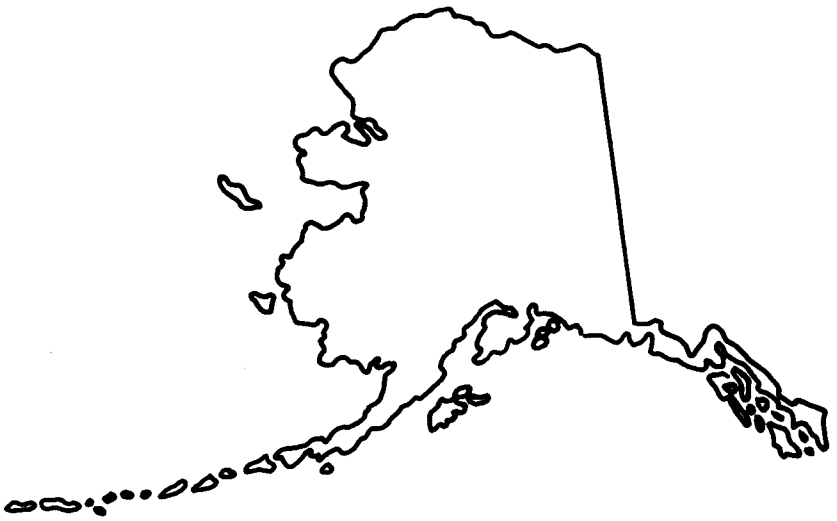
Critical and Strategic Minerals Investigations in Alaska: Chromium

By: Jeffrey Y. Foley, James C. Barker, and Lawrence L. Brown



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PREFACE

The Bureau of Mines is responsible for ensuring that mineral supplies are adequate to meet the nation's industrial needs. The Bureau's Alaska Field Operations Center is currently reviewing and investigating numerous reported occurrences of critical and strategic minerals in Alaska. Critical and strategic minerals include those that are essential to industry and defense, that are obtained from foreign sources, and for which no satisfactory domestic substitutes are known. This report summarizes numerous investigations of chromite deposits in Alaska by the Bureau's Alaska Field Operations Center and the Bureau's Albany (OR) Research Center.

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

With factors for conversion to units of the
International System of Units (SI)

Abbreviation	Unit of measure	To convert to--	Multiply by--
ft	foot	meters	0.3048
ft^2	square foot	square meters	0.0929
in	inch	centimeters	2.54
ton	short ton	long tons	0.8929
		metric tons	0.9072
		pounds	2,000
mi^2	square mile	square kilometers	2.590

CRITICAL AND STRATEGIC MINERALS INVESTIGATIONS IN ALASKA: CHROMIUM

By Jeffrey Y. Foley,[1] James C. Barker,[2] and Lawrence L. Brown[3]

ABSTRACT

The Bureau of Mines Alaska Field Operations Center investigated chromite deposits and occurrences in Alaska between 1979 and 1984 as part of the Bureau's critical and strategic minerals program. Chromite-bearing ultramafic rocks are known to occur in eight regions in Alaska; one hundred thirty-two subeconomic podiform-type deposits and one placer deposit are estimated to contain 3.4 million to 4.3 million short tons of chromic oxide (Cr_2O_3) in high-chromium and high-iron chromite. Most of the deposits contain between 5 and 10 pct chromite and mine-site beneficiation would be required to produce shipping-grade concentrates. In the Chugach trend, an inferred reserve base comprises 2.8 million short tons of Cr_2O_3 in 42 deposits that are all within 10 miles of tidewater or existing transportation routes. Most of these reserves are contained in the Turner stringer zone (1.25 million short tons) and Windy River placer deposit (556,000 short tons) at Red Mountain on Kenai Peninsula and in the Halibut Bay complex on Kodiak Island (201,000 short tons). Seventy less accessible deposits in the remote western Brooks Range contain between 576,000 and 1.4 million short tons of high-chromium chromite. The Rampart, Yukon-Koyukuk, and Southeast regions contain deposits with minor production potential. Chromite also occurs in southwest Alaska and in the Yukon-Tanana uplands, but no significant deposits are known and no reserves were estimated.

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INTRODUCTION

Alaska contains many minerals that are of critical or strategic importance to the United States. During periods of national shortage, including the First and Second World Wars and the Korean and Viet Nam conflicts, Alaska has been a source of chromium, tin, tungsten, antimony, mercury, platinum-group minerals, and small amounts of asbestos. The Bureau of Mines Alaska Field Operations Center (AFOC) began evaluating occurrences of critical and strategic minerals in Alaska in 1979 and the Bureau's Albany (OR) Research Center (ALRC) simultaneously conducted beneficiation and metallurgical studies on samples collected by AFOC. The objective of this program is to locate, identify, and review deposits that might alleviate prolonged shortages of those minerals. Factors including quality, grade, size, and location relative to existing or proposed transportation facilities were considered in reviewing the deposits. All the deposits discussed in this report are subeconomic under current market conditions. This report summarizes a literature search and field investigations of chromite occurrences in Alaska that were conducted as part of the critical and strategic minerals program.

ACKNOWLEDGMENTS

The information contained in this report was compiled from published and unpublished reports by the Bureau, other federal and state agencies, and private companies. Anaconda Minerals Company, Anchorage, AK, provided unpublished reports on exploration and development at Red Mountain on the Kenai Peninsula in 1981 and 1982. C.C. Hawley and Associates, Anchorage, AK, provided locations and descriptions of deposits and occurrences in the Kaiyuh Hills, near

Holonada Creek, and near the Kilolitna River. Howard McWilliams, prospector and placer miner, Anchorage, AK, and Tom Pittman, State Minerals Specialist, Bureau of Mines, Juneau, AK, provided data contained in descriptions of the chromite deposits near Tonsina. Jan Still, Mining Engineer, Bureau of Mines, Juneau, AK, provided information on chromite occurrences in southeast Alaska. William Roberts, Geologist, Bureau of Mines, Juneau, AK, examined and described chromite deposits at Mount Hurst and the Wolverine Complex.

CHROMIUM USES AND TERMINOLOGY

The United States relies almost totally on foreign sources for chromium, a metallic element that is essential to industry, and is imported in chromite concentrates, in ferrochromium alloys, and as pure chromium metal. Chromite is the ore mineral from which chromium is recovered: ferrochromium alloys are produced from chromite ores and include a variety of products that are used extensively in the manufacturing and construction industries. In 1983, the total United States demand for chromium metal was 252,000 short tons (61).[4] This is equivalent to about 368,000 short tons of chromic oxide (Cr_2O_3).

[4]Underlined numbers in parentheses refer to items in the list of references at the end of this report.

Recycling of stainless steel scrap currently accounts for about 10 pct of the nation's chromium demand (60-61). The U.S. demand for chromium is expected to increase at an annual rate of about 2 pct between 1981 and 2000 (61). Chromite is obtained primarily from the Republic of South Africa, the Philippines, the U.S.S.R., and to a lesser extent, Finland and Turkey. Ferrochromium alloys are imported primarily from the Republic of South Africa, Yugoslavia and Zimbabwe. Based on

current consumption and projected increases, foreign chromium resources are sufficient to satisfy the world's needs for centuries (61). However, supply could be disrupted because 98 pct of the known chromium resources are located in southern Africa (48).

Chromium is a versatile element, having a wide range of uses in the metallurgical, chemical, and refractory industries (61). According to the U.S. National Materials Advisory Board, approximately 30 pct of chromium-containing materials consumed by industry could be replaced by chromium-free substitutes and, with additional research, another 30 pct might be replaced (55). About 35 pct of chromium uses, however, are considered irreplaceable because no functionally acceptable chromium-free substitutes are available (55).

Chromite is a brownish- to iron-black mineral of the spinel group and has the general formula $(Fe^{+2},Mg)(Cr,Al,Fe^{+3})_2O_4$ (6). The metallic elements Fe, Mg, Al, and Cr substitute for one another in minerals of the spinel group. Chromite and other spinels that contain Cr_2O_3 are collectively referred to as chromian spinels. The spinel minerals seldom exist in pure forms, rather they are commonly gradational between ideal end members of chemical series and therefore, have variable Cr_2O_3 content. A pure chromite mineral would contain about 68 pct Cr_2O_3 by weight, but chromite concentrates rarely contain more than 50 pct Cr_2O_3 (61). In this report, the term chromite is used for any chromian spinel from which a concentrate that is suitable for industrial uses may be obtained.

High-grade chromite ores that are produced by hand-sorting and that require no further concentration at the mine are referred to as shipping-grade ores. Concentrating ores, on the other hand, are

typically upgraded at the mine site by gravity or gravity and magnetic concentrating methods.

Historically, there are three industrial grades of chromite concentrates. Metallurgical-grade concentrates contain a minimum of 46 pct Cr_2O_3 and have chromium to iron (Cr:Fe) ratios of 2.0 or greater. Chemical-grade concentrates contain 40 to 46 pct Cr_2O_3 with a Cr:Fe ratio of 1.5 to 2.0. Refractory-grade concentrates contain greater than 20 pct aluminum oxide (Al_2O_3), and the total Al_2O_3 plus Cr_2O_3 content must exceed 60 pct (55). The uses of the various grades are now more flexible than in the past, and because of recent changes in the uses of chromite concentrates, it has been proposed that they be classified as either high-chromium, high-iron, or high-alumina types (61). Owing to technological advances in the production of ferrochromium alloys, chromite concentrates with Cr:Fe ratios less than 2.0 are now used in the metallurgical industry, but to what extent is uncertain.

In this report, chromite deposits are differentiated from insignificant occurrences to distinguish potential mineral reserves. A chromite occurrence is herein defined as a small or unmeasured concentration of the mineral. A chromite deposit is a concentration of chromite that has a definable size and is large enough to warrant investigation as a possible reserve. Reserve and reserve potential estimates are given in short tons of contained Cr_2O_3.

HISTORY, PRODUCTION, RESERVES, AND RESERVE POTENTIAL

Thirty thousand tons of high-chromium chromite ore with reported grades between 38 and 49 pct Cr_2O_3 was produced in Alaska from deposits at Claim Point and Red Mountain on the Kenai Peninsula. At

Claim Point, 1,100 tons of chromite ore averaging between 46 and 49 pct Cr_2O_3 was produced from the Reef Mine in 1917 and another 1,100 tons averaging 40 pct Cr_2O_3 was produced in 1918 (40). At Red Mountain, over 7,000 tons of chromite ore that contained between 41 and 43 pct Cr_2O_3 was mined from the Star No. 4 and Chrome Queen deposits in 1943 and 1944 (40). In 1954, about 3,000 tons containing 38 pct Cr_2O_3 was mined and an additional 18,000 tons of chromite ore of unknown grade was mined from 1955 to 1957. Eight thousand tons of the ore produced at Red Mountain between 1955 and 1957 was sold and shipped to Japan about 1976 (79).

In recent years, exploration by industry and resource evaluation by government agencies have resulted in new discoveries. Deposits at Red Mountain and occurrences near Halibut Cove, both on the Kenai Peninsula, were discovered and evaluated by Anaconda Minerals Company. Deposits in the Kaiyuh Hills, Holonada, and Kilolitna ultramafic bodies and occurrences in the Christian mass were discovered by C.C. Hawley and Associates, the latter under contract to the Bureau of Indian Affairs. Chromite deposits in the Western Brooks Range, at Caribou Mountain, near the Kanuti River, at Mt. Hurst, near Tonsina, and on Kodiak Island were identified by the Bureau of Mines during the present investigations.

Total reserve estimates based on trench sample and drill core analyses for deposits on the Kenai Peninsula and at Eklutna (approximately 1,000 tons) are about 2 million tons of contained Cr_2O_3 (27). The bulk of these reserves are contained in the Turner stringer zone (1.25 million tons) and the Windy River placer deposit (556,000 tons) at Red Mountain in the Chugach Mountains. Additional chromite

reserve potential of about 700,000 tons Cr_2O_3 is estimated to be contained in deposits near Tonsina, on the Kenai Peninsula, and on Kodiak Island (27). About 600,000 to 1.4 million tons of Cr_2O_3 is estimated in the Western Brooks Range, to which a road is proposed from near Kivalina on the Bering Sea coast; these deposits are currently inaccessible by practical means of transportation (29).

BUREAU OF MINES INVESTIGATIONS

Published and unpublished reports by the Bureau on Alaska's chromite deposits are included in the list of references at the end of this report. Foremost among the earlier published reports (1940-1960) are those on drilling, trenching, and metallurgical testing of deposits on the Kenai Peninsula (76-77, 91) and deposits near Eklutna (11). Recent reports include results of literature searches and field investigations by the AFOC and beneficiation and mineralogical studies by the ALRC on deposits in the Western Brooks Range (29), the Caribou Mountain and Kanuti River areas (21,32), the Holonada Creeek area (30), the Kaiyuh Hills (31), at Mt. Hurst (70), Nail Ridge (80), near Tonsina, Palmer, and Eklutna, and on the Kenai Peninsula and Kodiak Island (23,27). Chemical and mineralogical data on selected Alaskan chromite deposits were compiled by Roberts (69). Excluding chromite deposits on the Kenai Peninsula, this investigation was limited to surface examinations. Therefore, reserve and reserve potential estimates are conservative.

REGIONS AND TRENDS IN ALASKA THAT CONTAIN CHROMITE DEPOSITS

Chromite deposits and occurrences in Alaska are concentrated in eight larger regions or trends (fig. 1, in pocket inside back leaf) that are variably defined on the basis of geology, geography, and

physiography. Geologic features on figure 1, including faults and mafic and ultramafic complexes, are adapted from the U.S. Geological Survey Geologic Map of Alaska (7). Most chromite-bearing regions are distinct linear or arcuate regions that parallel mountain ranges, major faults, or related geologic features, and are, therefore, appropriately called trends. Other regions contain scattered chromite-bearing, ultramafic bodies that are of uncertain relation to one another. Significant lode chromite deposits in Alaska are found only in the ultramafic portions of alpine peridotite and alpine peridotite-gabbro complexes. Many of these complexes are associated with pillow basalt, diabase, and chert and are therefore interpreted as ophiolite fragments, which are erosional remnants of oceanic crust that were tectonically emplaced along the margins of accreting continental crust. The peridotite bodies range from less than 1 mi^2 to almost 100 mi^2 in area, but most are smaller than 10 mi^2.

Chromite also occurs in minor amounts in zoned ultramafic and other igneous complexes that were intruded into the earth's crust as magma. Many of these complexes are found in southeast Alaska and one is known in southwest Alaska. More rarely, chromite occurs in igneous rocks of mafic to intermediate composition such as monzonite and alkali gabbro.

In the alpine peridotite and zoned ultramafic complexes, chromite occurs as disseminated grains and as magmatic segregations. The magmatic segregations form layers, lenses, and irregularly shaped masses that are generally referred to as podiform-type deposits. Often, parallel layers from less than one inch to several feet wide are concentrated in zones that measure tens, hundreds, or even

thousands of feet in one or more dimension. The largest known deposit of this type is the Turner stringer zone at Red Mountain on the Kenai Peninsula which contains 1.25 million tons of Cr_2O_3 at an average grade of 5.6 pct Cr_2O_3.

Chromite is also concentrated in placer deposits on beaches and in streams that are proximal to and eroding from chromite-bearing rocks. The Windy River placer deposit at Red Mountain on the Kenai Peninsula is inferred, on the basis of drilling and seismic surveys by Anaconda, to contain 556,000 tons of Cr_2O_3 at an average grade of 1.33 pct Cr_2O_3 (1, 27). Most placer chromite occurrences, however, consist of accessory to minor chromite in highly-concentrated black sands (18-20) that were produced during placer gold mining operations or sediment sampling where very little ultramafic rock exists, and are therefore not likely to be significant resources. Minor placer occurrences such as those on the Seward Peninsula (18, 20, 57, 92), on Kodiak Island (50), and in the eastern Gulf of Alaska (85) are not described in this report.

Western Brooks Range Trend

The Western Brooks Range Trend comprises chromite-bearing ultramafic rocks in the Iyikrok Mountain, Avan Hills, Misheguk Mountain, Siniktanneyak Mountain, and Asik Mountain complexes. This trend extends from the Chukchi Sea to Howard Pass, a distance of about 200 miles (fig. 1). Total estimated reserve potential for 70 deposits in the Western Brooks Range is between 576,000 and 1.4 million tons of Cr_2O_3 in high-chromium and high-iron chromite.

Alpine peridotite and alpine peridotite-gabbro complexes in this trend and associated underlying units of basalt, diabase, and chert

represent synclinal remnants of northward vergent, allochthonous sheets that originated along the northern margin of the Yukon-Koyukuk province (63). In each of the complexes, an upper unit of peridotite with abundant dunite and overlying layered gabbro, each up to thousands of feet thick, overlies a lower unit of basalt, diabase, and chert. Contacts between the two collective units are mapped as thrust faults, and together, these rocks represent dismembered ophiolite sequences (52, 56, 63, 72).

Chromite deposits at Iyikrok Mountain, in the Avan Hills, and at Misheguk Mountain were examined by the Bureau during the period from 1981 to 1983 (29). A chromite prospect at Asik Mountain was described by Saunders in 1955 (78). Accessory chromite is also reported in ultramafic rocks at Siniktanneyak Mountain (3, 45, 58). Chromite boulders up to 1 ft in diameter are reported in placer gold workings on Dahl Creek and the Shungnak River (2, 18, 38). Chromite deposits in the Western Brooks Range are summarized in table 1. Reserve estimates at Iyikrok Mountain, in the Avan Hills, and at Misheguk Mountain are based on surface measurements made during brief examinations of only small portions of the exposed peridotite and dunite in each complex. Because chromite was frequently observed and because large areas remain unexplored, it is likely that many undiscovered occurrences and deposits exist, and therefore, the potential reserves presented here are minimum estimates.

Because they are located near a proposed road between the Chukchi Sea and the Red Dog zinc-lead-silver deposit, deposits in the Avan Hills, 30 miles from Red Dog, and at Iyikrok Mountain, 10 miles from the proposed road, are the most likely to be developed. Deposits in

TABLE 1. - Summary of chromite deposits and occurrences in the Western Brooks Range trend

Location[1]	Number of deposits	Cr:Fe (2)	Number of samples (3)	Number of samples (4)	Cr_2O_3 pct in conc. (5)	Estimated reserve potential (tons, Cr_2O_3	Remarks
Iyikrok Mountain	2	2.8 3.1	3	3	58.4 44.2	144,000 to 383,000	Deposits include an 80- by 350-ft banded zone with 3 to 4 pct chromite (5,000-12,000 tons Cr_2O_3) and a 300- by 1,000-ft banded zone with 3 to 4 pct chromite (139,000-371,000 tons Cr_2O_3). Evidence exists for possible 3,000-ft, low-grade extensions at both deposits. 20 other unmeasured occurrences and minor placer potential. Less than 10 miles from proposed road (29).
Avan Hills	59	2.7 2.5	5	33	51.9 42.6	315,000 to 662,000	Deposits include: at least 40 irregular massive segregations containing from 5 to 1,000 tons Cr_2O_3 each (total 5,000-20,000 tons Cr_2O_3) and 2 larger zones, 150 and 500 ft long that contain more irregular massive chromite segregations (20,000-57,000 tons Cr_2O_3); 4 low-grade banded zones (4-5 pct chromite) with greater than 5,000 tons Cr_2O_3 each, the largest of which may contain over 500,000 tons Cr_2O_3; and 15 other low-grade banded zones (5-10 pct chromite) that contain between 5 and 2,500 tons Cr_2O_3 each. 50 other minor or unmeasured occurrences were observed. Large portions of dunite are unexplored and probably host similar deposits. Potential for large placer chromite reserves in nearby streams. Located about 30 miles from the Red Dog deposit (24, 29).

See notes at end of table.

TABLE 1. - Summary of chromite deposits and occurrences in the Western Brooks Range trend--Continued

Location[1]	Number of deposits	Cr:Fe	Number of samples		Cr_2O_3 pct in conc.	Estimated reserve potential (tons, Cr_2O_3	Remarks
		(2)	(3)	(4)	(5)		
Asik Mountain	0	ND	0	0	ND	ND	Two occurrences with chromite bands from 1- to 2-in wide. 2 samples contained 8.2 and 9.6 pct Cr_2O_3. No road access (78).
Misheguk Mountain	9	2.9 2.4	2	 6	49.9 33.3	117,000 to 349,000	Deposits include 9 banded zones with 3 to 6 pct chromite. 8 of these contain less than 20,000 tons Cr_2O_3 each and 1 large low-grade (3-5 pct chromite) banded zone contains from 78,000 to 261,000 tons of the total estimated reserves. At least 30 additional occurrences plus placer potential (24, 29).
Siniktanneyak Mountain	0	ND	0	0	ND	ND	Accessory disseminated and banded chromite reported. Largest reported occurrence is an 8-in by 12-ft lens. No road access (3, 45, 58).

ND Not determined.

[1]Formal names as established in geologic literature are used where available; otherwise, local geographic names are used.

[2]Average calculated chromium to iron ratio for indicated samples.

[3]Samples beneficiated by Bureau of Mines Albany (OR) Research Laboratory using combinations of gravity, magnetic, and electrodynamic concentration methods.

[4]Geochemical rock samples concentrated by hand-sorting chromite-rich material.

[5]Average chromic oxide in concentrate from data for samples in (3) and (4).

the Avan Hills have the greatest reserve potential of the known deposits in the Western Brooks Range. In the Avan Hills, there are 59 deposits that contain between 315,000 and 662,000 tons of Cr_2O_3. Of these estimated reserves, from 25,000 to 77,000 tons of Cr_2O_3 are contained in 42 zones comprising irregular, massive segregations of chromite in peridotite and dunite like that shown in figure 2. The remaining reserves are contained in low-grade (3 to 10 pct chromite) zones of banded, massive, disseminated, and nodular chromite. Potential also exists for large placer chromite deposits in broad alluvial valleys adjacent to the almost 100 mi^2 of chromite-bearing ultramafic rock in the Avan Hills complex (fig. 3). Two low-grade deposits at Iyikrok Mountain are estimated to contain between 144,000 and 383,000 tons Cr_2O_3.

Deposits at Misheguk Mountain, about 30 miles east of the Avan Hills, are less likely to be developed than the more readily accessible deposits in the Avan Hills and at Iyikrok Mountain. Nine low-grade banded deposits at Misheguk Mountain contain an estimated 117,000 to 349,000 tons Cr_2O_3. Of these, one large low-grade deposit contains between 78,000 and 261,000 tons Cr_2O_3. Potential also exists for large placer chromite deposits at Misheguk Mountain.

Metallurgical tests and geochemical analyses of samples from Iyikrok Mountain, the Avan Hills, and Misheguk Mountain indicate that high-chromium concentrates can be produced from hand sorted material at these locations (29).

Yukon-Koyukuk Trend

Chromite-bearing dunite occurs in a 65-mile-long trend known as the Caribou Mountain-Melozitna ultramafic belt in the southeastern limb of

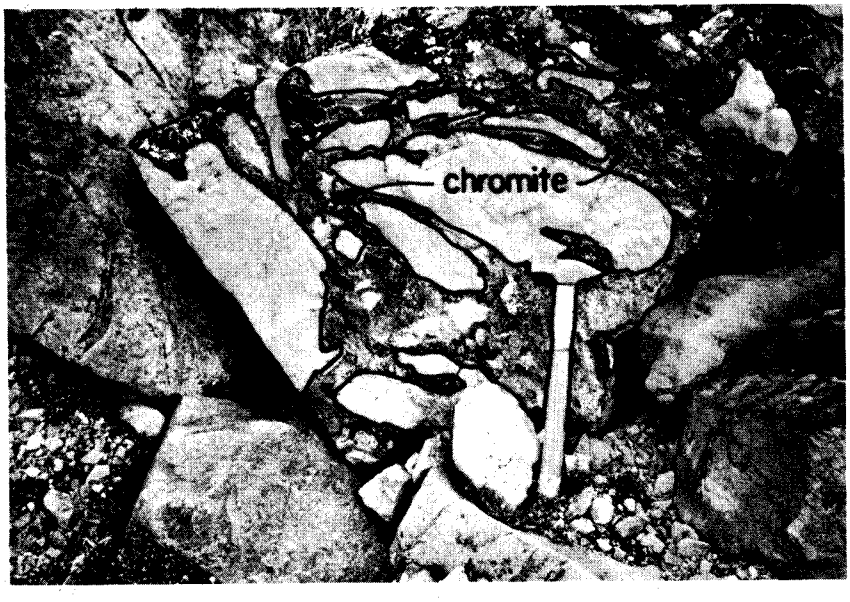

FIGURE 2. - Irregular massive chromite segregations in peridotite and dunite in the Avan Hills.

FIGURE 3. - Broad alluvial valley along the upper Avan River and well-exposed chromite-bearing peridotite and dunite in the Avan Hills. Potential exists for placer chromite deposits in this and other valleys adjacent to ultramafic rocks in the Western Brooks Range.

the much larger Yukon-Koyukuk trend in central and northern Alaska. This trend contains crudely layered peridotite and gabbro that overlie basalt, diabase, and chert sequences similar to those found in the Western Brooks Range and Rampart trends (62). The Caribou Mountain-Melozitna belt comprises Caribou Mountain, upper and lower Kanuti River, Sithylemenkat Lake, Kilolitna, and Holonada ultramafic masses (fig. 1).

The Bureau investigated ultramafic rocks in the Caribou Mountain-Melozitna belt between 1978 and 1983 (12-13, 17, 21, 30, 32). Podiform chromite deposits are present at Caribou Mountain, in the upper and lower Kanuti River masses, near the Kilolitna River, and in the Holonada mass. Minor disseminated chromite was observed in dunite at Sithylemenkat Lake. The Caribou Mountain occurrences are less than 2 miles from the Dalton Highway and others in the Yukon-Koyukuk trend range up to 70 miles from the road. These occurrences are summarized in table 2. Except for one deposit in the Holonada mass that is estimated to contain between 13,000 and 26,000 tons of Cr_2O_3, other deposits in the Yukon-Koyukuk trend are estimated to contain less than 3,000 tons of Cr_2O_3 each. Metallurgical tests indicate that high-chromium and high-iron chromite concentrates can be produced from material at these sites (12-13, 21).

Rampart Trend

The Rampart trend comprises the Christian, Hadweenzic, Rampart, Kaiyuh Hills masses and several smaller masses of mafic and ultramafic rocks that extend southwest from the eastern Brooks Range for 500 miles to the Kaiyuh Hills (62). The southwestern portion of this trend has been offset right-laterally along the Kaltag Fault (fig. 1).

TABLE 2. - Summary of chromite deposits and occurrences in the Yukon-Koyukuk trend

Location[1]	Number of deposits	Cr:Fe	Number of samples		Cr_2O_3 pct in conc.	Estimated reserve potential (tons, Cr_2O_3	Remarks
		(2)	(3)	(4)	(5)		
Caribou Mountain	3	1.5	3	0	36.9	2,000 to 2,500	Bands of massive and coalescent chromite and magnesian chromohercynite up to 10 ft thick and exposed for up to 50 ft in 3 deposits plus 7 additional occurrences of minor banded and disseminated chromite in dunite. High-chromium and high-iron chromite concentrates produced from deposits within 2 miles of Dalton Highway (17, 21, 32).
Upper Kanuti River	0	ND	0	0	ND	ND	Numerous small occurrences of disseminated chromite within 7 miles of Dalton Highway (32).
Lower Kanuti River	1	1.8	7	0	45.4	700 to 800	Bands of disseminated and massive chromite in dunite rubble and bedrock at 13 occurrences and 1 5-ft-wide deposit exposed for 80 ft contains 7.5 pct chromium. High-chromium and high-iron chromite concentrates produced from material collected between 12 and 22 miles from Dalton Highway (17, 21, 32, 62).
Sithylemenkat Lake	0	ND	0	0	ND	ND	Accessory chromite in small dunite body 40 miles from Dalton Highway (32).
Kilolitna River	0	1.7	2	0	46.7	ND	Numerous small occurrences of disseminated and massive chromite in dunite rubble and bedrock 65 miles from the Dalton Highway (13, 62).

See notes at end of table.

TABLE 2. - Summary of chromite deposits and occurrences in the Yukon-Koyukuk trend--Continued

Location[1]	Number of deposits	Cr:Fe (2)	Number of samples (3)	Number of samples (4)	Cr_2O_3 pct in conc. (5)	Estimated reserve potential (tons, Cr_2O_3	Remarks
Holonada	5	2.9 2.3	3	9	55.4 33.2	14,500 to 27,500	Bands of disseminated and massive chromite in dunite rubble and bedrock in 10 areas measuring tens of feet in 2 dimensions. These include 1 deposit over 400 ft long and 5 to 15 ft wide that contains over 20 pct chromite (13,000-26,000 tons Cr_2O_3). 4 other deposits with between 4 and 8 pct chromite contain less than 1,000 tons Cr_2O_3 each. Located about 75 miles from Dalton Highway (12, 30).

ND Not determined.

[1]Formal names as established in geologic literature are used where available; otherwise, local geographic names are used.

[2]Average calculated chromium to iron ratio for indicated samples.

[3]Samples beneficiated by Bureau of Mines Albany (OR) Research Laboratory using combinations of gravity, magnetic, and electrodynamic concentration methods.

[4]Geochemical rock samples concentrated by hand-sorting chromite-rich material.

[5]Average chromic oxide in concentrate from data for samples in (3) and (4).

The ophiolitic masses within this trend are poorly exposed compared to those in the Western Brooks Range trend but generally consist of the same rock types; however, ultramafic rocks are far more abundant in the Western Brooks Range than in the Rampart trend (63).

At least four chromite deposits and 17 unmeasured or minor occurrences are known in the Kaiyuh Hills (31). These deposits and occurrences are not accessible by road but are within 30 miles of the Yukon River. They are the only deposits in the Rampart trend for which reserve potential estimates (17,000 to 37,000 tons Cr_2O_3) exist (table 3). The Bureau examined and sampled four deposits in the Kaiyuh Hills in 1983, and metallurgical tests indicate that high-chromium and high-iron concentrates can be produced from hand-sorted material at these sites (31). Potential also exists for placer chromite deposits in streams that drain the chromite-bearing ultramafic rocks in the Kaiyuh Hills. Minor chromite is reported in the poorly exposed Christian mass (43). No chromite is reported in the poorly exposed Hadweenzic mass, but podiform chromite deposits may exist there and in unexposed ultramafic rocks in the area (25). Minor chromite is reported in placer gold concentrates from Little Minook Creek, near the village of Rampart on the Yukon River (53).

Yukon-Tanana Uplands Region

Alpine peridotite and serpentinite occur at numerous locations in the Yukon-Tanana uplands region which includes two smaller trends, the Livengood trend and the Eagle trend. The Livengood trend extends 130 miles from Serpentine Ridge, near Manley Hot Springs to the Beaver Creek serpentinite body in the White Mountains (fig. 1). Serpentinite also occurs as fault-bounded masses in rocks of Devonian age near

TABLE 3. - Summary of chromite deposits and occurrences in the Rampart trend

Location[1]	Number of deposits	Cr:Fe	Number of samples		Cr_2O_3 pct in conc.	Estimated reserve potential (tons, Cr_2O_3	Remarks
		[2]	[3]	[4]	[5]		
Christian	0	0.4	0	1	ND	ND	7 pct chromite in rock sample from Levi Creek and 6.6 pct Cr_2O_3 in a geochemical sample near Christian River at head of Timber and Marten Creeks, near the Christian mass (17, 25).
Kaiyuh Hills	4	2.9	4	0	54.1	17,000 to 37,000	Deposits include a 3-ft-wide band of massive chromite with inferred length of 300 ft based on geophysical data (2,000-5,000 tons Cr_2O_3) and 3 low-grade (3-5 pct chromite) zones that are from 5 to 75 ft wide and from 300 to 900 ft long with total estimated reserve potential of 15,000 to 32,000 tons Cr_2O_3. 14 additional occurrences plus placer potential (31).

ND Not determined.

[1]Formal names as established in geologic literature are used where available; otherwise, local geographic names are used.

[2]Average calculated chromium to iron ratio for indicated samples.

[3]Samples beneficiated by Bureau of Mines Albany (OR) Research Laboratory using combinations of gravity, magnetic, and electrodynamic concentration methods.

[4]Geochemical rock samples concentrated by hand-sorting chromite-rich material.

[5]Average chromic oxide in concentrate from data for samples in (3) and (4).

Livengood in the central portion of the trend (15). The Eagle trend consists of numerous serpentinized peridotite and serpentinite masses south of the Tintina Fault and related faults in a loosely defined belt that extends for over 100 miles from American Creek near Eagle to near Caribou on the Salcha River (fig. 1). Ultramafic rocks, gabbro, and pillow basalt along the Seventymile River, west of Eagle, and near the Salcha River, southwest of Eagle, are associated with red radiolarian chert of Permian age (34, 89). Serpentinized ultramafic rocks also occur at other scattered locations throughout the Eagle Quadrangle (35).

No economically significant chromite deposits are reported in the Yukon-Tanana region and no reserve potential estimates are available. Reported occurrences are summarized in table 4. Specimens of massive chromite are reported in serpentinite masses at two locations in the Livengood trend (5, 36). Accessory chromite in serpentinite in the Livengood trend (37) is probably the source of chromite reported in placer concentrates from gold-mining operations in the Livengood and Manley Hot Springs areas (18, 46, 59, 87-88, 90). A sluice box concentrate from Ruth Creek at Livengood and from a tributary of Livengood Creek contained 4.7 pct Cr (26). In 1981, the Bureau of Mines investigated serpentinized ultramafic rocks near Boundary, Butte Creek, American Creek, and Flume Creek, all in the U.S. Geological Survey 1:250,000 scale Eagle Quadrangle. The only chromite observed was in small discontinuous wispy bands and as disseminated grains at the head of Flume Creek (28). The Bureau and the Alaska Division of Geological and Geophysical Surveys (ADGGS) jointly investigated the ultramafic rocks at Nail Ridge, near the Salcha River in 1983 (80).

TABLE 4. - Summary of chromite occurrences in the Yukon-Tanana uplands region

Location[1]	Number of deposits	Cr:Fe (2)	Number of samples (3)	Cr_2O_3 pct in conc. (4)	Remarks
Flume Creek	0	ND	0	ND	Accessory chromite in serpentinized peridotite. Tractor trail exists from Eagle, 40 miles to the east (28).
Mount Sorenson	0	ND	0	ND	Accessory chromite in peridotite; 15 miles west of Flume Creek, no road access (35).
Nail Ridge	0	1.1	1	25.9	Up to 3 pct coarse-grained, disseminated chromian spinel tentatively identified as high-Al, high-Mg chromite in harzburgite and dunite body that measures 8 miles by 1 mile in area and varies from 50 to 800 ft thick (800. Mineral identification is based on chemical analyses of laboratory concentrated sample. 40 miles from Chena Hot Springs Road.
Beaver Creek	0	ND	0	ND	Chromitite collected from scree in Beaver Creek serpentinite mass 15 miles from Elliot Highway (36).
Livengood	0	ND	0	ND	Accessory chromite in serpentinite (5, 37).

ND Not determined.

[1]Formal names as established in geologic literature are used where available; otherwise, local geographic names are used.

[2]Average calculated chromium to iron ratio for indicated samples.

[3]Samples beneficiated by Bureau of Mines Albany (OR) Research Laboratory using combinations of gravity, magnetic, and electrodynamic concentration methods.

[4]Average chromic oxide in concentrate from data for samples in (3) and (4).

At Nail Ridge, coarse disseminated grains of high-aluminum high-magnesium chromite constitute up to 3 to 4 pct of the dunite in a crudely layered mass of serpentinized peridotite. Analyses of concentrates beneficiated from samples from this occurrence indicate that the best product that can be obtained is unsuitable for use by industry (80).

Alaska Range Trend

Fault-bounded and intrusive masses of alpine peridotite and serpentinite crop out at numerous locations in a narrow, 400-mile-long trend that parallels the Alaska Range from near the Canadian border to near Farewell (fig. 1). The origins and relative ages of these ultramafic rocks are unknown, but most are elongated parallel to the Denali Fault and were possibly emplaced into the crust during deformation along the fault.

Chromite is reported in alpine peridotite and serpentinite masses at several locations in the Alaska Range trend, but few of the masses have been thoroughly investigated for their chromite potential. No estimates of reserve potential are available. Reported hard-rock occurrences are summarized in table 5. Of the reported chromite occurrences in the Alaska Range, those near Lacuna and Yentna Glaciers and in the Chulitna area have the greatest reserve potential. Chromite is reported at several locations in the Lacuna and Yentna Glaciers area where the largest occurrence is an 8-ft by 60-ft lens of massive, high-chromium chromite (66). Nearly massive chromite bands up to 1 ft thick are reported in a 1,000-ft-wide by 3-mile-long serpentinite body near Copeland Creek in the Chulitna area. Geochemical analyses on one sample indicate that high-chromium

TABLE 5. - Summary of chromite occurrences in the Alaska Range trend

Location[1]	Number of deposits	Cr:Fe (2)	Number of samples (3)	Number of samples (4)	Cr_2O_3 pct in conc. (5)	Remarks
Carden Hills	0	ND	0	2	ND	Accessory to 6 pct coarse-grained disseminated, slightly magnetic chromian spinel in dunite layers that are interlayered with gabbro and pyroxenite. The largest exposed zone is from tens to hundreds of feet wide and possibly thousands of feet long. No road access. 20 miles from Alaska Highway. 2 miles from Carden Lake which is accessible by float plane (4).
Mirror Lake Creek	0	ND	0	0	ND	Cobble-size float of massive chromite derived from alpine-type ultramafic rocks 12 miles from Alaskan Highway (68). This occurrence was not confirmed during investigations by the Bureau.
Gillett Pass	0	ND	0	0	ND	Accessory chromite (<4 pct) in 2-mile-long dunite body. 18 miles from Glenn Highway (67).
Landslide Creek	0	ND	0	0	ND	Subeconomic concentration (vein?) of chromite in dunite. Less than 20 miles from Richardson Highway (73).
Copeland Creek	0	3.1	0	1	39.5	Blocks of massive chromite up to 1 ft across associated with 1,000-ft-wide by 3-mile-long lenticular body of serpentinite about 8 miles from Parks Highway (42).
Lacuna and Yentna Glaciers	0	2.7	0	3	58.4	Chromite occurs in dunite as disseminated grains, streaks, and lenses at 6 locations. The largest occurrence is a lens-like body up to 60 ft long by 8 ft thick. Chromite also occurs in placer concentrates in the Yentna district within 40 to 50 miles of Petersville Road (66).

ND Not determined.

[1]Formal names as established in geologic literature are used where available; otherwise, local geographic names are used.

[2]Average calculated chromium to iron ratio for indicated samples.

[3]Samples beneficiated by Bureau of Mines Albany (OR) Research Laboratory using combinations of gravity, magnetic, and electrodynamic concentration methods.

[4]Geochemical rock samples concentrated by hand-sorting chromite-rich material.

[5]Average chromic oxide in concentrate from data for samples in (3) and (4).

chromite is present (42). Chromite has been identified in panned concentrates from Rainy Creek (73) and Gunn Creek (75) and in placer concentrates from the middle fork of the Chistochina River (54). Investigations by the Bureau in the Rainy Creek area indicated no significant chromite concentrations exist there. In the Carden Hills, disseminated chromian spinel of unknown quality was observed in zones up to 0.5 miles long. None of the Alaska Range occurrences are accessible by road. No reserve potential estimates or metallurgical data are available.

Southwest Region

The southwest region includes chromite-bearing alpine peridotite and alpine peridotite-gabbro masses of varied origin and ages at Mount Hurst, Tatlignagpeke Mountain, Mitlak Mountain, Red Mountain, and Susie Mountain, and chromite-bearing monzonite near Moore Creek and Fourth of July Creek (fig. 1). This region extends southwest from Mount Hurst, near Tolstoi to Red Mountain, near Goodnews Bay, a distance of about 450 miles.

Mount Hurst is partially underlain by a mass of serpentinized peridotite which is bounded on the southeast by sedimentary and volcanic rocks of Jurassic (?) to Mississippian age and is bounded on the northwest by metamorphic rocks of early Paleozoic and Precambrian (?) age (14). The age of the peridotite and the contact relations of the peridotite with the surrounding rocks are uncertain (14). Ultramafic rocks at Mount Hurst may be related to ultramafic and related rocks in the Kaiyuh Hills, 75 miles to the north, which are in the Rampart ophiolite belt. Tatlignagpeke Mountain and Mitlak Mountain, between the Arolik and Goodnews Rivers, consist of

serpentinized, strongly tectonized, and layered peridotite and gabbroic rocks that structurally overlie Mesozoic and Paleozoic sedimentary and volcanic rocks (44). Red Mountain and Susie Mountain, adjacent to Goodnews Bay, are zoned masses of Jurassic age that consist mostly of dunite and peridotite that was intruded into Paleozoic sedimentary and volcanic rocks. Red Mountain is partially surrounded by a sheath of wehrlite, clinopyroxenite, hornblendite, and hornblende plagioclase pegmatite (81). Small monzonite plutons are intruded into sedimentary rocks of the Cretaceous Kuskokwim Group near Moore Creek and Fourth of July Creek.

Between 1981 and 1983, the Bureau investigated ultramafic rocks in southwest Alaska for their chromite potential. Chromite occurrences and deposits are summarized in table 6. No chromite reserve potential is estimated for these occurrences. One podiform-type deposit of ferroan picrochromite and 15 other occurrences were sampled and described by the Bureau at Mount Hurst (70). Tatlignagpeke, Mitlak, Red, and Susie Mountains all contain minor accessory chromite as disseminated grains, small clots, and rare discontinuous bands (33). Two samples of stream gravels collected from Moore Creek and Fourth of July Creek by T. K. Bundtzen[5] were processed by ALRC to concentrate

[5]Geologist, Alaska Division of Geological and Geophysical Surveys, Fairbanks, AK.

minor contained chromite in 1983; the beneficiation tests were not able to produce usable concentrates. The chromite at these locations was apparently derived from local chromite-bearing monzonite plutons and chromite probably derived from similar rocks is reported in other creeks in the vicinity (18, 51). Minor chromite is also reported in beach sands at Chagvan Bay and Hagemeister Strait (10).

TABLE 6. - Summary of chromite occurrences in the Southwest region

Location[1]	Number of deposits	Cr:Fe (2)	Number of samples (3)	Number of samples (4)	Cr_2O_3 pct in conc. (5)	Remarks
Mount Hurst	0	1.62	0	6	33.4	Seven bedrock and 9 float occurrences reported. Largest bedrock occurrence contains from 35 to 80 pct ferroan picrochromite, is exposed for 26 ft along strike, and ranges from 6 to 32 in wide. Potential exists for local placer and paleoplacer deposits (70).
Tatlignagpeke Mountain	0	ND	0	0	ND	Accessory chromite in dunite (33).
Mitlak Mountain	0	ND	0	0	ND	Do.
Red Mountain	0	ND	0	0	ND	Accessory chromite in dunite and adjacent streams and beach sands (80, 81).
Susie Mountain	0	ND	0	0	ND	Accessory chromite in dunite (80, 81).

ND Not determined.

[1]Formal names as established in geologic literature are used where available; otherwise, local geographic names are used.

[2]Average calculated chromium to iron ratio for indicated samples.

[3]Samples beneficiated by Bureau of Mines Albany (OR) Research Laboratory using combinations of gravity, magnetic, and electrodynamic concentration methods.

[4]Geochemical rock samples concentrated by hand-sorting chromite-rich material.

[5]Average chromic oxide in concentrate from data for samples in (3) and (4).

Chugach Trend

Numerous alpine peridotite and alpine peridotite-gabbro complexes occur along the Border Ranges Fault zone in southern Alaska (27). This fault zone and the discontinuous belt of peridotite and peridotite-gabbro complexes that parallels it, extend in an arcuate fashion for over 600 miles across southern Alaska from near the Canadian border to Kodiak Island. From east to west, along the southward concave arc of the Chugach trend, are peridotite and peridotite-gabbro masses near the Chakina, Klu, and Hanagita Rivers, at Dust Mountain, Sheep Hill, and Bernard Mountain near Tonsina, at the head of Barnette Creek, tributary to the Nelchina River, at the Wolverine and Eklutna complexes near Palmer, at Red Mountain and Claim Point on Kenai Peninsula, on Ban Island, and at the Sturgeon River, Halibut Bay, Grant Lagoon, and Miners Point complexes on Kodiak Island.

The Bureau investigated about 100 deposits and occurrences in this trend between 1981 and 1983 (22, 27). These deposits and occurrences are summarized in table 7. Total estimated reserve potential in the Chugach trend is about 2.8 million tons of Cr_2O_3 in 41 hard-rock deposits and one placer deposit. Additional unmeasured reserve potential exists for high-chromium and high-iron chromite. Deposits at Claim Point (figs. 4-5) and Red Mountain are the only ones in Alaska from which chromite has been mined. The largest chromite deposits in Alaska, including hard-rock deposits at Red Mountain and the nearby Windy River placer deposit, are described primarily on the basis of information released to the Bureau by Anaconda Minerals Company (1). All the deposits for which reserves or reserve potential

TABLE 7. - Summary of chromite deposits and occurrences in the Chugach trend

Location[1]	Number of deposits	Cr:Fe (2)	Number of samples (3)	Number of samples (4)	Cr_2O_3 pct in conc. (5)	Estimated reserve potential (tons, Cr_2O_3	Remarks
Hanagita River	0	ND	0	0	ND	ND	A 2-in clot of massive chromite in wehrlite and accessory disseminated chromite in dunite; 15 miles south of road that connects with the Edgerton Highway (27).
Dust Mountain	0	1.1	2	0	37.6	ND	A 190-ft-wide zone containing about 3 pct chromian spinel persists for 3,600 ft along strike. No reserve estimates calculated because of inferior quality of concentrate. At least 8 other occurrences, all within 10 miles of Richardson Highway (23, 27, 64).
Sheep Hill	1	1.6	3	0	48.4	26,000	300- by 100-ft zone contains 5 pct banded chromite. High-chromium concentrate was produced from this zone. At least 2 other occurrences, with 3 pct inferior quality chromian spinel (Cr:Fe = 1.4), one a large zone; less than 8 miles to Richardson Highway (23, 27, 64).
Bernard Mountain	7	2.5	7	0	53.3	343,000	Three deposits of banded and disseminated chromite containing 5 pct chromite range from 1,000 to over 300,000 tons of contained Cr_2O_3 plus 4 additional deposits each with less than 1,000 tons contained Cr_2O_3 and at least 8 other occurrences of banded chromite. Within 3 miles of Richardson Highway (23, 27, 64).
Barnette	0	ND	0	0	ND	ND	Accessory disseminated chromite in fault-bounded serpentinized dunite mass less than 500 ft in maximum dimension (27).

See notes at end of table.

TABLE 7. - Summary of chromite deposits and occurrences in the Chugach trend--Continued

Location[1]	Number of deposits	Cr:Fe (2)	Number of samples (3)	Number of samples (4)	Cr_2O_3 pct in conc. (5)	Estimated reserve potential (tons, Cr_2O_3	Remarks
Wolverine Complex	0	1.6 1.6	1	 1	47.5 54.2	ND	Samples from a 50- by 200-ft exposed zone containing about 5 pct chromian spinel. 2 additional hardrock and 4 occurrences in talus or moraine. Located within 10 miles of gravel road to Palmer, 17 miles to west (16, 27, 71).
Eklutna Complex	4	ND	0	0	ND	1,000	Deposits ranging up to 175 ft long and about 40 ft wide were trenched and drilled by the Bureau during previous investigations. 2 other reported occurrences. No metallurgical data available. Deposits are now covered by dense vegetation. Less than 5 miles from Glenn Highway (27, 74).
Red Mountain	33	2.7	6	0	56.7	1,582,000	Three low-grade (5 to 6 pct Cr_2O_3) deposits contain 1,487,000 tons Cr_2O_3. An additional 95,000 tons are contained in 16 higher grade (>20 pct Cr_2O_3) deposits. Three other low-grade (3 to 15 pct Cr_2O_3) deposits and 11 additional high-grade deposits (≥20 pct chromite) contain unmeasured reserves. 10 miles by road from Seldovia which is on Kachemak Bay (1, 23, 27, 39-40, 91).
Windy River	1	1.8	4	0	52.9	556,000	Reserve estimates based on drilling and seismic exploration by Anaconda, and surface sampling and beneficiation by the Bureau. 10 miles from Seldovia (22-23, 76).

See notes at end of table.

TABLE 7. - Summary of chromite deposits and occurrences in the Chugach trend--Continued

Location[1]	Number of deposits	Cr:Fe	Number of samples		Cr_2O_3 pct in conc.	Estimated reserve potential (tons, Cr_2O_3	Remarks
		(2)	(3)	(4)	(5)		
Claim Point	16	2.6	2	0	56.7	90,000	65,000 tons Cr_2O_3 in 8 deposits that contain from 14 to 30 pct Cr_2O_3. An additional 25,000 tons Cr_2O_3 are inferred in low-grade extensions for 2 of the 8 deposits. Revised grades for the two deposits are about 9 pct Cr_2O_3. 8 other deposits for which no reserves are calculated exist at Claim Point which is situated at tidewater (23, 27, 39, 40, 77).
Miners Point	0	2.0	1	0	47.5	ND	Minor banded and disseminated chromite in small, fault-bounded dunite body exposed on north shore of Kokiak Island (23).
Saddle Mountain	0	ND	0	0	ND	ND	Do.
Grant Lagoon	0	3.0	1	0	62.0	ND	Minor disseminated chromite in small, fault-bounded dunite body near north shore shore of Kokiak Island (23, 27).
Sturgeon River	0	ND	0	0	ND	ND	Minor, wispy segregations of chromite in dunite near north shore of Kodiak Island (23, 27).
Halibut Bay	7	2.2	8	0	50.7	201,000	Deposits contain from 5 to 20 pct chromite and range in size from less than 1,000 to 196,000 tons contained Cr_2O_3. 4 additional occurrences and placer potential exist in nearby valleys; within 10 miles of tidewater on Kodiak Island (23, 27).

See notes at end of table.

TABLE 7. - Summary of chromite deposits and occurrences in the Chugach trend--Continued

Location[1]	Number of deposits	Cr:Fe (2)	Number of samples (3)	Number of samples (4)	Cr_2O_3 pct in conc. (5)	Estimated reserve potential (tons, Cr_2O_3	Remarks
Gurney Bay	0	ND	0	0	ND	ND	Minor disseminated and banded chromite in small dunite body near north shore of Kokiak Island, (23, 27).

ND Not determined.

[1]Formal names as established in geologic literature are used where available; otherwise, local geographic names are used.

[2]Average calculated chromium to iron ratio for indicated samples.

[3]Samples beneficiated by Bureau of Mines Albany (OR) Research Laboratory using combinations of gravity, magnetic, and electrodynamic concentration methods.

[4]Geochemical rock samples concentrated by hand-sorting chromite-rich material.

[5]Average chromic oxide in concentrate from data for samples in (3) and (4).

FIGURE 4. - Oblique aerial photograph of Claim Point. The Reef deposit, from which 2,200 tons of chromite ore was produced in 1917 and 1918, is located on the partially emerged shoals in the far left portion of the photograph.

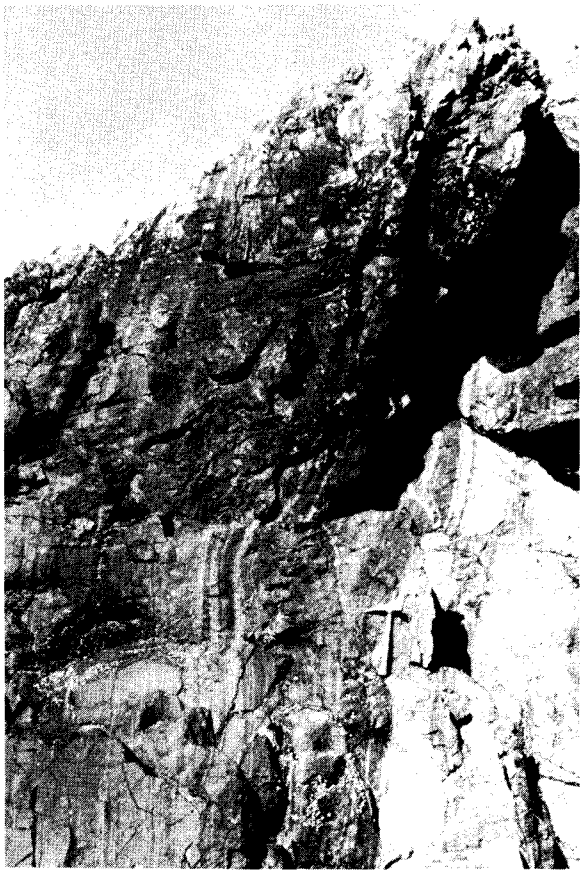

FIGURE 5. - Banded chromite in the Reef deposit at Claim Point where at least 4,000 tons of Cr_2O_3 remain. Additional unmeasured reserves exist below sea level.

are estimated are within 10 miles of tidewater or existing transportation routes.

Deposits in the Chugach trend range in size from less than 1,000 tons to 1.25 million tons (figs. 5-7) of Cr_2O_3. Grades range from about 5 to 10 pct chromite for most, but a few smaller and less significant deposits with greater than 20 pct chromite exist. Excluding all deposits more than 10 miles from either tidewater or existing roads, and all deposits containing only high-iron or high-alumina chromite, about 2,236,000 tons of Cr_2O_3 in high-chromium chromite are contained in 41 hard-rock deposits in the Chugach trend. The Windy River placer deposit (fig. 7) contains an additional 40 million tons at an average grade of 1.33 pct Cr_2O_3. This is equivalent to about 556,000 tons of Cr_2O_3.

Southeast Region

Chromite-bearing dunite is locally associated with two types of igneous complexes in southeast Alaska. A 36-mile-long belt comprises "layered" mafic and ultramafic rocks in the Fairweather, Crillon-La Perouse, and Astrolabe-De Langle plutons (fig. 1) (65). A separate 350-mile-long belt includes more than 35 mafic-ultramafic complexes that generally show concentric zoning of rock types (84). The layered plutons and the zoned complexes were all intruded into folded and metamorphosed Paleozoic and Mesozoic rocks of varied origins (65, 84).

Minor chromite is reported in dunite float derived from the Fairweather and Crillon-La Perouse plutons which are underlain by rugged, glaciated mountains for which the plutons are named (table 8 and fig. 1). Neither of these two plutons have been thoroughly investigated, but dunite and other ultramafic rocks are apparently

FIGURE 6. - Banded chromite in the Turner stringer zone which is estimated to contain 1.25 million tons of Cr_2O_3 at an average grade of 5.6 pct Cr_2O_3. Most of the estimated chromite reserves in Alaska are contained in similar, low-grade deposits.

FIGURE 7. - Windy River Valley at Red Mountain. Inferred reserves are 556,000 tons of contained Cr_2O_3 at an average grade of 1.33 pct Cr_2O_3.

TABLE 8. - Summary of chromite deposits and occurrences in the Southeast Region

Location[1]	Number of deposits	Cr:Fe (2)	Number of samples (3)	Number of samples (4)	Cr_2O_3 pct in conc. (5)	Estimated reserve potential (tons, Cr_2O_3	Remarks
Mount Fairweather	0	ND	0	0	ND	ND	Accessory to a few percent disseminated chromited in dunite float from layered mafic and ultramafic pluton. 10 miles from tidewater in extremely rugged terrain with over 12,000 ft of relief (65).
Lituya Bay - Mount Crillon	0	ND	0	0	ND	ND	Chromite float reported on glaciers in the area (47).
Blue Lake	0	ND	0	0	ND	ND	Chromite in serpentinite at two locations on Baranof Island, both within 3 miles of tidewater (49).
Hill	0	ND	0	0	ND	ND	Abundant accessory chromite in sills of serpentinized dunite on central Baranof Island. 4.2 pct Cr_2O_3 in a chip sample collected from a 5- by 50-ft area (41, 47, 83).
Red Bluff Bay	8	2.5 2.2	1	 5	50.5 28.0	4,000	Small lenses, thin layers, and disseminated grains of chromite in dunite. 5 deposits of shipping-grade ore and 3 of concentrating ore contain a total of 570 tons with greater than 40 pct Cr_2O_3. 32,000 tons of low-grade material containing 12 pct Cr_2O_3 is estimated. Cr:Fe ratios for 12 samples ranged from 0.7 to 2.18. Located on Baranof Island by Chatham Strait (41, 47, 83-84).
Blashke Islands	0	ND	0	0	ND	ND	Sparse but ubiquitous chromite in dunite and augite dunite exposed on the southeastern part of the islands. X-ray analyses of one grain indicates relatively pure chromite is present. Dunite is

See notes at end of table.

TABLE 8. - Summary of chromite deposits and occurrences in the Southeast Region --Continued

Location[1]	Number of deposits	Cr:Fe	Number of samples		Cr_2O_3 pct in conc. (5)	Estimated reserve potential (tons, Cr_2O_3	Remarks
		(2)	(3)	(4)			
Blashke Islands (continued)							estimated to contain 1.3 pct chromite and "augite dunite" 0.7 pct chromite. A sample collected from a 50- by 100-ft area contained 0.51 pct Cr_2O_3. No economically significant concentrations were noted; located near tidewater (42, 83-84, 86).
Union Bay (Mount Burnett)	1	ND	0	0	ND	ND	Numerous small chromite pods in dunite, most only an inch to several inches in size. A 5,000 ft^2 area is estimated to contain 5 pct chromite. A chip sample collected across 25 ft in the northern part of the complex contained 1.5 pct Cr_2O_3 and a chip sample collected from a 90- by 300-ft area in the southern part contained 1.2 pct Cr_2O_3 near tidewater (47, 83-84).
Yellow Hill (Annette Island)		ND	1	0	ND	ND	Sparse veinlets and disseminated grains of chromite in partially serpentinized dunite on Annette Island. 0.93 pct Cr_2O_3 in a chip sample collected from a 30- by 100-ft area. Road access to Tamgas Harbor (8, 83-84).
Percy Island	0	ND	0	0	ND	ND	Dunite layers as much as 200 to 300 ft thick (84).
Duke Island	ND	ND	1	0	ND	ND	Accessory chromite in 2 dunite bodies near tidewater. 0.67 pct Cr in a chip sample collected over a 20- by 30-ft area in the Judd Harbor body. A similar sample from the Hall Cove body contained 0.48 pct Cr_2O_3 (83-84).

See notes at end of table.

TABLE 8. - Summary of chromite deposits and occurrences in the Southeast Region --Continued

ND Not determined.
[1]Formal names as established in geologic literature are used where available; otherwise, local geographic names are used.
[2]Average calculated chromium to iron ratio for indicated samples.
[3]Samples beneficiated by Bureau of Mines Albany (OR) Research Laboratory using combinations of gravity, magnetic, and electrodynamic concentration methods.
[4]Geochemical rock samples concentrated by hand-sorting chromite-rich material.
[5]Average chromic oxide in concentrate from data for samples in (3) and (4).

restricted to the northern portion of the Fairweather pluton, are less abundant in the Crillon-La Perouse pluton, and are generally lacking elsewhere in the belt (65). No significant deposits are reported in the layered complexes and the potential for chromite reserves in this belt remains unknown.

Chromite occurs as disseminated grains and as banded or lens-shaped segregations in the dunite portions of zoned mafic-ultramafic complexes. Deposits or occurrences in seven areas are described in table 8. Poorly exposed dunite that probably contains accessory chromite is also reported at Kane Peak and Percy Islands (84).

Based on investigations of chromite prospects at the Mount Burnett, Duke Island, Yellow Hill, Blashke Islands, and the Hill areas by the Bureau in 1981 and 1982 (83) and descriptions of reported deposits at other locations by earlier investigators (8, 41-42, 47, 49, 65, 83-84, 86) the only potentially significant chromite deposits in the Southeast Region are at Red Bluff Bay where over 32,000 tons of material containing about 12 pct Cr_2O_3 is estimated in eight deposits (table 8). Chromite compositions vary widely in the zoned complexes, with both high-chromium and high-iron varieties reported (49, 86).

DISCUSSION

Because chromium is of strategic importance, domestic chromite deposits that meet specific criteria can be considered an inferred reserve base that might offset shortages in the event of an interruption of chromium supplies from foreign sources. These criteria include size, grade, chemical quality, and accessibility. Because of current world market conditions, all the Alaskan chromite deposits described in this report are currently subeconomic.

Podiform-type deposits vary in size from a few pounds to several million tons. Most production from podiform-type deposits has come from deposits that contain 100,000 tons or more of chromite (61). Most Alaskan podiform deposits are small by comparison but the bulk of the reserves described in this report are contained in four hard-rock and one placer deposit that each have estimated reserves of more than 172,000 tons of chromite. These include the Turner stringer zone and the Windy River placer deposit at Red Mountain on Kenai Peninsula, a zone comprising four smaller deposits at Bernard Mountain near Tonsina, and deposit 51 at the Halibut Bay complex on Kodiak Island. Because most of the data reported here regarding deposit size is based on surface observations, many of the other deposits may contain significantly larger reserves. Past production was from smaller, high-grade deposits that contain only a small portion of the reserves compiled in this report.

Most Alaskan deposits are relatively low-grade, containing less than 10 pct chromite. To make shipping feasible, chromite would have to be concentrated at the mine site. Metallurgical tests performed during this investigation indicate that although most of the deposits are low-grade, usable concentrates can be produced. Additional research by the Bureau that might make production from low-grade deposits more practical is underway (48).

The quality of chromite concentrates determines their end-uses. In 1981, the metallurgical industry consumed 76 pct of chromium imports (48) and, for this reason, a practical reserve base or stockpile must contain a proportionate amount of metallurgical-grade chromite. Most Alaskan chromite deposits are podiform-type which typically contain

high-chromium chromite from which metallurgical-grade concentrates can be produced.

Accessibility, particularly in Alaska where transportation and related costs are relatively high, is a critical factor in assessing the economic feasibility of developing a mineral deposit. All the deposits in the Chugach trend with estimated reserve potential (table 7) are within 10 miles of tidewater or existing roads. Also, potentially significant deposits at Iyikrok Mountain and in the Avan Hills are near a proposed road from the Red Dog Deposit to tidewater and may become accessible in the future.

SUMMARY

Estimates of chromium contained in Alaskan deposits are summarized in table 9. Most of these estimates are based on surface observations made during brief surveys of the chromite-bearing masses: additional reserves probably exist in undiscovered buried deposits, covered extensions of known deposits, and placer deposits in streams adjacent to the chromite-bearing masses. The deposits occur within eight geographic or geologic regions. Most of the deposits are podiform-type, and they range in size from a few tons to over 1 million tons of contained Cr_2O_3. The total estimated reserve potential is 3.4 million to 4.3 million tons of contained Cr_2O_3. These tonnages are mostly contained in low-grade deposits with less than 10 pct chromite. Mine site beneficiation of the chromite would be required to produce shipping-grade concentrates. Metallurgical tests and geochemical analyses on samples from most of these deposits indicate that high-chromium concentrates can be recovered.

TABLE 9. - Summary of chromite deposits and estimated reserve potential

Region	Number of deposits (1)	Type of chromite	Estimated reserve potential (tons, Cr_2O_3)	Remarks
Western Brooks Range trend	70	High-chromium (metallurgical-grade).	576,000 to 1,394,000	Numerous deposits and occurrences in the largest known peridotite masses in Alaska. Most deposits are small, but large low-grade zones that contain many smaller, higher-grade concentrations exist within 30 miles of proposed road.
Yukon-Koyukuk trend	9	High-chromium and high-iron (chemical grade).	17,000 to 31,000	Numerous occurrences and several small deposits, in 6 areas between 1 and 75 miles from the Dalton Highway.
Rampart trend	4	High-chromium and high-iron.	17,000 to 37,000	Four small deposits, numerous occurrences, and placer potential in the Kaiyuh Hills. Chromite in placer concentrates from Little Minook Creek. Chromite in geochemical rock sample from Christian complex. No road access.
Yukon-Tanana upland	0	Inferior quality chromian spinel.	0	A large area containing about 3 pct high-Al, high-Mg chromite at Nail Ridge and chromite in placer concentration and accessory chromite in serpentinite and serpentinized peridotite from 5 other areas all within 40 miles of existing roads.
Alaska Range trend	0	High-chromium.	0	Accessory chromite in numerous fault-bounded serpentinite and dunite masses. Variable access.
Southwest region	0	Inferior quality chromian spinel.	0	Accessory chromite in fault-bounded serpentinized peridotite masses. 1 zoned ultramafic complex, 1 small

See notes at end of table.

TABLE 9. - Summary of chromite deposits and estimated reserve potential--Continued

Region	Number of deposits (1)	Type of chromite	Estimated reserve potential (tons, Cr_2O_3)	Remarks
Southwest region (continued)				monzonite pluton, and adjacent streams and beach sands. No road access.
Chugach trend	68	High-chromium.	2,800,000	41 hard-rock and 1 placer deposit, all within 10 miles of tidewater or existing roads. Most reserves are in large, low-grade (5 to 10 pct chromite) zones of banded chromite.
Southeast region	8	Inferior quality to high-chromium.	4,000	Minor chromite in zoned mafic-ultramafic complexes.

[1]Includes only deposits for which estimated reserves or estimated reserve potential is indicated. Additional deposits are summarized in remarks column of this table.

Only the Chugach trend contains deposits that are large enough (2.8 million tons of Cr_2O_3 in 42 low-grade deposits) and close enough to tidewater or existing transportation routes to significantly offset chromium shortages in the event of an interruption of foreign supplies.

Seventy low-grade deposits in the remote Western Brooks Range trend contain an estimated 576,000 to 1.4 million tons of Cr_2O_3. Most of the Western Brooks Range deposits will become more accessible when the proposed road to the Red Dog zinc-lead-silver deposit is constructed.

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