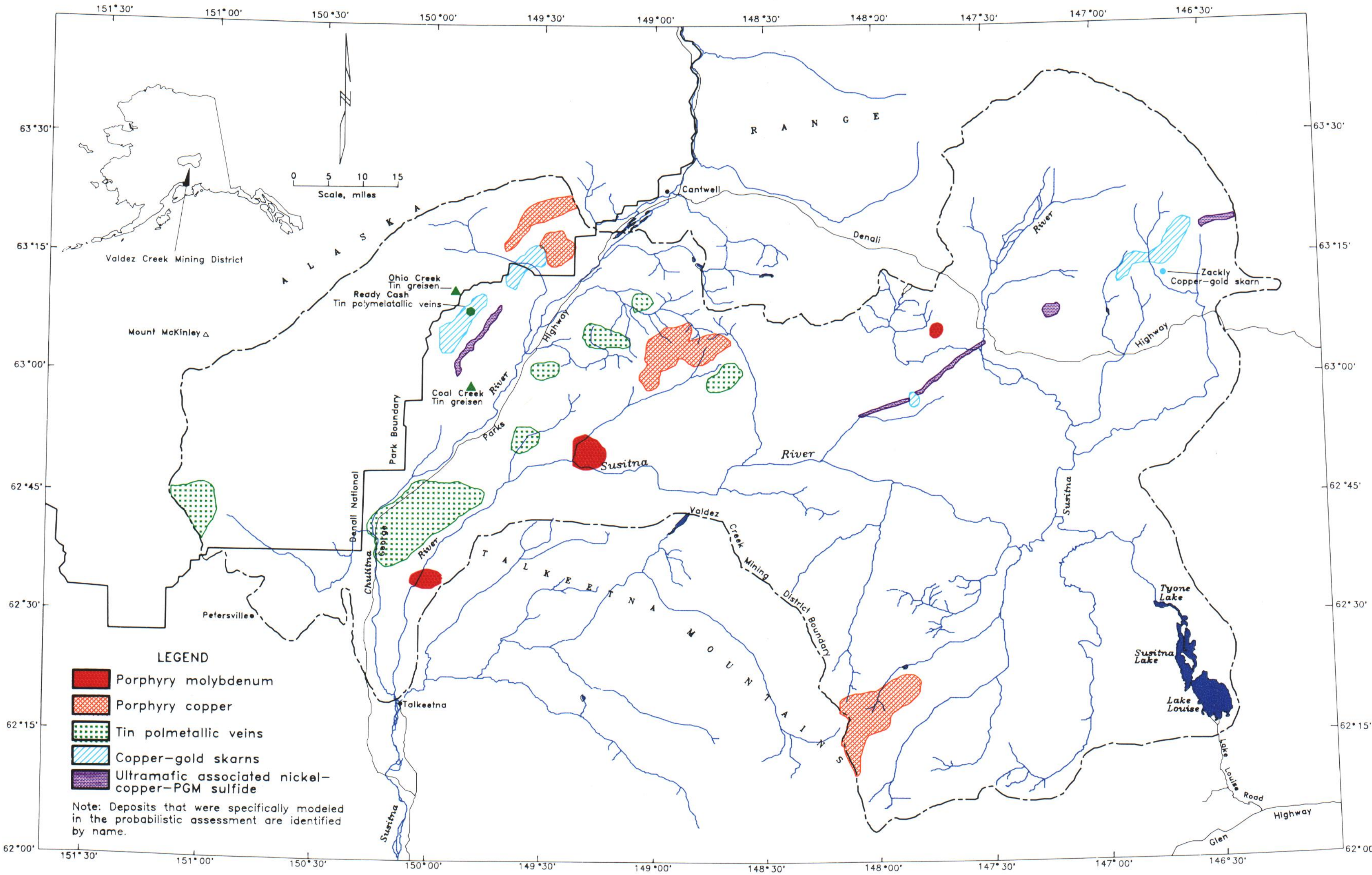

FIGURE 20. - Regions favorable for the occurrence of porphyry molybdenum and copper, tin-bearing polymetallic veins, copper-gold skarns, and ultramafic associated nickel-copper-PGM sulfides.

and partly reflects the fact that many plutonic-related deposit types contain huge amounts of metal. Much of this plutonic-related endowment is highly speculative, however, because so little is known about the plutonic rocks in the district.

An economic assessment of the endowment in the VCMD is beyond the scope of this report, but it should be noted that placer deposits not only constitute the bulk of the "near-certain" component of the endowment, but they also constitute that portion most amenable to ready extraction. Of the lode deposit types, the plutonic- and metamorphic-gold deposits are probably most minable at the present. It is unlikely, given current transportation and metal prices that the other components to the endowment could be economically recovered in large amounts at the present time.

RECOMMENDATIONS

The VCMD contains many areas that are geologically favorable for the existence of a considerable variety of mineral deposits. Many areas within the district are under-explored, and deserve greater attention. Even though the Bureau invested three field seasons in the VCMD, the immense size and location of the district precludes complete coverage of the entire surface area. The remoteness of the district, like much of Alaska, is the greatest hindrance to geologists and prospectors in their mineral exploration efforts, and is the main reason that the district has a good potential for containing undiscovered mineral deposits. As a result of the Bureau's investigation, the land has relinquished some of its geological secrets, and the Bureau has shown that there are areas that do indeed contain undiscovered mineral occurrences. There are many areas in the district that show promise for future mineral discoveries. Some of these deserve special mention here.

The McCallie Glacier disseminated sulfide and polymetallic stockwork vein occurrence, located in the central Alaska Range, should be thoroughly prospected throughout the entire head-wall area of the McCallie Glacier. Samples collected at the occurrence in 1989 show that the mineralization discovered the previous year continues in a southwesterly trend for at least ½ mile. Technical climbing expertise and gear will be needed to thoroughly investigate the occurrence.

The Ready Cash prospect, located in the Ohio Creek drainage, has had some development work in the past, but not to the degree necessary to determine if there is an economic ore body present. The prospect needs to be systematically mapped, sampled, and drilled in order to adequately determine the true nature of the deposit.

Across the Chulitna River valley from the Ready Cash is the Honolulu prospect. The prospect has had some drilling, but the work done was not sufficient to fully evaluate the prospect. The prospect needs to be further investigated through geologic mapping, detailed sampling, and drilling.

The Bureau collected numerous samples that were anomalous in gold, silver, lead, and zinc at the head of the drainage in which the Honolulu prospect is located. This area also deserves a close look for sulfide veins that could possibly contain tin-silver mineralization.

At the headwaters of Honolulu Creek, several placer samples were collected that contained highly anomalous levels of placer gold. It has not been determined where the possible lode source for the placer gold is located, hence the area deserves a greater prospecting effort to locate placer gold and possible lode gold resources.

Based on several placer samples collected from the lower reaches of the East Fork Chulitna River, there is a potential gold-placer resource downstream from the terminal moraine in the East Fork valley. It appears that erosion of the East Fork through the terminal moraine is concentrating a gold-placer that exists in the moraine. Prospecting should be concentrated on the benches and gravel bars below the moraine. The use of a backhoe would enable proper evaluation of the occurrence.

The Bureau collected several samples from a series of tributaries that flow north into the Susitna River in the Devils Canyon area that were anomalous in platinum, gold, silver, arsenic, copper, molybdenum, lead, tin, and zinc. The samples could represent minerals that are being disseminated downstream from a lode source in the granitic highlands to the south. There are few rock exposures in the region south of the sample sites, and the area has been largely unexplored. Therefore, a significant potential exists for mineral discoveries in the region if a systematic geological, geochemical, and geophysical investigation is conducted in this area.

The Tsusena Creek prospect exhibits high-grade tin-silver mineralization in hydrothermal polymetallic veins and mineralized shear zones. The prospect has previously been geologically mapped and sampled by private industry, and additional sampling by the Bureau has confirmed the presence of high-grade mineralization. The prospect could represent tin-silver vein type mineralization associated with a tin granite. Further geologic mapping, geochemical sampling, and drilling is needed to properly assess the mineral development potential of the prospect.

In the Watana Creek drainage, the lower reaches of the creek drain through a Tertiary conglomerate unit. The Delusion Creek tributary to Watana Creek also drains through areas of Tertiary conglomerate. Both creeks contain potential gold-placer resources. There have been gold-placer claims staked on both creeks in the past, and the Bureau documented the presence of significant placer gold in the fluvial gravel. Both of these drainages should be further explored for gold-placers. A suction dredge or backhoe would enable the proper examination of the potential resource.

Reconnaissance placer exploration in the East Fork Susitna River drainage resulted in the discovery of two tributary creeks that contain significant levels of placer gold. Prospecting in the hanging valleys of the tributary creeks showed that the source for the placer gold is located below the lip of the hanging valley. A sample collected from the lateral moraine along the north valley wall of the East Fork Susitna River contained placer gold in significant, but un-weighable quantity. This suggests that the lateral moraine contains a disseminated gold-placer resource, and that the tributaries are concentrating the disseminated gold by eroding through the lateral moraine. The entire drainage of the East Fork should be prospected for occurrences of placer gold, and for the lode source of the disseminated gold that exists in the lateral moraine. The alluvial fans of the tributaries should be evaluated as a potential economic source of placer gold.

The Viking copper-gold-magnetite vein occurrence exists 3 miles northeast of the Zackly skarn prospect, and is hosted in metavolcanic rocks. This occurrence contains areas of high-grade gold-copper mineralization as documented by Bureau sample results. Little is known about the

FIGURE 21. - Bureau geologist collecting a placer sample from a tributary to the Susitna Glacier.

extent of mineralization at the Viking, hence it is recommended that the occurrence be geologically mapped and sampled in detail.

The Eureka Glacier ultramafic-associated PGM-nickel-chrome occurrence is an attractive exploration target for many reasons. The occurrence is centered along a trend of ultramafic rocks that outcrop infrequently over a distance that extends to Slate Creek 60 miles to the southeast, and to Butte Creek 55 miles to the southwest (55). The Broxon Gulch occurrence, located several miles to the east, is genetically related, and has associated massive copper-nickel-sulfide mineralization. Aerially, the ultramafic rocks associated with the Eureka Glacier occurrence cover close to 100 acres, and contain sulfide mineralization in several locations. A thorough examination of this occurrence is warranted and should involve a detailed geological mapping and geochemical sampling program.

Related to the Eureka Glacier occurrence is the Peak 5532 (Butte Creek) ultramafic-associated copper-nickel-PGM disseminated sulfide occurrence. Like the Eureka Glacier occurrence, Butte Creek ultramafic rocks also outcrop over a large area, and should be mapped and sampled in detail.

The Mex and the Gossan mineral occurrences, near the head of Little Clearwater Creek, have potential for disseminated and stockwork-type precious metal deposits. Altered carbonate sediments and Carlin-type metal assemblages at the Mex and the Gossan occurrences suggest the presence of a sediment-hosted low-grade, large-tonnage precious-metals deposit. As with other geochemically anomalous and geologically favorable areas in the VCMD, these occurrences should be mapped and sampled in detail. Mapping and sampling completed to date at these occurrences could possibly provide drilling targets.

The Windy Creek drainage flows parallel to and just south of the Valdez Creek drainage. Even though a small section of the lower portion of Windy Creek has been drilled on a widely spaced grid for gold-placer deposits (33), the creek has potential for placer gold beyond those areas already drilled, and represents a significant gold placer exploration target.

A newly discovered area at the headwaters of the West Fork Maclaren River (33) has potential for placer and lode gold occurrences. Reconnaissance placer samples collected at the confluence of three glacial tributaries (also known as "Three Glaciers") to the West Fork contained anomalous quantities of placer gold, and indicate that there is potential for a gold-placer deposit and related lode gold deposit(s). The area should have additional reconnaissance geochemical sampling and geologic mapping performed to locate potential gold-bearing rocks, and the streams should be investigated for gold-placer resources.

FIGURE 22. - Bureau geologist collecting a rock sample near the source of the Susitna River.

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ABOVE - The "Mountain" is known locally by its Athapaskan name Denali, meaning "the great one". The mountain is otherwise known as Mt. Mckinley. This view is of the south face with the Ruth Glacier in the foreground. Denali can be seen from many locations with the Valdez Creek Mining District.

BACK COVER - Bureau geologist is dwarfed by the high rugged mountains of the Alaska Range.