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Chromite Deposits Along the Border Ranges Fault, Southern Alaska

(In Two Parts)

1. Field Investigations and Descriptions of Chromite Deposits

By Jeffrey Y. Foley and James C. Barker

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CHROMITE DEPOSITS ALONG THE BORDER RANGES FAULT, SOUTHERN ALASKA

(In Two Parts)

1. Field Investigations and Descriptions of Chromite Deposits

By Jeffrey Y. Foley[1] and James C. Barker[2]

ABSTRACT

Chromite deposits along the Border Ranges Fault in southern Alaska were investigated by the Bureau of Mines. This report, part 1 of a two-part series, describes the deposits. Part 2 describes the mineralogy and the results of metallurgical tests. Fieldwork began in 1981 and continued through 1983. Ninety-four subeconomic podiform chromite deposits in eight mafic-ultramafic complexes were investigated. Previously unreported chromite deposits at Red Mountain on Kenai Peninsula, on Kodiak Island, and near Tonsina are described. Deposits range in size from less than a thousand tons to over 1.25 million tons of contained chromic oxide (Cr_2O_3). Grades range from about 5 to 10 pct chromite. Excluding all deposits more than 10 miles from tidewater or existing roads and all deposits containing only chemical- or refractory-grade chromite, about 2,200,000 tons of Cr_2O_3 are contained in 41 hard-rock deposits. A placer deposit contains an additional 556,000 tons. These 42 deposits constitute a subeconomic indicated and inferred reserve sufficient to meet the Nation's chromite demands for about 4 yr, or the metallurgical industry's demands for over 5 yr, at 1981 consumption rates.

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INTRODUCTION

To help ensure that chromium supplies are adequate to meet the Nation's needs, the Bureau of Mines Alaska Field Operations Center (AFOC) and Albany (OR) Research Center (ALCR) jointly investigated chromite deposits along the Border Ranges Fault in southern Alaska from 1981 to 1983 as part of the Bureau's critical and strategic minerals program.

The results of this investigation are presented in two reports. This report--part 1--was prepared at AFOC and describes the field investigations, summarizes the relevant literature, describes the chromite deposits, and presents a compilation of chromite and chromite reserves contained in the deposits. Part 2 (13),[3] prepared at ALRC, presents the results of mineralogical and beneficiation studies of bulk samples collected during the field investigations. The sample identification key in the appendix of this report relates field sample numbers to sample numbers used in parts 1 and 2. Sample locations and geologic information are presented on U.S. Geological Survey 1:63,360 scale topographic series maps, unless indicated otherwise.

ACKNOWLEDGMENTS

Chromite samples and drill data from Red Mountain and the Windy River Valley on Kenai Peninsula were provided by the Anaconda Minerals Co. under memorandum of agreement 14-09-0070-937 with the Bureau of Mines. The authors are especially grateful to William T. Ellis, geologist, Anaconda Minerals Co., Anchorage, AK, for his cooperation in describing the chromite deposits at Red Mountain.

CHROMIUM USES AND TERMINOLOGY

The United States relies almost totally on foreign sources for chromium, a metallic element essential to industry that is imported in chromite concentrates, in ferrochromium alloys, and as pure metal. Chromite is the ore mineral from which chromium is recovered: Ferrochromium alloys are produced from chromite concentrates and include a variety of products that are used extensively in the manufacturing and construction industries. In 1981, the United States imported 898,000 tons of chromite concentrates (34). This is equivalent to about 368,000 tons of chromic oxide (Cr_2O_3). Metallurgical uses consumed 181,400 tons of this Cr_2O_3 and another 369,000 tons of Cr_2O_3 in imported ferrochromium alloys and metal (33-34). Recycling of stainless steel scrap currently accounts for about 10 pct of the Nation's chromium demand. The U.S. demand for chromite is expected to increase 2 pct annually between 1981 and 2000 (33, 35). 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.

Chromium is a versatile element, having a wide range of uses in the metallurgical, chemical, and refractory industries (34). According to the National Materials Advisory Board, approximately 30 pct of chromium-containing materials consumed could be replaced by chromium-free substitutes, and with additional research, another 30 pct might also be replaced (31, pp. 174-175). About 35 pct of chromium uses, however, are considered irreplaceable; that is, no functionally acceptable chromium-free substitutes are available (31).

Chromite is a brownish- to iron-black mineral of the spinel group and has the general formula $(Fe^{+2},Mg)\cdot(Cr,Al,Fe^{+3})_2O_4$ (2). 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 referred to as chromian spinels. Spinel minerals that may contain minor Cr_2O_3 include hercynite ($Fe^{+2}Al_2O_4$), magnetite ($Fe^{+2}Fe^{+3}{}_2O_4$), picrochromite ($MgCr_2O_4$),

[3] Underlined numbers in parentheses refer to items in the list of references preceding the appendix.

spinel ($MgAl_2O_4$), and magnesioferrite ($MgFe^{+3}_2O_4$) (23). The spinel minerals seldom exist in pure forms; rather they are commonly gradational between ideal end members of chemical series and have variable Cr_2O_3 content. A pure chromite mineral would ideally contain about 68 pct Cr_2O_3, but chromite concentrates rarely contain more than 50 pct Cr_2O_3 (33). In this report, the term "chromite" is used for any chromian spinel from which a concentrate suitable for industrial uses may be obtained.

High-grade chromite ores produced by hand sorting or requiring no further concentration 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 a chromium-to-iron (Cr:Fe) ratio 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 (31, p. 169). The uses of the various grades are now more interchangeable than in the past, although usually at some increase in metallurgical cost. 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 (46). Owing to technological advancements in the production of ferrochromium alloys, chromite concentrates containing less than 46 pct Cr_2O_3 and with Cr:Fe ratios less than 2.0 are now used in the metallurgical industry (22, p. 18), but to what extent is uncertain. Because of this uncertainty, the historical classification is used in this report as a basis for evaluating chromite deposits. Adoption of the newer classification probably would result in an increase in the reserves estimates.

In this report, a chromite occurrence is defined as a small or undetermined 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.

LOCATION

Chromite deposits occur in ultramafic and mafic-ultramafic complexes along an arcuate mountain belt comprising from east to west the Chugach Range, mountains on Kenai Peninsula, and mountains on northern Afognak and Kodiak Islands (fig. 1). The complexes are aligned with a major structural feature known as the Border Ranges Fault. Areas known to contain chromite deposits and areas with similar geology along the fault zone were investigated.

This report describes several complexes that are widely spaced along the fault zone. Therefore, physiography, access, and land status are discussed in the sections containing descriptions of the individual areas and chromite deposits.

REGIONAL GEOLOGY

The Border Ranges Fault system, traced for over 1,000 miles (fig. 2), roughly parallels the Pacific coast of Alaska from southeast Alaska to Kodiak Island. This report is concerned with the 600-mile segment in the northern Chugach Mountains, in the Kenai Mountains in southern Alaska, and extending to Kodiak Island. This major structural feature consists of numerous, closely spaced faults in most areas. The fault planes vary from high-angle features, along which right lateral displacement has occurred, to shallower dipping thrust faults. The Border Ranges Fault is further described by MacKevett and Plafker (26).

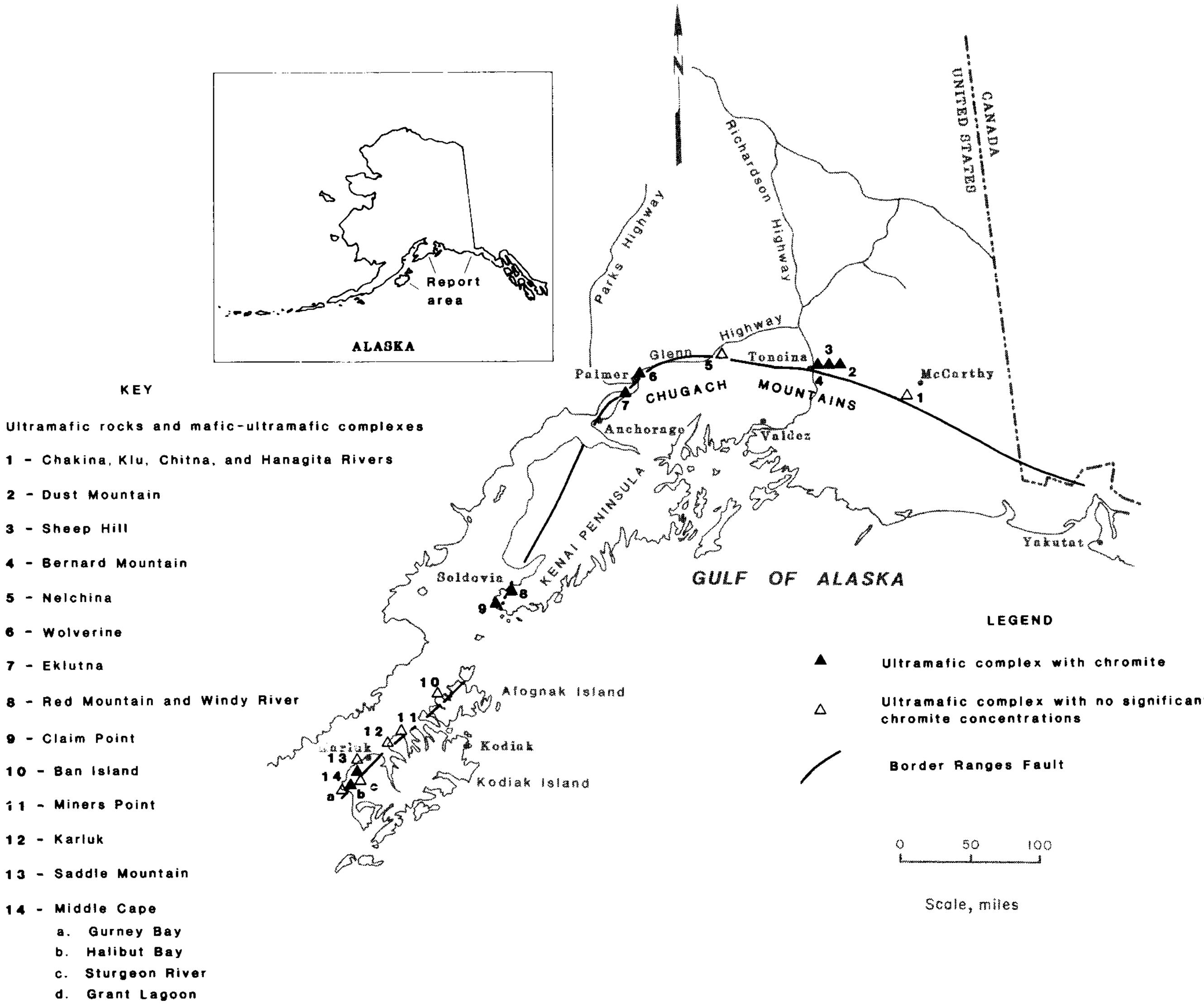


FIGURE 1. - Map of southern Alaska showing ultramafic and mafic-ultramafic complexes along the Border Ranges Fault.

The Border Ranges Fault probably represents a crustal plate boundary of Mesozoic through Tertiary age. It separates upper Paleozoic through Triassic rocks of the Peninsular and Wrangellia terranes to the north and west from upper Mesozoic and Tertiary rocks of the Chugach terrane to the south and east (24, 26).

The Peninsular terrane comprises a belt of upper Paleozoic and Mesozoic volcanic rocks and overlying clastic marine sediments that extends southwest from the Talkeetna Mountains to the Alaska Peninsula (24).

The Wrangellia terrane lies east of the Peninsular terrane and comprises four formations and one unnamed unit, all of Triassic age (24). Where present, the unnamed unit is the lowest unit in the sequence. It consists primarily of chert, siltstone, and shale. Overlying the unnamed unit, or otherwise at the base of the sequence, is the Nikolai Greenstone, which in turn is overlain by a thick sequence of carbonate rocks consisting of the Chitistone and Nizina Limestones. Above this carbonate sequence is the McCarthy Formation, which comprises limestone, chert, and spiculite (24).

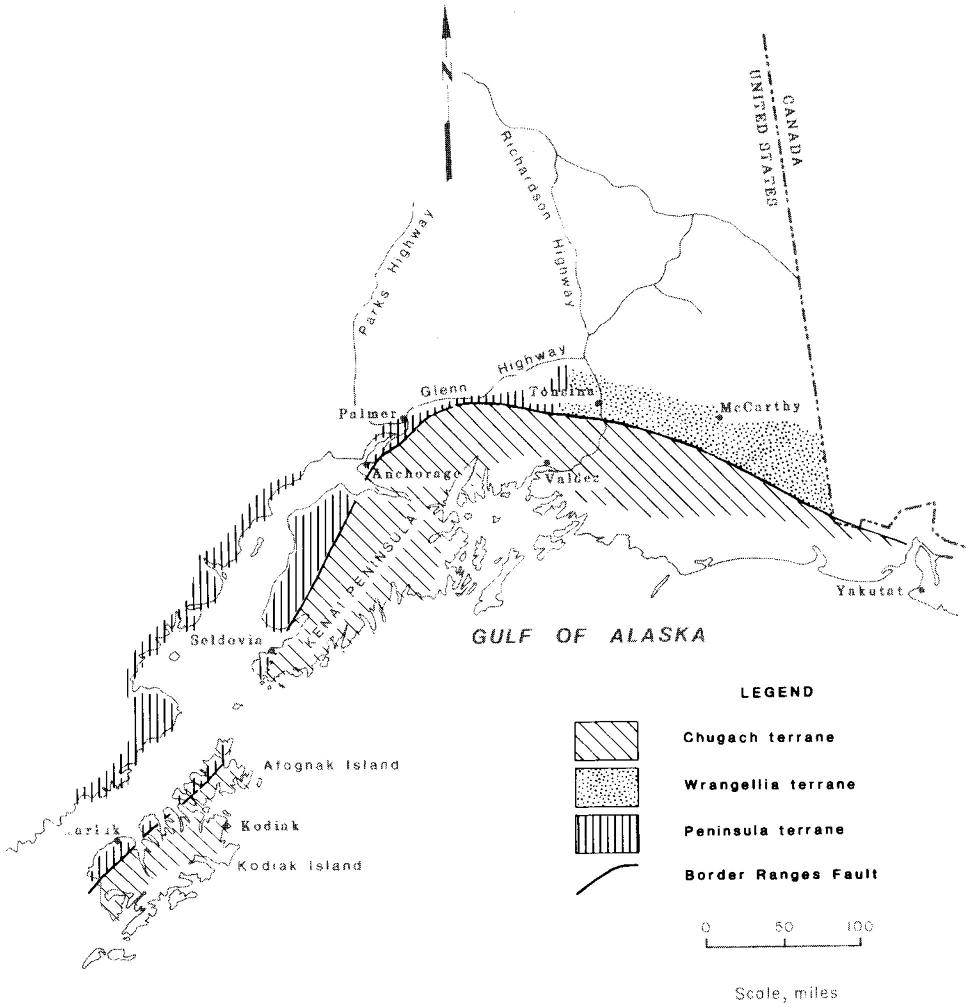


FIGURE 2. - Border Ranges Fault and tectonostratigraphic terranes in southern Alaska. (After Jones and Silberling (24, fig.1))

To the south of the Border Ranges Fault is the Chugach terrane, which includes rocks of the Triassic Valdez Group in the Prince William Sound and Cook Inlet areas (8) and similar-age rocks of the Yakutat Group in the Gulf of Alaska (39). The Chugach terrane is dominated by a thick flysch sequence consisting mainly of interbedded graywacke and argillite with minor slate and volcanic rocks (21). The flysch sequence has been interpreted as a trench deposit, which, together with associated clastic sediments and magmatic rocks, was accreted to Alaska during Late Cretaceous subduction of the Pacific plate (32).

Ultramafic and mafic-ultramafic complexes occur in the Peninsular and Wrangellia terranes discontinuously along the Border Ranges Fault system from near McCarthy to Kodiak Island, as shown in figure 1. All but the Red Mountain and Claim Point complexes on the Kenai Peninsula and part of the Eklutna complex near Palmer are situated north of the Border Ranges Fault. MacKevett and Plafker (26) speculate that Red Mountain and Claim Point may lie north of an unmapped, southward-projecting lobe of the fault; however, no evidence for this has been reported. The Eklutna complex lies along a major splay of the Border Ranges Fault system.

Most of the complexes appear to be discordant structural features that were tectonically emplaced into the stratified country rock. Previous investigators have mapped most contacts between the complexes and country rocks as faults (3, 18-19, 25-26).

The crudely to complexly layered ultramafic and mafic-ultramafic complexes consist primarily of variably serpentinized dunite, peridotite, and pyroxenite, with associated gabbroic rocks in some of the complexes. The proportions of these lithologies vary among the complexes; of the ultramafic rocks, dunite is generally the most abundant, with lesser pyroxene peridotites including harzburgite, wehrlite, and lherzolite. Clinopyroxenite dikes and layers are frequently present throughout the complexes, but these are volumetrically less important.

The Border Ranges Complex (5) includes ultramafic and mafic rocks near Tonsina, Nelchina, and Palmer, and on the Kenai Peninsula. Burns (5) described the relationship of ultramafic rocks to associated quartz diorite and andesitic volcanics. From south to north is a faulted sequence of metaperidotite(?) through ultramafic and gabbroic cumulates, which are overlain by andesitic volcanics. These units have all been intruded by gabbro and quartz diorite (5).

Interpretations of origin of mafic-ultramafic complexes vary. Connelly (10) states that the ultramafic and associated mafic rocks on Kodiak Island are fault-bonded slabs interpreted as fragments of oceanic crust. Other investigators have similarly interpreted various segments of this trend of mafic and ultramafic rocks as fragments of oceanic crust accreted to Alaska during the Cretaceous period (3, 18-19, 26). In contrast to earlier interpretations, Burns (5) contends that, based on trace element content, bulk chemistry, and mineral composition, these mafic and ultramafic rocks represent the intrusive core of an island arc complex that formed during Jurassic time.

BUREAU OF MINES INVESTIGATION

This investigation was undertaken to assess the mineral development potential of chromite deposits and the likelihood for associated deposits of platinum-group metals in southern Alaska. Ninety-four chromite occurrences in mafic-ultramafic complexes were examined, and previously described deposits were reviewed to identify those deposits that contain chromite potentially recoverable as metallurgical-grade concentrates. Previously unreported chromite deposits on Kodiak Island and near Tonsina are also described. Anaconda Minerals Co. and the Bureau cooperatively examined and described previously unreported hard-rock chromite deposits and one placer deposit on Kenai Peninsula.

The chromite deposits were classified according to nomenclature developed by the U.S. Geological Survey and the Bureau of Mines (fig. 3). The deposits identified in the compilations constitute an inferred reserve base. Some of the deposits defined on the basis of drill data contain indicated reserves in addition to inferred reserves. All the deposits described in this report are subeconomic based on current metal prices. The total tonnage of chromite inferred to be present was compared to past annual consumption to determine if these deposits contain sufficient chromite to be useful in meeting U.S. requirements in the event of a prolonged interruption of foreign chromium supplies.

CHROMITE DEPOSITS

The only chromite produced in Alaska has come from mines on Kenai Peninsula. These and other chromite deposits in mafic-ultramafic complexes along the Border Ranges Fault are described in this report. Deposits consist of pods, wisps, bands, nodular aggregates, and concentrations of disseminated chromite in definable zones, hosted by variably serpentinized dunite and other peridotites.

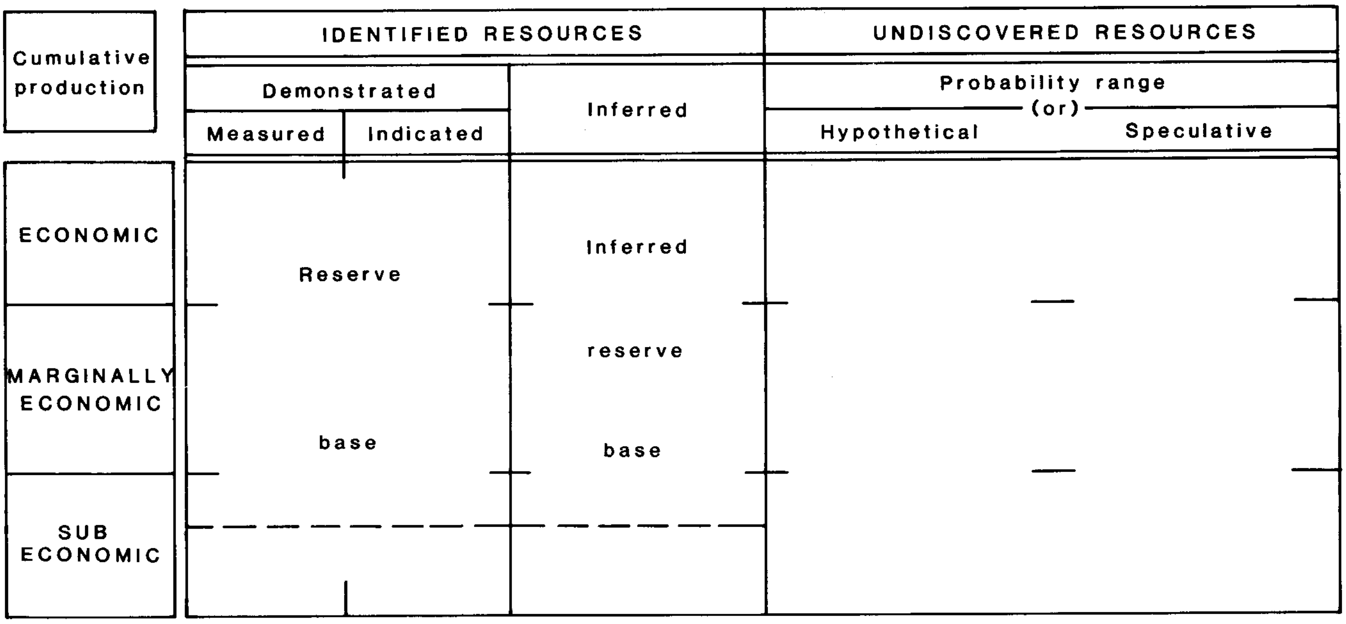


FIGURE 3. - Mineral resource classification categories (48).

The zones generally parallel cumulate layering in the complexes. On the basis of the relationship between the zones and primary layering, and because of the general lensoidal or discoidal shape of the better exposed deposits, continuity is also assumed for some of the less exposed deposits.

Most of the deposits discussed in this report are relatively low grade, containing less than 10 pct chromite, but in a few cases, higher grade material, containing up to 40 pct chromite, occurs across minable widths. The hard-rock deposits included in the compilations contain at least 5 pct chromite.

The Windy River deposit on the Kenai Peninsula was the only placer chromite deposit investigated. That deposit contains about 1.3 pct Cr_2O_3, which is equivalent to about 2.3 pct chromite.

DEPOSIT SELECTION

The following criteria were arbitrarily used to select deposits with chromite development potential. Deposits meeting these criteria are included in the compilations.

1. Access route must not exceed 10 miles to tidewater or existing transportation systems.

2. Chromite contained in these deposits must be recoverable and must be suitable to meet metallurgical-grade specifications; that is, a product containing a minimum of 46 pct Cr_2O_3 at a Cr:Fe ratio of nearly 2.0 or greater must be obtainable through the use of standard concentration techniques. Chromite concentrations and Cr:Fe values from all deposits sampled in a given ultramafic complex were considered to determine if that complex hosts chromite that could be concentrated to meet metallurgical specifications. If the average values did not meet these specifications, no recoverable chromite was inferred for that complex. Chemical- and refractory-grade chromite deposits were described but were not included in the compilations.

3. Deposits must be amenable to low-cost bulk mining methods, such as open pit or block caving operations. Concentration of low-grade ores by sorting and gravity methods would be required to produce shipping concentrates that meet industrial specifications.

4. Chromite content in some of the lode deposits was visually estimated. Only lode deposits containing a minimum of 5 pct chromite were included in the compilations.

5. Placer deposits were evaluated on the basis of Cr_2O_3 assays and must contain a minimum of 1 pct Cr_2O_3.

6. Deposits containing less than 1,000 tons of Cr_2O_3 were not included in the compilations.

SAMPLING AND EVALUATION PROCEDURES

Bulk samples containing about 50 to 200 lb of chromite-bearing material were collected from bedrock and rubble overlying hard-rock deposits; logistical constraints generally made it impractical to collect larger samples. Head analyses that reflect the Cr_2O_3 content in unconcentrated samples and Cr_2O_3 analyses and Cr:Fe ratios of chromite concentrates are presented in the deposit descriptions. More complete analyses of the samples are presented in part 2 (13). To collect samples with chromite content sufficient for metallurgical testing, the samples were intentionally high-graded or they were collected as channel samples from high-grade zones. This may have resulted in higher Cr_2O_3 values and higher recovery than would occur during metallurgical testing of larger samples. The only exception was at Red Mountain on Kenai Peninsula, where Anaconda Minerals Co. provided more representative samples weighing up to 1,000 lb.

Procedures used in sampling the Windy River placer deposit on Kenai Peninsula are included with the description of the deposit.

Platinum group metals (PGM) are sometimes associated with chromite deposits. Therefore, geochemical rock and panned concentrate samples were analyzed for PGM. Results are included in the deposit descriptions in this report. Bulk sample heads and chromite concentrates produced by ALRC were also analyzed for PGM, and those results are presented in part 2 (13). Although platinum and palladium were detected in the bulk samples, the data are insufficient to assess the potential for economic deposits of these metals.

CALCULATION PROCEDURES

The following assumptions and procedures were used when calculating the size of deposits:

1. If the measured length or width of the mineralized zone was open ended due to surficial cover, a factor of 25 pct, if covered at one end, or 50 pct, if covered at both ends, was added to the measured length in order to calculate the inferred length.

2. The depth of the zone was calculated as 25 pct of the inferred length.

3. The average chromite content (volume percent) of individual deposits was visually estimated in the field and later adjusted according to assays on samples collected in the field. Estimated chromite content by weight was multiplied by 0.58 to estimate the Cr_2O_3 content because Guild found this relationship to be consistent for Kenai Peninsula chromite (17, p. 150). For lack of more widespread determinations, it is assumed that the chromian spinel in the other areas is similar to the chromite at Kenai Peninsula.

4. When available, drill core analyses and analytical results from previous investigations were also used in the calculations. These data are cited where used.

5. Deposit size estimates are presented in short tons (2,000 lb) of Cr_2O_3. Published reserve estimates for Claim Point and Red Mountain were presented in short tons or long tons (2,240 lb) of chromite by earlier workers (16-17). These were converted to short tons of contained Cr_2O_3 for this report.

6. A specific gravity of 3.3 for the dunite and peridotite host rock was used in the calculations.

DESCRIPTION OF DEPOSITS AND OCCURRENCES

Of 94 podiform chromite deposits investigated or reviewed, 42 contain recoverable chromite that contains more than 1,000 tons of Cr_2O_3 and is suitable for use by the metallurgical industry. Eighteen other deposits contain less than 1,000 tons of Cr_2O_3, and additional deposits contain chromite that may be used by the chemical and refractory industries. Numerous occurrences of undetermined size also exist. Most of the deposits, which range in size from less than 1,000 tons to about 1.25 million tons of contained Cr_2O_3, contain between 5 and 10 pct chromite. One placer deposit with a grade of 1.3 pct Cr_2O_3 contains 0.56 million tons of Cr_2O_3.

McCARTHY AREA

Ultramafic rocks crop out in three areas southwest of McCarthy (fig. 4). Two are near Goodlata Peak at the headwaters of the Chakina River. The third is between the Hanagita, Klu, Chakina, and Chitina Rivers. All three are in the rugged terrain on the north flank of the Chugach Mountains and are best reached by helicopter. There is an unpaved road 12 miles north of the Hanagita site that connects McCarthy with the Edgerton Highway.

The ultramafic rocks in these areas have been tectonically emplaced into the metamorphosed Skolai Group (25). The small, fault-bounded masses are sheared and serpentinized, consisting mostly of peridotite with minor gabbro. A 2-in clot of massive chromite was observed in dunite associated with very coarse-grained wehrlite near the Hanagita River, but disseminated chromite grains generally make up less than 1 pct of the peridotite. No economically significant concentrations of chromite were observed at any of the three locations, and no bulk samples were collected.

TONSINA AREA

Chromite is locally concentrated in three discrete bodies of serpentinized dunite and peridotite near Tonsina (fig. 5). These bodies are herein referred to as the Bernard Mountain, Sheep Hill, and Dust Mountain complexes. Tonsina is located at approximately milepost 80 on the Richardson Highway, and the three complexes are all within 9 air miles of the highway, southeast of Tonsina. Unimproved trails, passable by tracked vehicles, reach the complexes from Tonsina and from a gravel pit at milepost 73 on the Richardson Highway.

Maximum relief in the area is about 3,200 ft, with Dust Mountain (elevation 5,210 ft) being the highest point in the vicinity (figs. 5-6). The three mountains are generally bare of vegetation above tree line (about 3,000 ft); lower slopes and valleys are densely vegetated.

Above tree line, the slopes are typically covered with loose, frost-riven rubble, but infrequent outcrops occur in the upper reaches of gullies and headwater streams. Well-developed colluvial and alluvial fans form at the mouths of the gullies (fig. 6). Discontinuous outcrops also occur along ridge crests and along steeper slopes, where massive blocks of bedrock have slumped.

The lands underlain by these three complexes are currently administered by the Bureau of Land Management, U.S. Department of the Interior. Most of the area underlain by the Dust Mountain complex (township 3 south, range 3 east) is closed to mineral entry as mandated by Public Land Order 5184. The status of the remaining areas discussed in this section is uncertain due to pending selections by the State and applications by private interests.

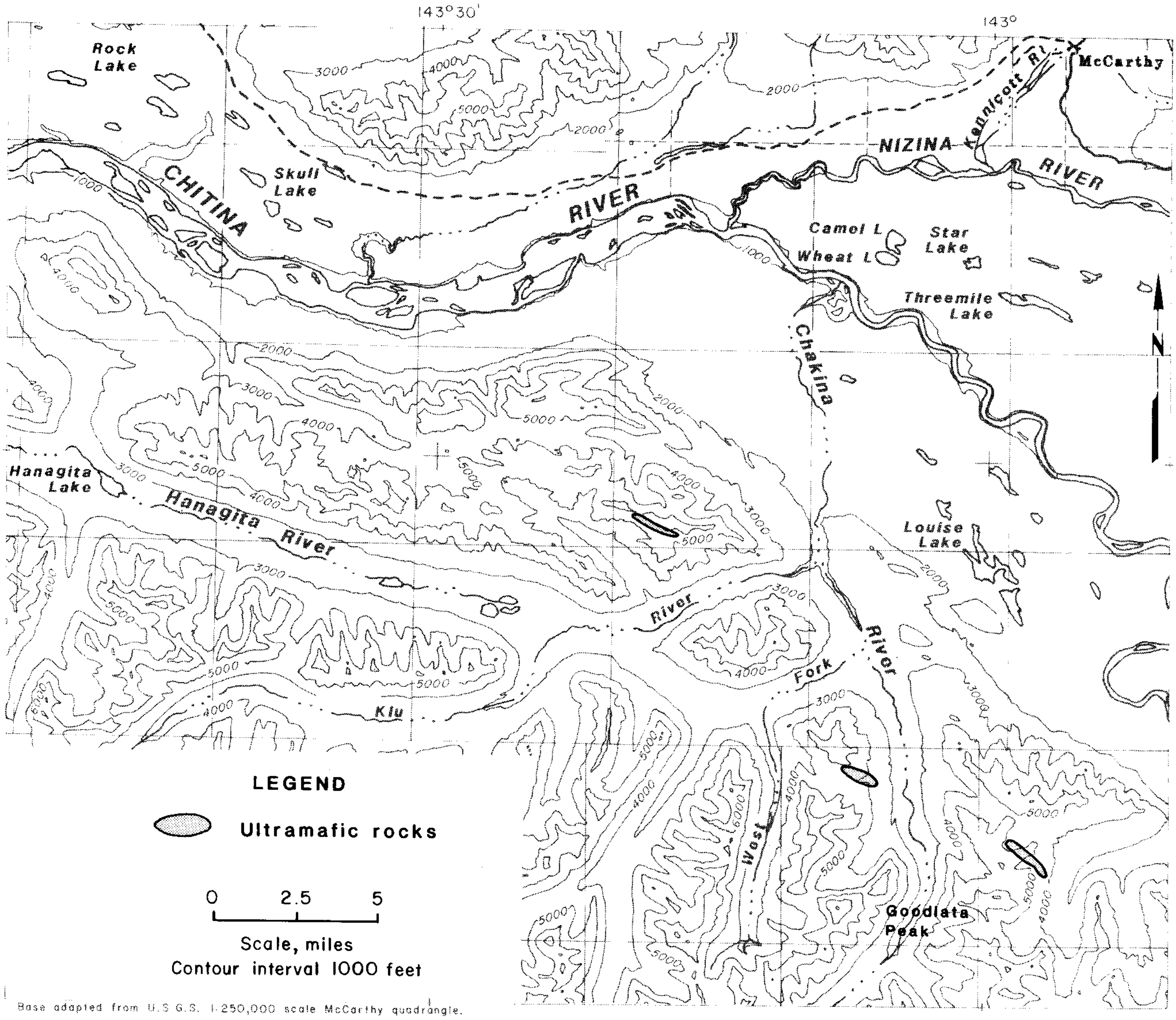


FIGURE 4. - Ultramafic rocks near McCarthy. (After MacKevett (25))

Chromite was discovered at Bernard Mountain in 1954 by Howard F. McWilliams and Henry G. Lund. By 1956, mineral claims were located over the areas of exposed ultramafic rocks at Bernard Mountain and Dust Mountain. T. L. Pittman, a mining engineer at the Bureau's Alaska Mining Experiment Station, Juneau, AK (now AFOC), briefly examined some of the claims in 1957 (38). Ten channel samples and two grab samples were collected from six chromite deposits at Bernard Mountain and from one occurrence each at Sheep Hill and Dust Mountain (38). Mineral dressing tests were conducted on the samples at the Bureau's laboratory in Juneau by R. R. Wells, who concluded that chromite concentrates meeting metallurgical- and chemical-grade specifications were obtainable from chromite at Bernard Mountain and Sheep Hill (49).

In 1956, the U.S. Government was purchasing chromite ore and concentrates at incentive prices under the Minerals Stockpile Program (49). This program was halted before the deposits near Tonsina could be developed, and the claims were allowed to lapse in succeeding years.

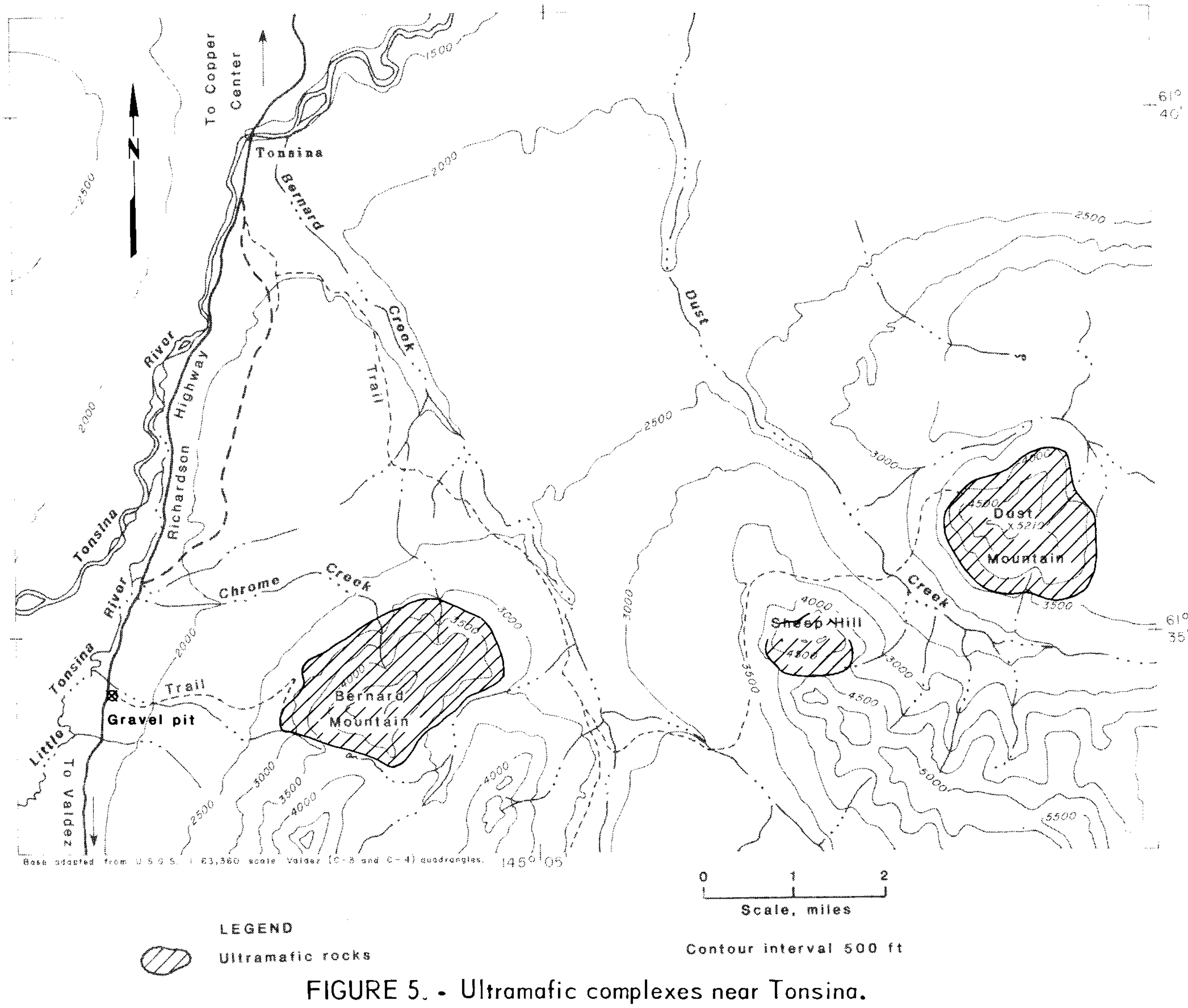


FIGURE 5. - Ultramafic complexes near Tonsina.

Previous geologic reports on the area include a Master of Science thesis on the geology of the Bernard Mountain area by Hoffman (20) and a geologic map and summary of geochronology in the Valdez Quadrangle by Winkler (51).

Bernard Mountain

Locations of 15 chromite deposits and occurrences at Bernard Mountain are shown in figure 7. These include concentrations of chromite in frost-riven rubble and in fractured bedrock that is cut by many small-scale, high-angle faults. Chromite content was estimated on the basis of data presented in table 1.

Three exposed deposits at Bernard Mountain contain identified resources equal to 343,000 tons of Cr_2O_3. Four other exposed deposits contain less than 1,000 tons each. Additional, undiscovered chromite deposits probably exist beneath the surface. Seven bulk samples were collected at Bernard Mountain during this investigation; sample locations are shown in figure 8. Chromic oxide content of concentrates obtained from these samples range from 45.9 to 56.8 pct, and Cr:Fe ratios ranged from 1.9 to 2.8 (13). These analyses indicate that chromite from Bernard Mountain can be concentrated to meet metallurgical-grade specifications.

TABLE 1. - Identified chromite in deposits (343,000 tons Cr_2O_3) at Bernard Mountain

Deposit or occurrence	1-4	5	6	7	8	9
Dimensions, ft:						
Length	3,000	300	68	75	ND	ND
Width	50	90	30	5	ND	ND
Depth	750	75	17	19	ND	ND
Weight ... 10^3 tons	11,598	209	4	3	NC	NC
Estimated chromite content ... pct	5.0	5.0	5.0	5.0	NC	NC
Contained Cr_2O_3 ... 10^3 tons	336	6	1	<1	NC	NC
Bulk sample: Number	[1]BM1M	BM2M	BM3M	BM4M	([2])	([2])
Cr_2O_3 content, pct:						
Heads	39.9	41.4	24.8	25.9	NAp	NAp
Concentrate	50.6	49.9	49.1	45.9	NAp	NAp
Cr:Fe ratio	2.6	2.5	1.9	2.1	NAp	NAp
Deposit or occurrence	**10**	**11**	**12**	**13**	**14**	**15**
Dimensions, ft:						
Length	15	75	75	300	104	38
Width	10	50	8	100	4	7
Depth	4	19	19	125	26	9
Weight ... 10^3 tons	<1	7	1	387	1	<1
Estimated chromite content ... pct	5.0	3.0	17.4	3.0	8.0	48
Contained Cr_2O_3 ... 10^3 tons	NC	NC	<1	NC	<1	<1
Bulk sample: Number	([2])	([2])	([2])	BM5M	BM6M	BM7M
Cr_2O_3 content, pct:						
Heads	NAp	NAp	NAp	45.7	34.2	27.9
Concentrate	NAp	NAp	NAp	54.5	53.8	56.8
Cr:Fe ratio	NAp	NAp	NAp	2.5	2.2	2.8

NAp Not applicable. NC Existing data do not warrant calculation.
ND Not determined.
[1]Bulk sample from deposit 4. [2]No bulk sample.

NOTE.--See figure 7 for deposit locations.

At the southwestern end of Bernard Mountain, deposits 1 through 4 consist of banded chromite in dunite rubble and intermittently exposed dunite bedrock along the west-striking ridge. Pittman (38) sampled and described deposits 1 through 3 and suggested they may be part of a single, 2,000-ft-long mineralized zone. This zone and the chromite bands contained in it strike from N 75° E to N 85° E, and the bands dip from 60° to 70° N. Each deposit consists of numerous, thin lenses or bands of chromite up to several inches thick in dunite gangue. Here and at the other deposits at Bernard Mountain bands of chromite typically have sharp contacts with the dunite host rock. Chromite also occurs as disseminated grains ranging from 0.1 to 2 mm in diameter.

Deposits 1 through 3 are each about 50 ft wide and are exposed intermittently for tens to hundreds of feet along strike. Three channel samples were collected by Pittman (38) from higher grade portions of these deposits. Sampled intervals ranged from 3.5 to 4.0 ft, and reported values were 5.3, 6.6, and 12.5 pct Cr_2O_3. These correspond to chromite contents of about 9 to 22 pct. Lower grade chromite concentrations persist for tens of feet on either side of the higher grade cores of the deposits. The chromite bands increase in thickness to the east, from deposit 1 to deposit 3.

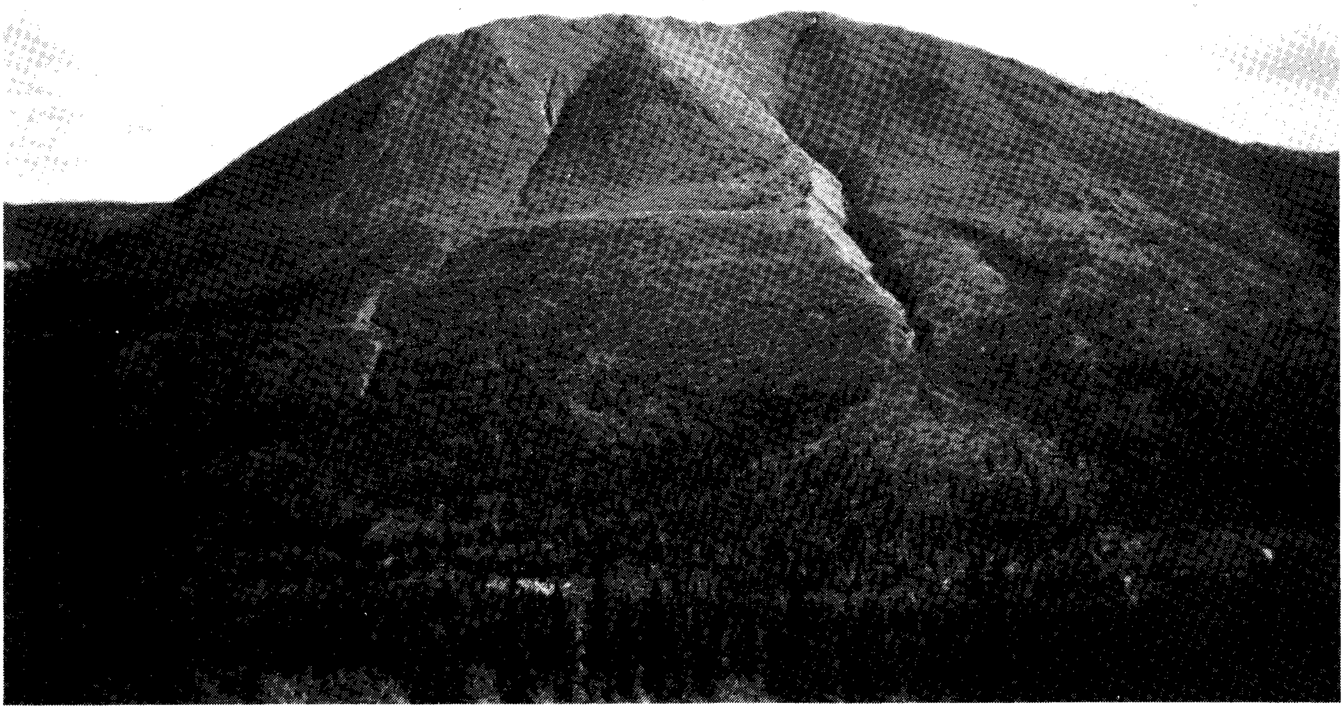


FIGURE 6. - Dust Mountain from the east side of Sheep Hill. Note the well-developed alluvial and colluvial fans at the mouths of the gullies.

Downslope from deposit 3 and east at deposit 4, blocks of massive chromite up to 10 in thick and pieces of banded chromite averaging 1 to 2 in thick were observed in dunite rubble. Bulk sample BM1M[4] was collected from deposit 4 in 1982, and a concentrate containing 50.6 pct Cr_2O_3 with a Cr:Fe ratio of 2.6 was produced from this sample (13).

Deposit 4 is probably a larger, higher grade eastern extension of the 2,000-ft-long zone Pittman described that comprises deposits 1 through 3. This larger zone, comprising all four deposits, remains open ended, and a strike length of 3,000 ft was inferred. The tonnages listed in table 1 are based on a estimated 5-pct chromite content and an inferred depth of 750 ft.

Deposit 5 is a 300-ft-long by 90-ft-wide stringer zone of banded, massive, and disseminated chrommite in dunite rubble near the summit of Bernard Mountain. Although the individual chromite bands have sharp contacts, the larger zone grades into barren dunite and peridotite rubble at its margins. A grab sample collected at this location by Pittman contained 31.7 pct Cr_2O_3, with a Cr:Fe ratio of 1.97. Bulk sample BM2M was collected from the same deposit during this investigation and was concentrated at ALRC. Head analyses indicate a Cr_2O_3, content of 41.4 pct, and the concentrate contained 49.9 pct Cr_2O_3 with a Cr:Fe ratio of 2.5. This zone was estimated to contain 5 pct chromite, and tonnages are based on an inferred depth of 75 ft.

Deposit 6, 45 by 30 ft, is located about 2,100 ft northeast of the summit, in a saddle at about 4,550-ft elevation. Bands of massive and disseminated, coarse-grained chromite occur in dunite rubble that grades into barren rock on two sides but appears to continue beneath barren dunite rubble along strike. The lack of exposed bedrock prevented determination of the bands' structural orientation. A concentrate from bulk sample

[4]See appendix for sample identification key.

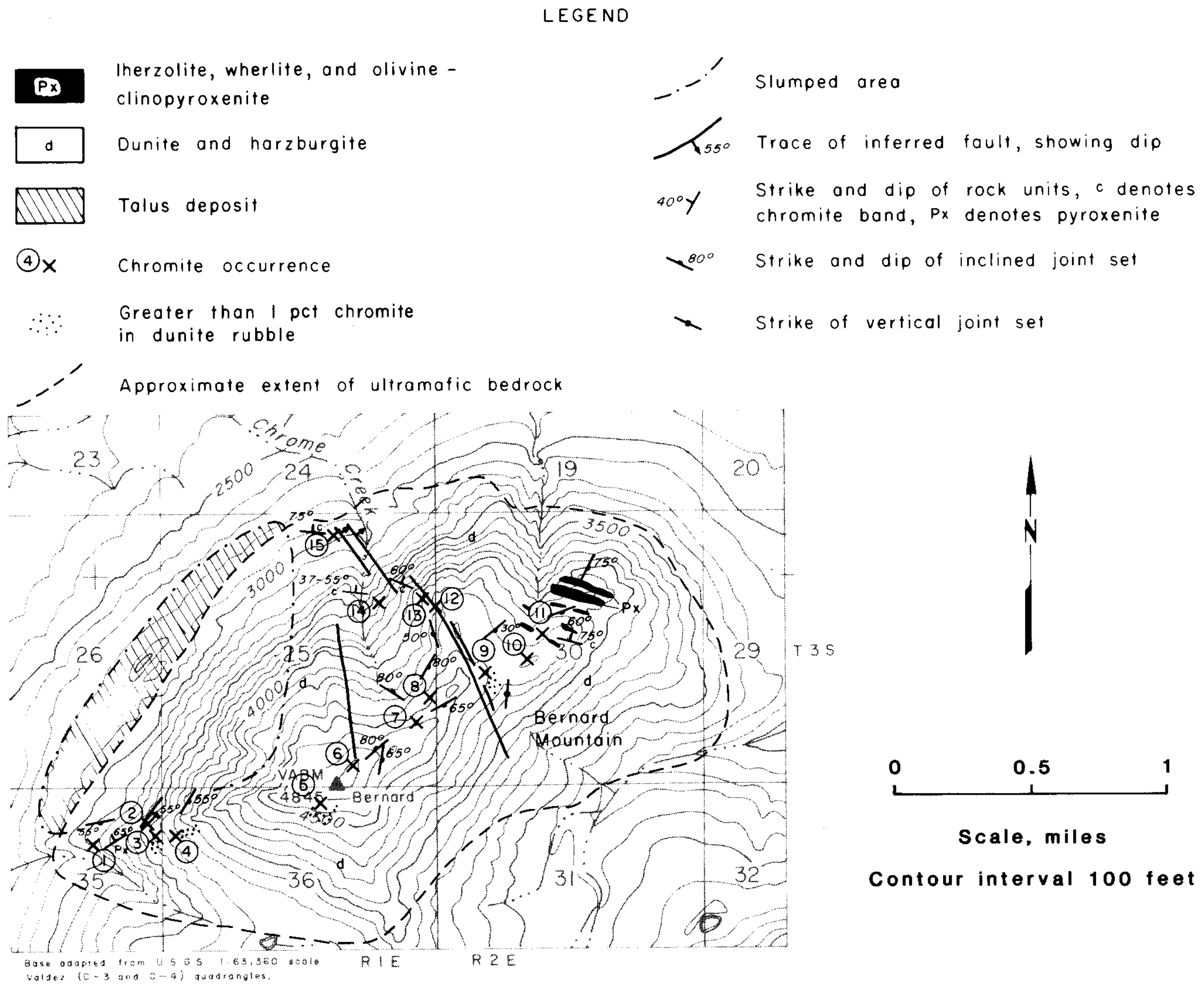


FIGURE 7. - Simplified geologic map and locations of chromite occurrences at Bernard Mountain.

BM3M contained 49.1 pct Cr_2O_3 with a Cr:Fe ratio of 1.9. Estimated chromite content is based on a visually estimated grade of 5 pct chromite, an inferred strike length of 68 ft, and an inferred depth of 17 ft.

Deposit 7, located about 4,500 ft northeast of the summit of Bernard Mountain, trends southeast for 50 ft and is 5 ft wide. This deposit is similar to deposits 5 and 6 and contains about 5 pct chromite. Orientation of the chromite bands was not determined. Bulk sample BM4M yielded a concentrate containing 45.9 pct Cr_2O_3 with a Cr:Fe ratio of 1.9. A length of 75 ft and a depth of 19 ft are inferred for this deposit.

Occurrences 8 and 9 are poorly exposed, but banded and disseminated chromite concentrations in dunite rubble were observed at both locations (fig. 7). Orientation of the chromite bands was not determined, and no samples were collected. No recoverable chromite estimates were calculated for occurrences 8 and 9.

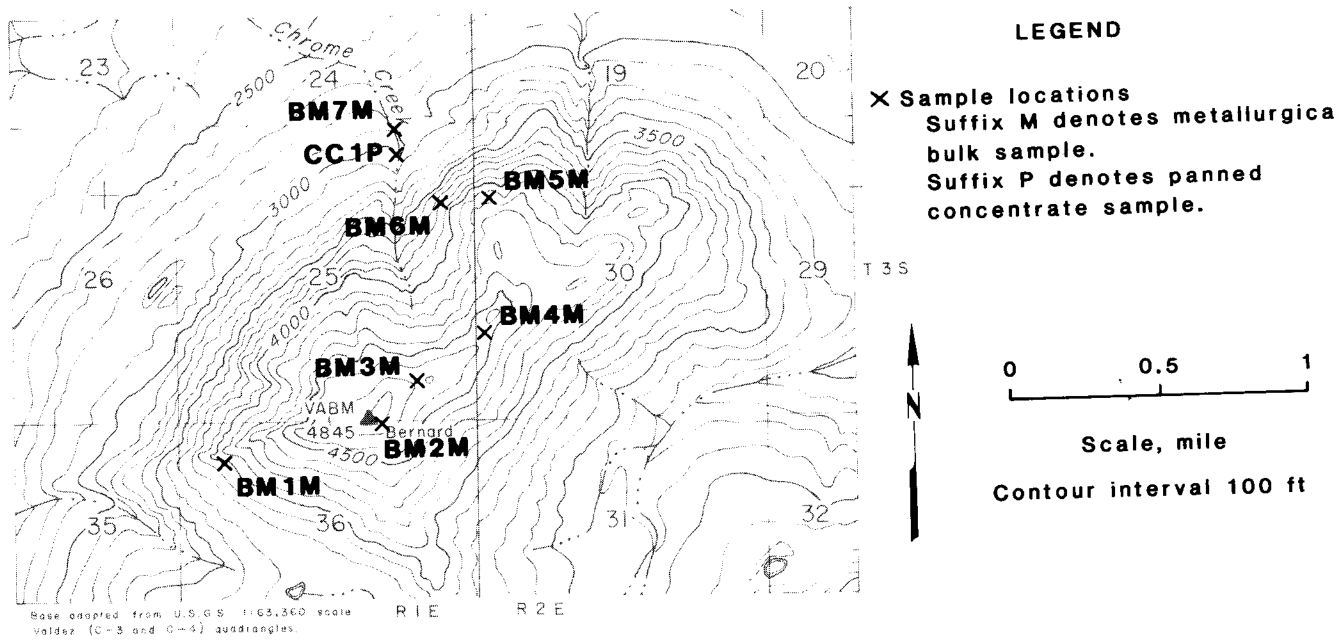


FIGURE 8. - Sample locations at Bernard Mountain.

Deposit 10 consists of 1- to 2-in-thick bands of chromite in dunite rubble over an area measuring 10 by 10 ft. The chromite bands strike N 60° E and dip 65° N. The apparent small size of this deposit precluded calculation of tonnages.

Banded chromite is exposed in bedrock at deposit 11 over an area measuring 75 by 50 ft. The chromite bands, which are less than or equal to 1 in thick, strike N 85° W and dip 75° NE. Because the chromite content was visually estimated at 3 pct, no tonnage estimates were calculated for this deposit.

Chromite bands strike N 60° E and dip 65° NW at deposit 12. A 6-ft-wide zone is exposed for 50 ft along strike but is covered by talus at both ends and at the base of the outcrop. Pittman (38) collected a channel sample here that contained 11.3 pct Cr_2O_3. This corresponds to a chromite content of about 20 pct. A strike length of 75 ft, a width of 8 ft, and a depth of 19 ft are inferred for this deposit.

Deposit 13 is 70 ft downslope from deposit 12. Thin bands of chromite striking N 75° W and dipping 60° N and irregular segregations of massive chromite were observed in outcrop and rubble. The exposed portion of the mineralized zone measures 200 by 100 by 100 ft. Bulk sample BM5M was collected here, and a concentrate containing 54.5 pct Cr_2O with a Cr:Fe ratio of 2.5 was produced. A strike length of 300 ft and a depth of 125 ft were inferred for this deposit, but the chromite content was visually estimated at 3 pct. Because of the low grade, no recoverable chromite is inferred for this deposit.

Banded chromite in dunite outcrops at deposit 14 as shown in figure 9. The mineralized interval is 2 to 5 ft wide and is exposed for 83 ft along strike. The chromite bands strike N 80° W, dip 37° to 55° NE, and appear to continue be-neath talus at the east end of the depos-it. The west end of the deposit appears to be truncated by a fault or pinches out. No extensions of the chromite bands are visible in the west wall of the steep gully in which the deposit is exposed. Bulk sample BM6M was collected at this location, and a concentrate containing 53.8 pct Cr_2O_3 with a Cr:Fe ratio of 2.2 was produced. The chromite content in this deposit was visually estimated at 8 pct. Recoverable chromite estimates are based on an inferred strike length of 104 ft, a width of 4 ft, and a depth of 26 ft.

A 7-ft-thick interval of banded chromite in dunite crops out in a cliff on the west side of Chrome Creek at deposit 15. This interval is intermittently exposed for 38 ft. A depth of 9 ft is inferred, as shown in table 1. The chromite bands strike N 80° W and dip 75° N. The chromite bands pinch out at the west end and are truncated by a fault on the east end. Pittman collected two channel samples here that contained 24.0 and 26.2 pct Cr_2O_3 (38). Bulk sample BM7M is a channel sample collected at this location, and the head analyses indicate this mineralized zone contains 27.9 pct Cr_2O_3. This corresponds to a chromite content of about 48 pct. A concentrate containing 56.8 pct Cr_2O_3 with a Cr:Fe ratio of 2.8 was obtained from this sample.

Massive and banded chromite was observed in dunite talus, which forms a terrace at the western base of Bernard Mountain, where a massive portion of the mountain has slumped (fig. 7). Additional chromite of undetermined quantity is indicated in the terraced colluvial deposit.

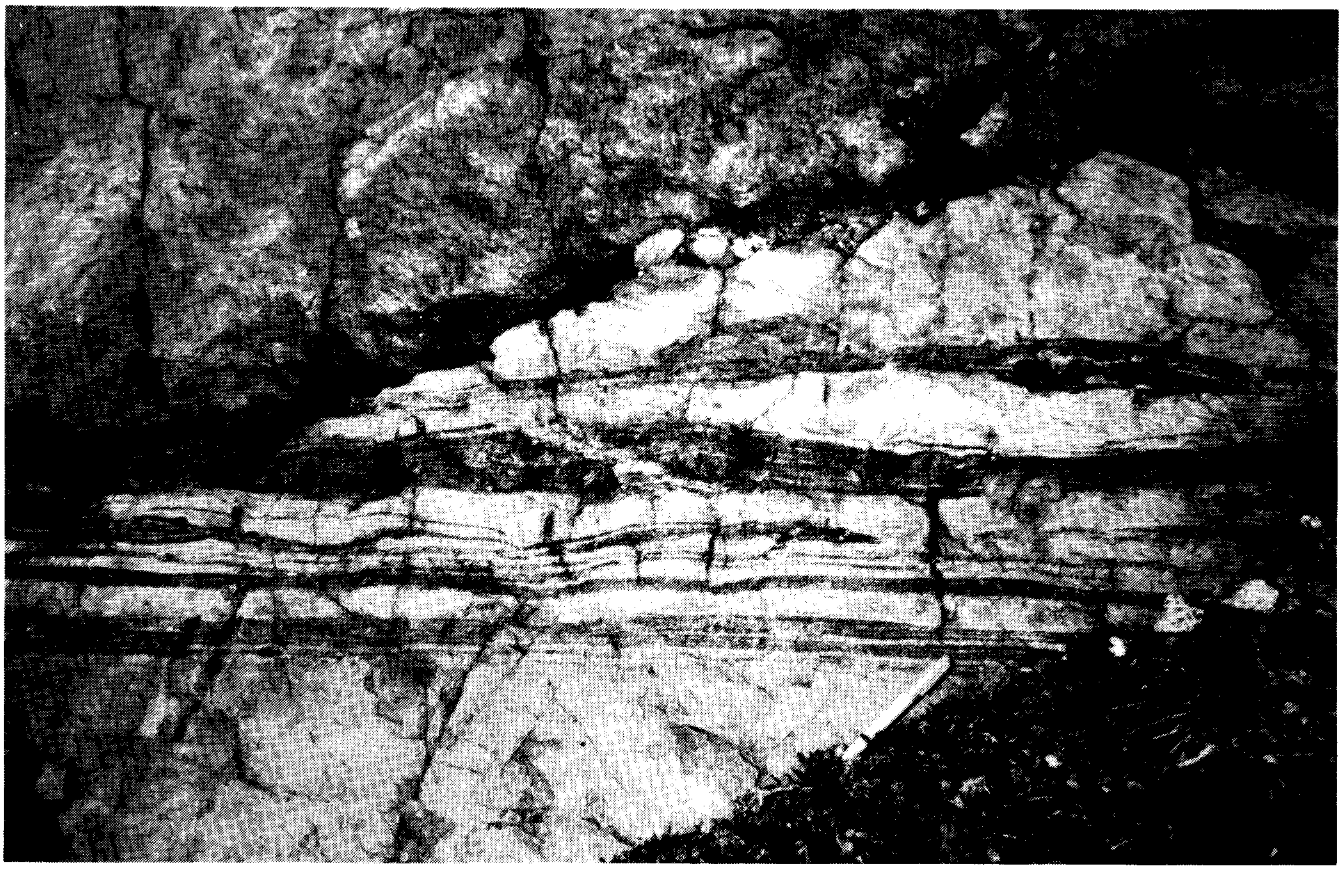


FIGURE 9. - Banded chromite at deposit 14, Bernard Mountain.

Sheep Hill and Dust Mountain

Locations of 12 chromite deposits and occurrences at Sheep Hill and Dust Mountain are shown in figure 10. The chromite deposits are labeled 16 through 27, and recoverable chromite estimates are listed in table 2. Deposit 17 at Sheep Hill contains 26,000 tons of Cr_2O_3, and deposit 16 contains less than 1,000 tons. The other 10 deposits and occurrences at Sheep Hill and Dust Mountain contain chromite that does not meet the deposit selection criteria specified earlier in this report. Seven bulk sample and five geochemical sample locations are shown in figure 11. Geochemical rock sample analysis and PGM assay results are presented in table 3.

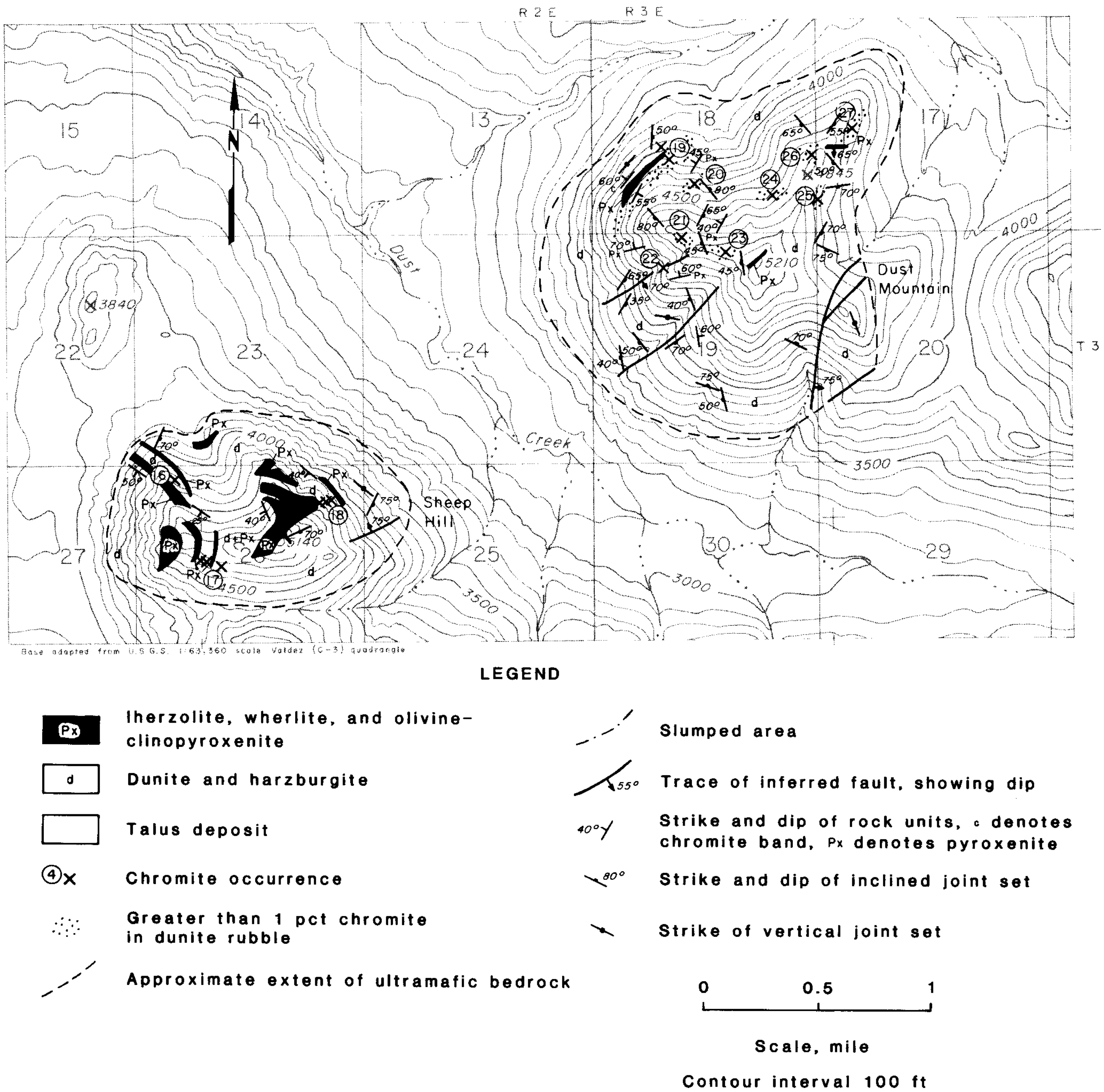


FIGURE 10 - Simplified geologic map and locations of chromite occurrences at Sheep Hill and Dust Mountain.

TABLE 2. - Identified chromite in deposits (26,000 tons Cr_2O_3) at Sheep Hill and Dust Mountain

Deposit or occurrence	16	17	18	19	20	21
Dimensions, ft:						
Length	150	450	450	3,600	ND	ND
Width	20	100	50	190	ND	ND
Depth	31	112	112	900	ND	ND
Weight ... 10^3 tons	10	520	261	63,464	NC	NC
Estimated chromite content ... pct	5	5	7	2.6	2-3	2-3
Contained Cr_2O_3 ... 10^3 tons	<1	26	NC	NC	NC	NC
Bulk sample: Number	SH1M	SH2M	SH3M SH4M	DM1M DM2M	([1])	([1])
Cr_2O_3 content, pct:						
Heads	0.6	22.9	[2]36.1 [4]27.0	[3]17.1 [5]1.5	NAp	NAp
Concentrate	([1])	51.6	[2]37.2 [4]49.9	[3]25.0 [5]35.3	NAp	NAp
Cr:Fe ratio	([1])	1.9	[2]1.1 [4]1.8	[3]0.6 [5]1.1	NAp	NAp

Deposit or occurrence	22	23	24	25	26	27
Dimensions, ft:						
Length	NC	NC	NC	NC	NC	900
Width	NC	NC	NC	NC	NC	100
Depth	NC	NC	NC	NC	NC	225
Weight ... 10^3 tons	NC	NC	NC	NC	NC	2,082
Estimated chromite content ... pct	NC	3-4	3	3-4	4	3
Contained Cr_2O_3 ... 10^3 tons	NC	NC	NC	NC	NC	NC
Bulk sample: Number	([1])	([1])	([1])	([1])	([1])	DM3M
Cr_2O_3 content, pct:						
Heads	NAp	NAp	NAp	NAp	NAp	0.8
Concentrate	NAp	NAp	NAp	NAp	NAp	([6])
Cr:Fe ratio	NAp	NAp	NAp	NAp	NAp	([6])

NAp Not applicable. NC Existing data do not warrant calculation.
ND Not determined.
[1]No bulk sample. [2]SH3M. [3]DM1M. [4]SH4M. [5]DM2M. [6]No concentrate.

NOTE.--See figure 10 for deposit locations.

Bulk samples from deposits at Sheep Hill and Dust Mountain yielded concentrates containing from 25.0 to 51.6 pct Cr_2O_3, with Cr:Fe ratios ranging from 0.6 to 1.9. These data indicate that not all chromian spinel at Sheep Hill and Dust Mountain is chromite and only some of the material may be concentrated to meet metallurgical specifications. It is unclear if the low Cr:Fe ratios are due to the presence of magnetite or if the primary chromian spinel at Sheep Hill and Dust Mountain is consistently different from that at Bernard Mountain.

TABLE 3. - Analytical results and descriptions of rock samples from Sheep Hill[1]

Sample	Deposit	Ag, ppm	Au, tr oz/ton	Co, ppm	Cr, pct	Cu, ppm	Ni, ppm	Pd, tr oz/ton	Pt, tr oz/ton	Description
SH5G..	18	0.2	<0.0001	99	3.2	8	1,180	0.002	0.002	Representative sample of dunite with disseminated chromite.
SH6G..	18	.2	<.0001	65	10.31	4	1,200	[2].001	.0006	Chips from bands of disseminated chromite in dunite.
SH7G..	18	.2	<.0003	31	13.12	12	790	[2].001	<.0006	Chromite schlieren and disseminated coarse-grained chromite in dunite.
SH8G..	16	.2	<.0001	97	2.31	31	1,000	<.0003	<.0003	Disseminated chromite in 10- to 20-ft-thick dunite unit in pyroxenite.
SH9G..	17	.2	<.0001	118	3.53	46	720	<.0006	<.0006	Chromite bands in dunite rubble.

[1]Ag, Co, Cr, Cu, and Ni were analyzed by Technical Services Laboratories in Spokane, WA, and by Bondar-Clegg, Inc., Lakewood, CO, by atomic absorption. Au, Pd, and Pt were preconcentrated by fire assay procedures; beads were analyzed by inductively coupled plasma techniques at the Bureau's Reno (NV) Research Center.

NOTE.--See figure 11 for sample locations.

Deposit 16 consists of disseminated chromite in a 20-ft-wide dunite layer at Sheep Hill. This unit strikes N 55° W for at least 100 ft and dips 52° SW. The dunite layer is bounded above and below by clinopyroxenite and is covered by rubble at both ends. Sample SH8G (table 3) is a random chip sample collected from dunite along 50 ft of strike length at this location. This sample contained 2.3 pct Cr (3.4 pct Cr_2O_3), which corresponds to a chromite content of about 5 pct. A strike length of 150 ft and a depth of 31 ft were assumed for this unit, but no recoverable chromite was estimated because of the low grade.

Deposit 17 consists of banded chromite in dunite rubble on the south side of Sheep Hill. The strike of the chromite bands could not be determined because of a lack of outcrop. Bulk sample SH2M was collected from chromite-rich float within this zone, which measures 300 by 100 ft. A concentrate containing 55.1 pct Cr_2O_3 with a Cr:Fe ratio of 2.2 was obtained from this sample. The chromite content was visually estimated at 5 pct. A strike length of 450 ft and a depth of 112 ft were inferred for this deposit.

Deposit 18 consists of a variably mineralized section of dunite and pyroxenite exposed in a prominent gully on the east side of Sheep Hill between 4,390- and 4,600-ft elevations. Banded, disseminated, and irregular segregations of massive chromite are common in dunite layers that alternate with less abundant, unmineralized pyroxenite layers. The dunite and pyroxenite layers strike northwest and dip southwest into the mountain. The entire section is about 210 ft thick, and dunite with banded chromite crops out intermittently for 300 ft along strike. The chromite bands show variable strikes, most of which are oblique to the dunite and pyroxenite layers. The chromite content of a higher grade, 50-ft-wide portion of this zone was visually estimated

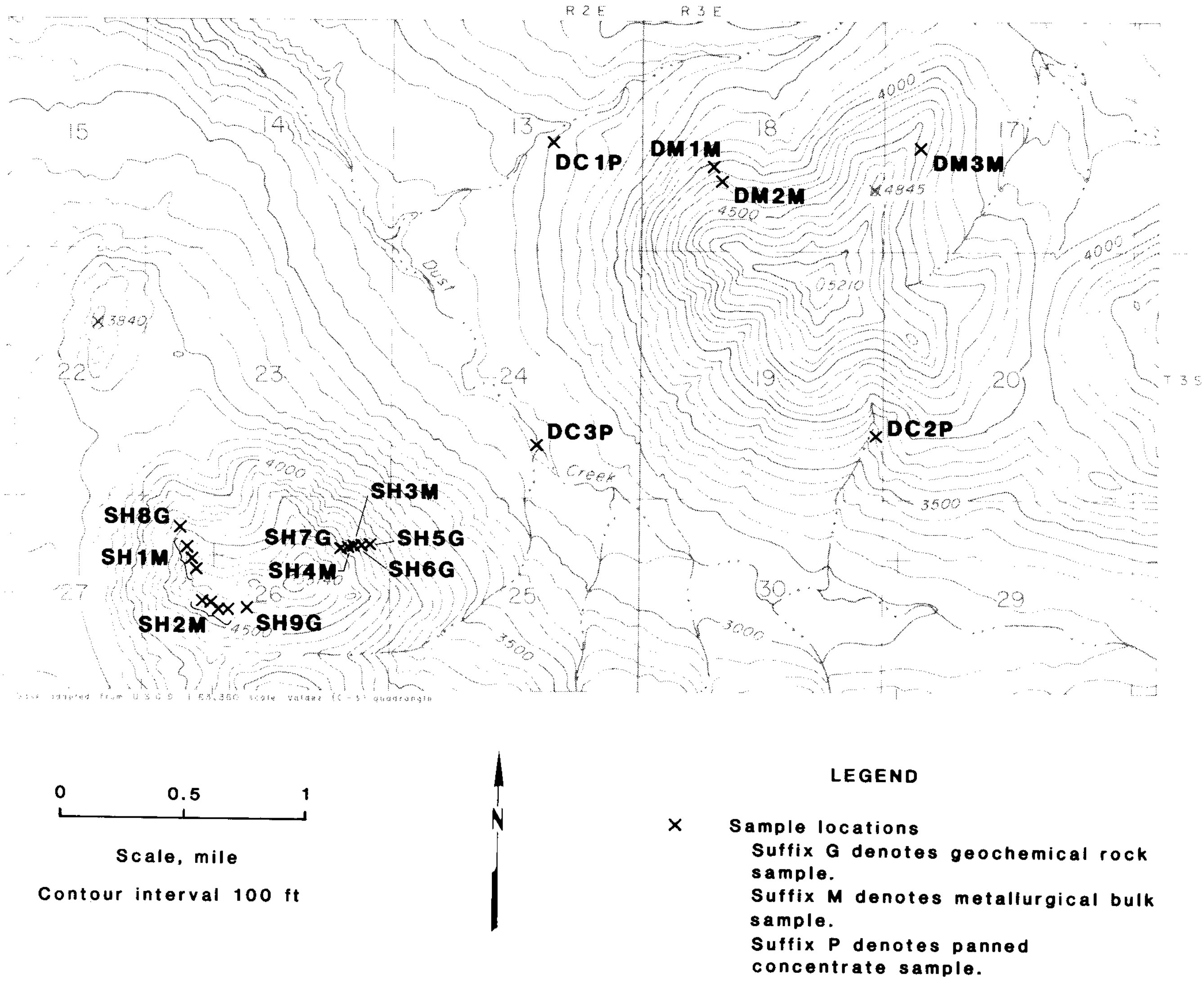


FIGURE 11. - Sample locations at Sheep Hill, Dust Mountain, and Dust Creek.

as 7 pct. The remainder of the deposit was estimated to contain significantly less than 5 pct chromite. Bulk samples SH3M and SH4M are from the higher grade portion of the deposit. A concentrate containing 37.2 pct Cr_2O_3 with a Cr:Fe ratio of 1.1 was obtained from SH3M. The concentrate from SH4M contained 49.9 pct Cr_2O_3 and had a Cr:Fe ratio of 1.8. Because this deposit is covered at both ends, a strike length of 450 ft and a depth of 112 ft were inferred. No tonnages were calculated because of the low Cr:Fe ratios.

Deposit 19 is a large, low-grade zone at Dust Mountain consisting of disseminated, banded, and massive chromite which occurs between 4,000- and 4,240-ft elevations along the northwest side of Dust Mountain. This zone persists for 3,600 ft along strike, and the individual chromite bands strike N 35° E and dip between 45° and 60° NW, forming a dipslope. The mineralized intervals are from less than 1 ft to as much as 10 ft wide, with the wider intervals containing more disseminated chromite than the narrower intervals. The entire section is interrupted by a 50-ft-wide concordant layer of barren pyroxenite. Bulk samples DM1M and DM2M were collected from 100- and 190-ft-wide dunite intervals above and below the pyroxenite.

Bulk sample DM1M was high-graded from chromite-rich rubble and bedrock in a 100-ft-wide dunite interval beneath the pyroxenite. The concentrate contained 25.0 pct Cr_2O_3 with a Cr:Fe ratio of 0.6. Sample DM2M is a more representative chip sample, collected from bedrock exposed in a gully that transects the entire 190-ft-thick mineralized section. This sample was collected above and below the pyroxenite and contained 1.5 pct Cr_2O_3, which corresponds to a chromite content of about 2.6 pct. A concentrate containing 35.3 pct Cr_2O_3 with a Cr:Fe ratio of 1.1 was obtained.

Hand specimens of chromite-rich dunite from deposit 19 were observed in the field to be more magnetic than specimens at the other Tonsina area chromite occurrences. The presence of magnetite may explain the low Cr:Fe values in the concentrates. The overall chromite content of this deposit was estimated at less than 5 pct in the field. No tonnages were calculated because of the inferior quality of the concentrated material and the low deposit grade.

At occurrences 20 and 21, coarse-grained disseminated chromite was observed in dunite bedrock and in dunite rubble. The extent of mineralization was not determined owing to poor exposure. The chromite content is estimated between 2 and 3 pct at both locations. No tonnages were calculated, but these mineral occurrences may represent the surface expression of larger, poorly exposed deposits.

Occurrence 22 is a small, irregularly shaped concentration of massive chromite with a maximum dimension of 2 ft exposed at the head of a gully at the upper, west end of Dust Mountain.

Disseminated and thin banded chromite is exposed in bedrock at occurrence 23 near the summit of Dust Mountain. The chromite content is estimated to be between 3 and 4 pct, but the extent of the occurrence could not be determined owing to the presence of abundant frost-riven rubble.

At occurrences 24 through 26, near the north side and the northeast ridge of Dust Mountain, disseminated chromite grains averaging greater than 1 mm in maximum dimension were observed to constitute an estimated 4 pct of the dunite. Because of extensive mixing of frost-riven rubble, no samples were collected and dimensions were not determined at these occurrences.

Occurrence 27 consists of disseminated, coarse-grained chromite in dunite bedrock and in rubble between 2,475- and 2,700-ft elevations on the northeast ridge of Dust Mountain. In the field, the chromite content was estimated between 2 and 3 pct. Bulk chip sample DM3M was collected from this area. The heads contained 0.8 pct Cr_2O_3, which corresponds to a chromite content of about 1.4 pct. Beneficiation tests failed to produce a usable concentrate from this material.

Additional unmeasured chromite is contained in the thick talus deposit at the base of the north side of Dust Mountain. Massive and banded chromite in dunite is mixed with barren dunite and peridotite rubble in this area.

Chrome Creek and Dust Creek

Results of surficial heavy mineral sampling indicate that chromite is present in Chrome Creek and Dust Creek, but data are insufficient to estimate the size and grade of placer chromite deposits that may have been concentrated by alluvial processes. Three bulk gravel samples from active stream beds on Dust Creek were reduced to black sands by screening and panning. Sample locations are shown in figure 11. Chromic oxide content in each of these samples was about 7 pct (table 4). No samples were collected on Bernard Creek, but a pan sample was collected on upper Chrome Creek (fig. 8), a tributary of the Little Tonsina River, and it contained 29 pct Cr_2O_3.

NELCHINA GLACIER AND MATANUSKA RIVER AREAS

Mafic and ultramafic rocks were reported to crop out (30, 36) in the Nelchina Glacier area and in the vicinity of the South Fork of the Matanuska River (fig. 12).

H. F. McWilliams (30), a prospector and placer miner, reported that massive chromite occurs in dunite and colluvium at the head of Barnette Creek on the east side of the Nelchina Glacier. A brief visit by Bureau personnel in the summer of 1983 failed to confirm the occurrence owing to residual snow cover over parts of the area. Minor, disseminated chromite was observed in a fault-bounded and sheared mass of serpentinized dunite on a ridge to the north of Barnette Creek. The maximum dimension of the serpentinized ultramafic body is less than 500 ft, and the chromite content is less than 5 pct.

Pessel (36) mapped numerous small serpentinite bodies associated with tectonic melange west of the South Fork of the Matanuska River (fig. 12). Roberts (40) investigated a 9-mi^2 portion of this area in 1981 but did not observe any chromite. He noted a general lack of dunite in the area, and this precludes potential for significant chromite occurrences.

PALMER AREA

Chromite occurs at 13 locations in the Wolverine and Eklutna mafic-ultramafic complexes near the town of Palmer (fig. 13). Seven occurrences in the Wolverine complex were sampled and described, but because of low grade, inferior quality, and lack of exposure, no recoverable chromite was calculated. Recoverable chromite was calculated for four of six deposits in the Eklutna complex.

The Wolverine complex is about 14 miles east of Palmer and 7 miles south of the Glenn Highway at the head of Wolverine Creek. It is separated from existing roads by rugged terrain and the Matanuska River Valley. Wolverine and Carpenter Creeks head at the complex, and their valleys are likely routes for overland access. A gravel road from Palmer ends near the mouth of Wolverine Creek.

The Wolverine complex crops out above timberline in rugged topography between 3,000- and 7,000-ft elevations. The complex is dissected by an active glacier. Because of its elevation and proximity to the coast, the area is subject to heavy snowfall, which may occur any time of year.

The Wolverine complex lies within an area tentatively approved for selection by the State of Alaska and is open to mineral entry. As of October 1983, there were no records of claim locations, mining activity, or development of mineral resources in the area underlain by the complex.

Previous work in the area is limited. A USGS open-file report by Clark (9) on the area contains a geologic map of the Wolverine complex and a brief description of a single chromite occurrence. Roberts (41) sampled and described seven chromite occurrences in 1981.

TABLE 4. - Analytical results of heavy mineral concentrates from stream gravels at Chrome Creek and Dust Creek[1]

Sample	CC1P	DC1P	DC2P	DC3P
Original volume of sample[2] ..... ft^3	1.2	2.5	1.1	3.0
Weight of black sand ..... g	24.6	13.0	30.9	16.9
Au ..... tr oz/ton	0.020	NA	0.0005	NA
Cr_2O_3 ..... pct	29.2	7.3	7.3	7.3

NA Not analyzed.

[1]Cr was analyzed by Bondar-Clegg, Inc., Lakewood, CO, using atomic absorption. Au was preconcentrated by fire assay procedures; beads were analyzed by inductively coupled plasma techniques at the Bureau's Reno (NV) Research Center.

[2]Original sample volumes were calculated on the basis of measured, loose volumes minus a 25-pct swell factor.

NOTE.--See figure 11 for sample locations.

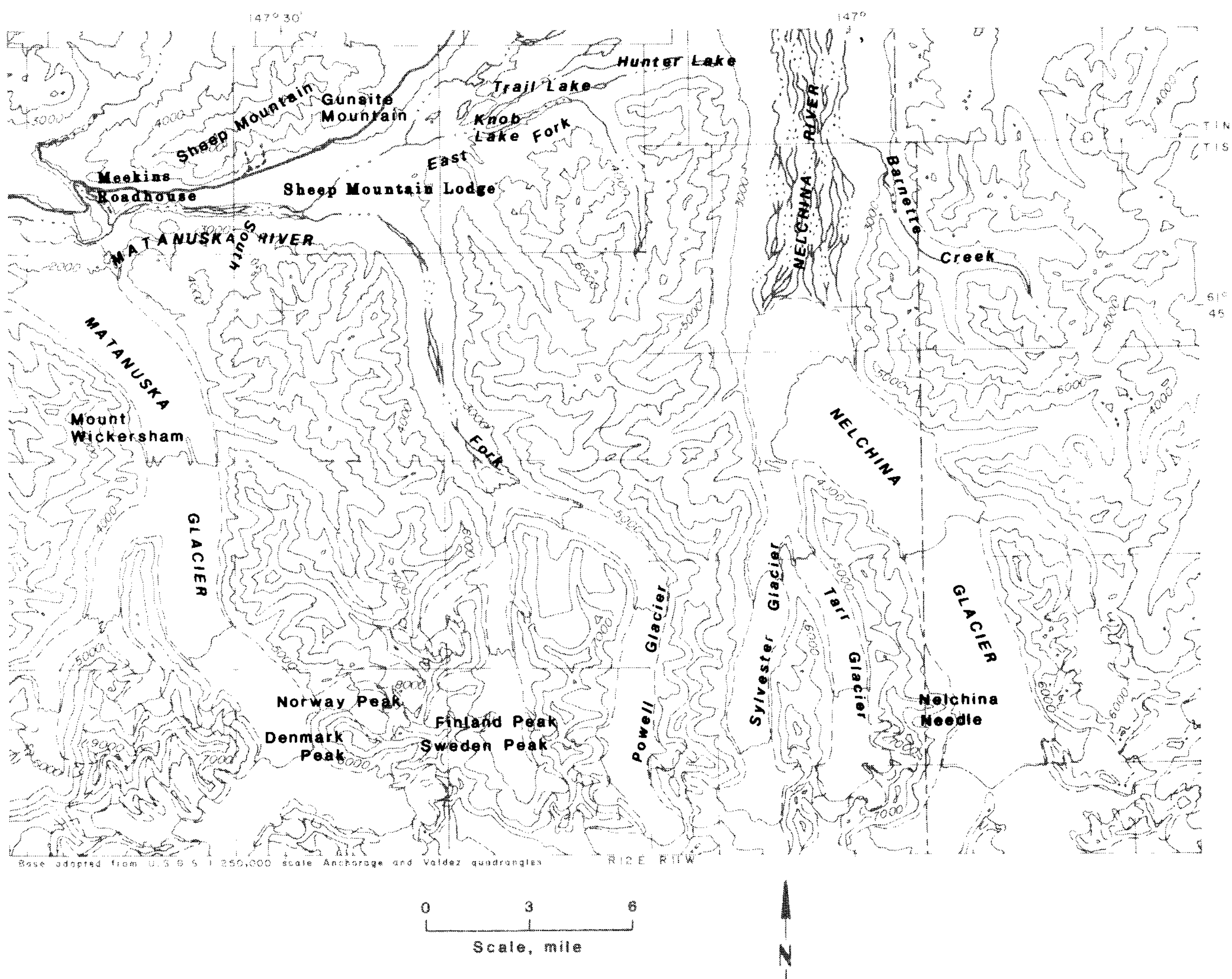
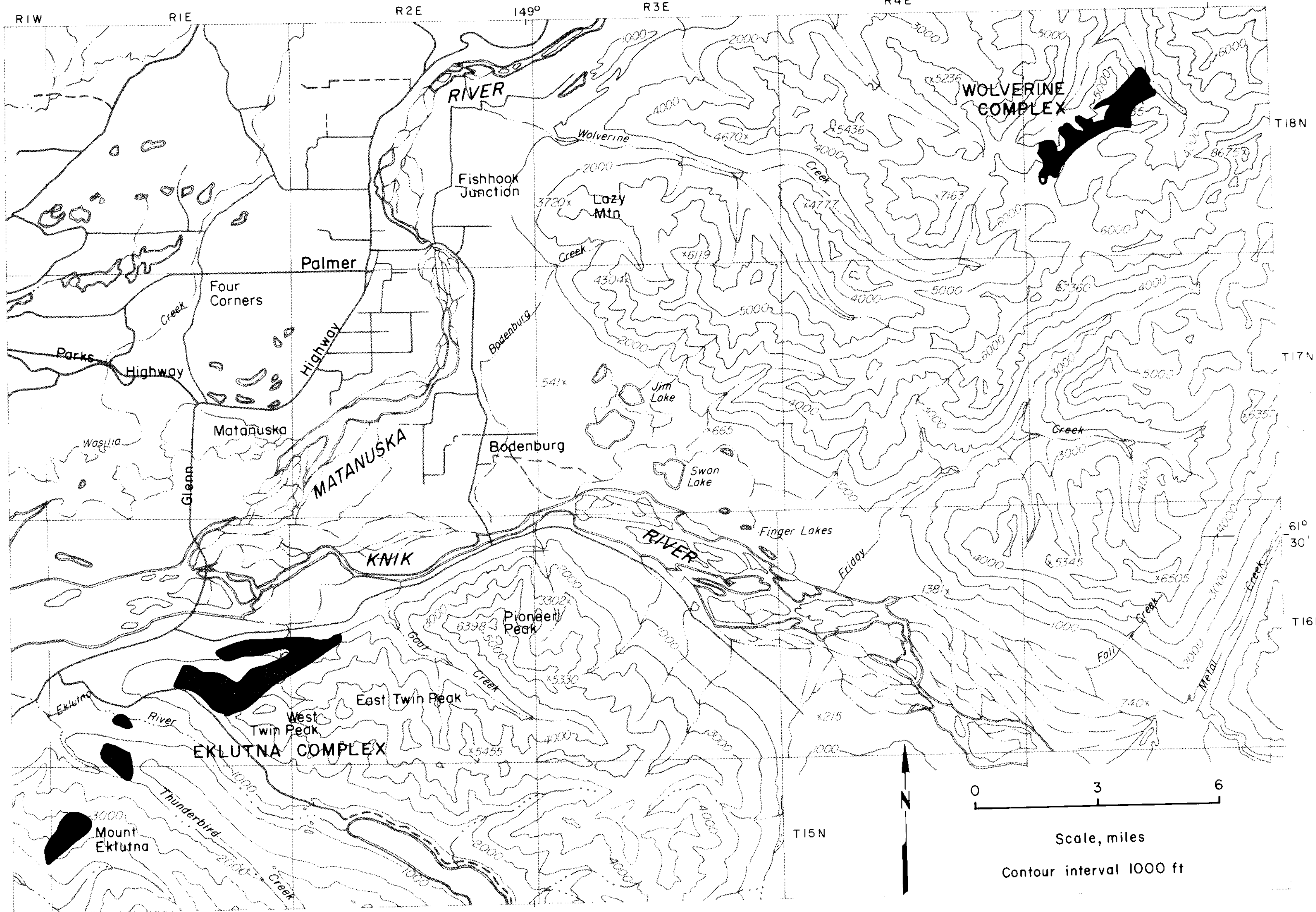


FIGURE 12. - Map of Nelchina Glacier and Matanuska River areas.



Base adapted from U.S.G.S. 1:250,000 scale Anchorage quadrangle

FIGURE 13. - Mafic-ultramafic complexes near Palmer.

The Eklutna complex crops out at four locations south of Eklutna near the Glenn Highway (fig. 13). These outcrops are all within 3 miles of existing roads and are below the 4,000-ft elevation. The area is mostly covered by dense forest and thick undergrowth, with timberline at about 3,000 ft.

The land status of the area underlain by the Eklutna complex is uncertain. A complex array of selections, applications, and patents covers the area. Interested parties are encouraged to check with the Bureau of Land Management and the Alaska Department of Natural Resources, Division of Lands, before considering further mineral investigation of these lands.

No chromite has been produced from the deposits in the Eklutna complex, but extensive prospecting was done on them in the past. Claims were located at the Mount Eklutna, Pioneer Creek, and Highway deposits at various times between 1900 and 1974, but these are no longer active.

Chromite deposits in the Eklutna complex have been described by Freedman (14), Gates (15), Bjorkland and Wright (4), and Rose (42). Those reports present the results of trenching, mapping, limited drilling, and detailed sampling.

Wolverine Complex

The Wolverine complex was briefly examined by the Bureau in 1981 (41) and in 1983. Chromite in dunite was observed at seven locations (fig. 14). Three of these are in bedrock (30, 31, and 33), and the other four are in talus or moraine (28, 29, 32, and 34). Locations of rock samples collected are shown in figure 15, and the corresponding analytical results are presented in table 5.

At occurrence 28, banded chromite was observed in boulders in moraine. Maximum thickness of individual bands is 2 in, and the boulders contain up to 30 pct chromite. The source of the boulders was not located. No recoverable chromite was inferred for this occurrence.

Bands of chromite less than 1 in thick were also observed in talus at occurrence 29. The bedrock source of the chromite could not be located, and no recoverable chromite was inferred.

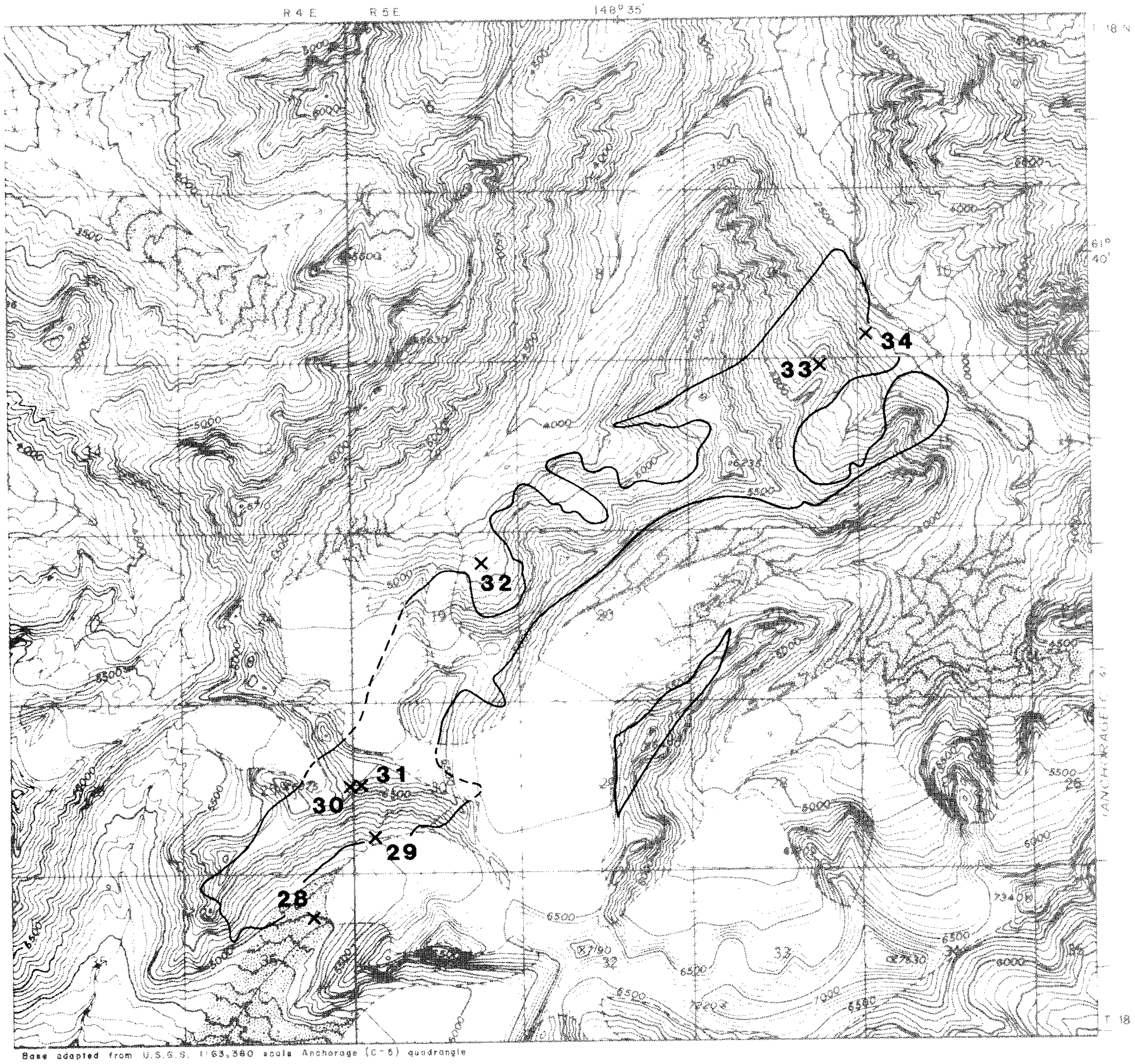
At occurrence 30, multiple chromite bands up to 2 in thick were observed in frost-riven bedrock over a 50- by 50-ft area. The chromite content was visually estimated at less than 5 pct, and no recoverable chromite was inferred because of the apparent low grade.

TABLE 5. - Analytical results and descriptions of rock samples from the Wolverine complex[1]

Sample	Deposit	Ag, ppm	Au, tr oz/ton	Co, ppm	Cr, pct	Cu, ppm	Ni, ppm	Pd, tr oz/ton	Pt, tr oz/ton	Description
WC2G..	32	0.40	<0.0002	57	4.40	10	1,850	<0.001	<0.001	Discontinuous chromite stringers in dunite.
WC3G..	32	.30	<.0002	76	3.30	2	1,400	<.001	<.001	Do.
WC4G..	32	<.03	<.0002	65	1.95	14	1,700	<.001	<.001	Do.
WC5G..	34	<.03	<.0002	78	1.05	10	1,550	<.001	<.001	Wispy chromite bands in dunite.

[1]Ag, Co, Cr, Cu, and Ni were analyzed by Technical Services Laboratories in Spokane, WA, by atomic absorption. Au, Pd, and Pt were preconcentrated by fire assay procedures; beads were analyzed by inductively coupled plasma techniques at the Bureau's Reno (NV) Research Center.

NOTE.--See figure 15 for sample locations.



0 0.5 1

Scale, miles

Contour interval 100 feet

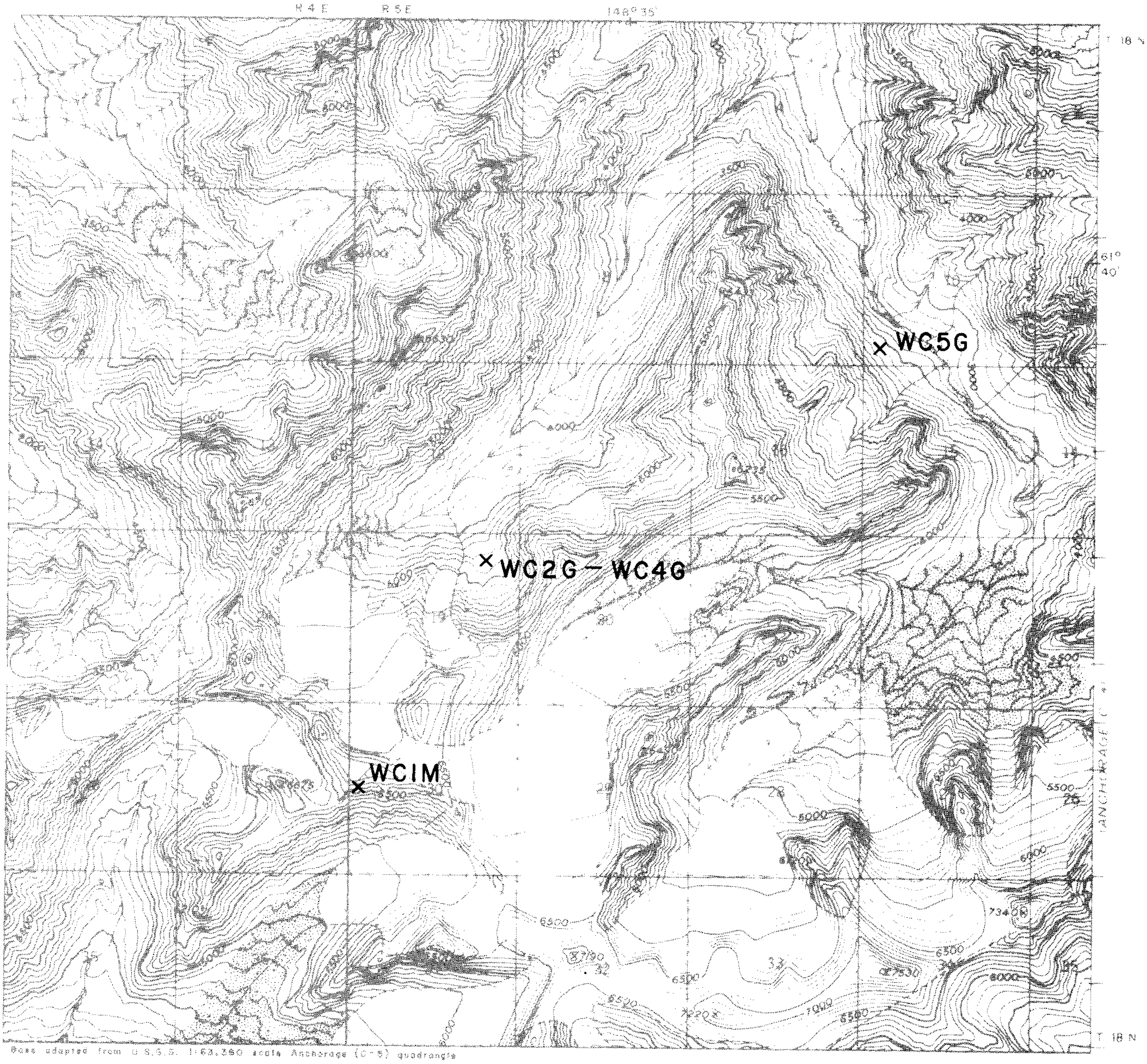
N

LEGEND

× Chromite occurrence described in text

Outline of Wolverine ultramafic complex, dashed where inferred

FIGURE 14. - Locations of chromite occurrences at the Wolverine complex. (After Clark (9, fig. 1))



N

0 0.5 1

Scale, mile

Contour interval 100 ft

LEGEND

× Sample locations

Suffix G denotes geochemical rock sample

Suffix M denotes metallurgical bulk sample.

FIGURE 15. - Sample locations at the Wolverine complex.

Deposit 31 is better exposed than the other chromite occurrences in the Wolverine complex. Discontinuous chromite bands typically measuring from 1/4 to 2 in thick were observed in a zone measuring 50 by 200 ft. The chromite bands strike N 40° E and dip vertically. At one location, the cumulative thickness of chromite bands is 22 in within a 64-in interval. The chromite content was estimated to be 5 pct within the entire 50-ft-wide zone.

Chromite grains from bulk sample WC1M, collected at deposit 31, were analyzed by X-ray fluorescence procedures (41). The analyzed material contained 54.2 pct Cr_2O_3 with a Cr:Fe ratio of 1.6. The remainder of the sample was concentrated by ALRC; the concentrate contained 47.9 pct Cr_2O_3 with a Cr:Fe ratio of 1.6. Because of the low Cr:Fe ratios, no recoverable chromite was inferred for this deposit.

Minor chromite bands less than 1 in thick were observed in moraine and talus at occurrences 32 and 34. Chromite bands less than 1/2 in thick were also observed in sheared dunite at occurrence 33. Because of apparent low grade, inferior quality, and lack of exposure, no recoverable chromite was calculated for these occurrences.

Eklutna Complex

Chromite occurs at six locations in the Eklutna complex (fig. 16). Recoverable chromite (table 6) was calculated for four of these deposits on the basis of data presented by previous investigators (4, 42). The Eklutna complex is the most poorly exposed of all the ultramafic complexes discussed in this report; chromite development potential remains largely unknown.

In 1966, Rose (42, p. 11) described banded chromite in serpentinized greenish-yellow-weathering dunite on the ridge between Eklutna River and Thunderbird Creek, and on the west slope of Mount Eklutna (35 and 36, fig. 16). No deposit dimensions were included in Rose's descriptions.

At deposit 37, located west-northwest of West Twin Peak, another zone of serpentinized chromite-rich dunite measuring 10 by 30 ft was described by Rose (42, p. 11). The dunite host strikes about N 10° E and is bounded to the west and east by peridotite. No strike was given for the chromite bands, which are up to 1 in wide. A chip sample collected by Rose across the 10-ft-wide zone contained 7 pct Cr_2O_3. This corresponds to a chromite content of about 12 pct. Because this deposit is covered by talus at both ends, a strike length of 45 ft and a depth of 9 ft are inferred.

Deposits 38 and 39 at Pioneer Creek were trenched by the Bureau of Mines in 1942; these deposits were described by Bjorklund and Wright (4, pp. 4-5).

TABLE 6. - Identified chromite deposits[1] (1,000 tons Cr_2O_3) at the Eklutna complex

Deposit	35	36	37	38	39	40
Dimensions, ft:						
Length	ND	ND	45	82	50	175
Width	ND	ND	10	30	13	10
Depth	ND	ND	9	20	12	44
Weight ... 10^3 tons	NC	NC	<1	5	1	8
Estimated chromite content ... pct	NC	NC	12.0	8.0	8.0	19.0
Contained Cr_2O_3 ... 10^3 tons	NC	NC	<1	<1	<1	1

NC Existing data do not warrant calculation. ND Not determined.
[1]Based on data in Bjorklund and Wright (4).

NOTE.--See figure 16 for deposit locations.

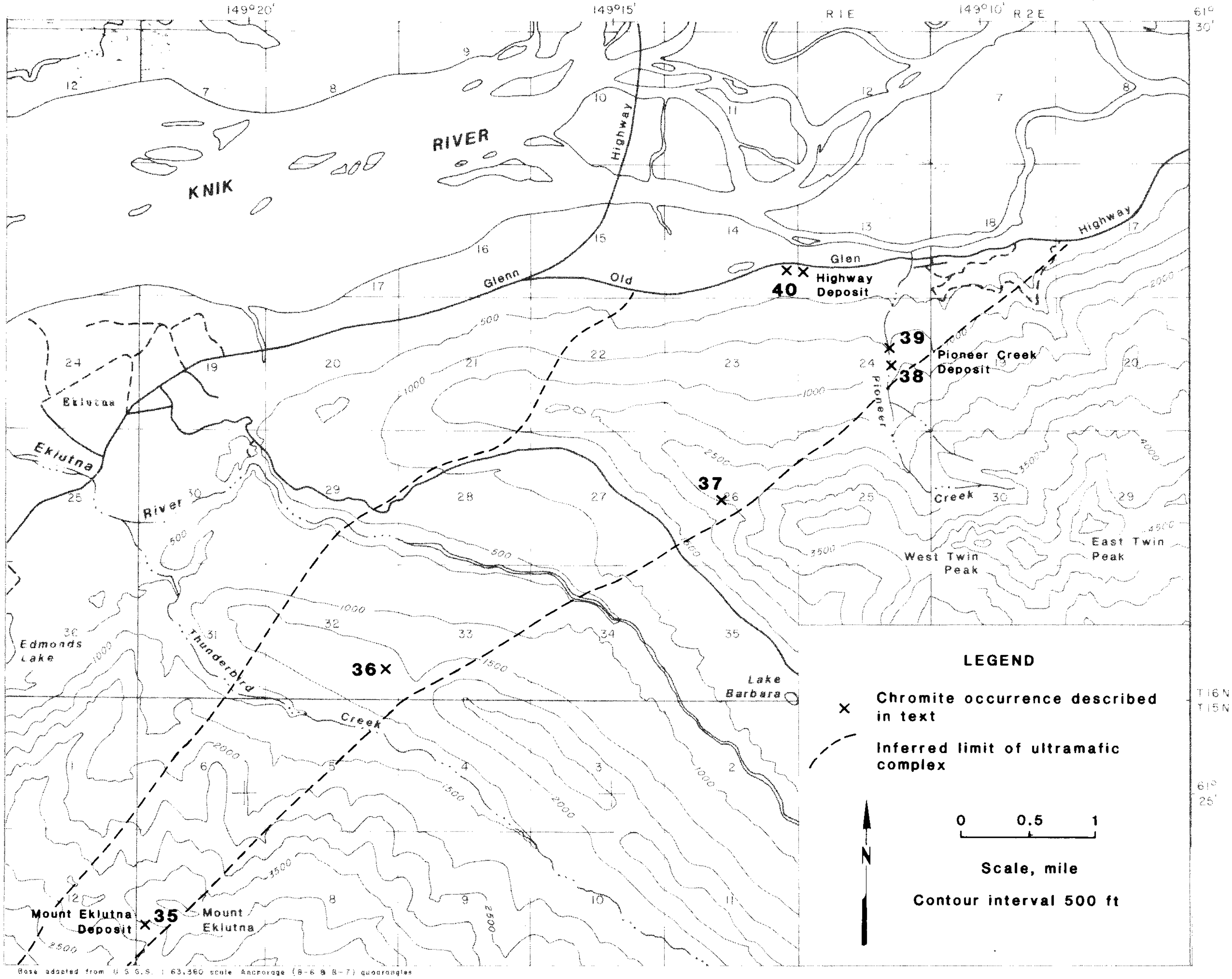


FIGURE 16. - Location of chromite deposits at the Eklutna complex. (After Rose (42), fig. 2))

Deposit 38 was described by Bjorklund as a zone composd of a number of small pods and ellipsoidal segregations of disseminated chromite. The zone trends due north for 82 ft and has a width of 30 ft. Weighted assays of channel samples collected by Bjorklund and Wright (4) from three trenches transecting the deposit indicate Cr_2O_3 content between 5 and 8 pct. These correspond to chromite content between 8 and 14 pct. A depth of 20 ft is inferred for this deposit.

Deposit 39 consists of disseminated chromite and 1-in stringers in a zone that measures 50 ft in length and is up to 13 ft wide. Owing to normal faulting, the dunite and chromite in this zone are severely shattered. Slumping has developed open crevices, which have filled with colluvium and soil (4). Strikes and dips are erratic, but the general trend of the chromite stringers is N 50° W. Dips range from 52° to 78° NE (4). Stripping and trenching by the Bureau of Mines in 1942 did not disclose continuations of this zone. Weighted assays of trench samples indicate a Cr_2O_3 content of at least 5 pct for this deposit. This corresponds to a chromite content of about 8 pct. A depth of 12 ft is inferred.

Deposit 40 was called the Highway deposit by Bjorklund and Wright (4) and by Rose (42). This deposit was also trenched and drilled by the Bureau of Mines (4). Banded chromite and chromite lenses were exposed in a roadcut at the time of the earlier investigations (4, 42) but were not seen during the present investigation owing to slumping and vegetation cover. According to Rose (42), the mineralized zone is 8 ft wide and strikes N 10° E for 175 ft. Dips range from vertical to 70° W. Channel samples collected by Bjorklund and wright (4) indicated a Cr_2O_3 content of 11 pct. This corresponds to a chromite content of about 19 pct. The Bureau of Mines drilled a single hole in 1942 to test the downward extension of this deposit. No chromite was encountered at a depth of 170 ft beneath the nearly vertical zone. A depth of 44 ft and a width of 10 ft were inferred for this deposit. Deposit 40 contains nearly 1,000 tons of Cr_2O_3.

KENAI PENINSULA

The only chromite produced in Alaska through 1983 was mined from deposits at Red Mountain and Claim Point on Kenai Peninsula. Chromite also occurs in gravel deposits of the Windy River Valley, which heads on Red Mountain. All three locations are shown in figure 17.

At Claim Point, 1,100 short tons of chromite ore averaging between 46 and 49 pct Cr_2O_3 was mined from the Reef Mine in 1917. Another 1,100 tons of ore averaging 40 pct Cr_2O_3 was shipped in 1918. At Red mountain, chromite ore was mined from the Star No. 4 and Chrome Queen (17, fig. 19) deposits between 1943 and 1958. Grades of 41 to 43 pct Cr_2O_3 were reported for 7,414 tons produced and stockpiled in 1943 and 1944. During 1954, 2,953 tons of chromite with a grade of 38 pct Cr_2O_3 was produced. An additional 18,482 tons of unknown grade was produced from 1955 to 1957. Eight thousand tons of the ore produced and stockpiled between 1954 and 1957 was sold and shipped to Japan about 1976 (45, p. 73).

The Red Mountain area, including the Windy River Valley, is about 10 miles southeast of Seldovia and is accessible by an existing road from that community. Claim Point is at tidewater near the southern tip of Kenai Peninsula and can only be reached by boat or float plane.

Red Mountain, elevation 3,524 ft, is a prominent and well-exposed topographic feature. Vegetation is generally lacking on upper Red Mountain, but thick forest with dense undergrowth covers the lower slopes and hills closer to Jakalof Bay and along the shoreline. Claim Point is a low hill at the southern end of the Kenai Peninsula and is almost completely surrounded by water. The area is typical of densely forested coastal areas in southern Alaska and has a cool maritime climate. Much of the Claim Point complex is covered by vegetation or is

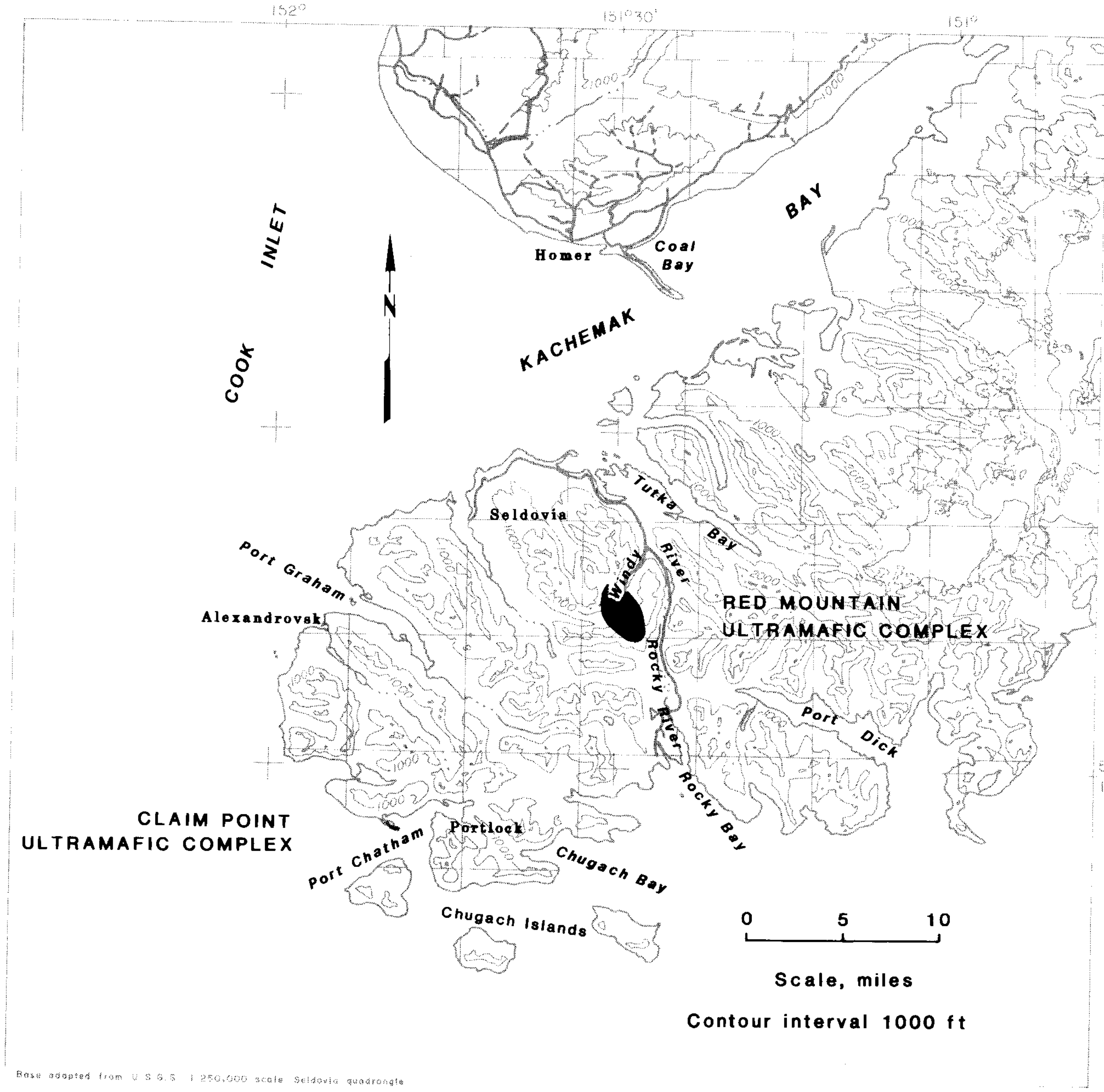


FIGURE 17. - Locations of Red Mountain and Claim Point ultramafic complexes on Kenai Peninsula. (After Gill (16, plate I) and Sanford and Cole (44, fig. 2))

under water. Outcrops are mostly limited to beaches, where excellent bedrock exposures may be seen at low tide (fig. 18).

Red Mountain and Claim Point are both covered by patented and unpatented mining claims. Claim owners include Anaconda Minerals Co. and Union Carbide Corp. Cook Inlet Region, Inc., and Chugach Natives, Inc., also own portions of the mineral deposits and have filed land entitlement selection applications in the general vicinity.

Numerous reports on chromite deposits at Kenai Peninsula have been published. The earliest detailed report is by Gill in 1922 (16), who described 23 deposits at Red Mountain and 14 deposits at Claim Point. Geologic maps of Red Mountain and Claim Point showing additional deposits were compiled by Guild (17). The Bureau

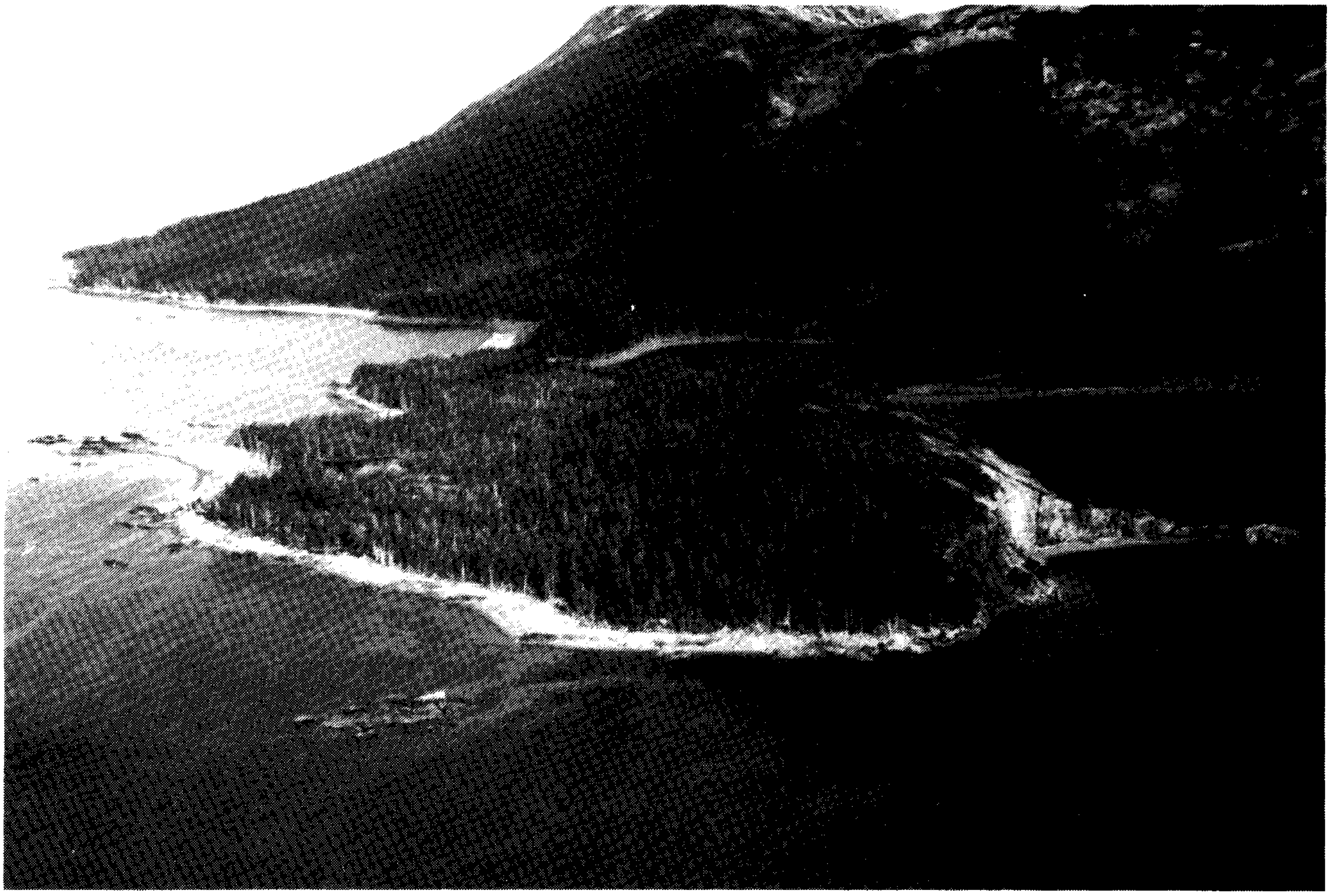


FIGURE 18. - Oblique aerial view of Claim Point, Kenai Peninsula. The Reef mine was located on the partially emerged shoals in the far left portion of the photograph. Ultramafic bedrock extends beneath the sea to all sides of the point.

of Mines reported on Red Mountain chromite deposits and Claim Point chromite deposits (43, 50). A report on the petrology, geochemistry, and origin of the Red Mountain ultramafic body was authored by Toth in 1981 (47).

Red Mountain

Previous investigations at Red Mountain focused primarily on high grade portions of 31 deposits that contain 30 pct or more chromite (16-17). Published reserves contained in 20 deposits are equivalent to about 97,000 tons of contained Cr_2O_3 (table 7). Because of their small size or lack of exposure, no reserves were inferred for the other deposits. This investigation reports an additional 1,487,000 tons of contained Cr_2O_3 in three low-grade deposits at Red Mountain, as shown in table 8. These estimates include about 2,000 tons of Cr_2O_3 contained in the previously described deposits. The total estimated development potential for 23 deposits is about 1.6 million tons of Cr_2O_3.

Earlier workers found that the chromite at Red Mountain generally has Cr:Fe ratios that exceed metallurgical-grade specifications. Wells and others reported Cr:Fe ratios ranging from 1.8 to 3.1 for Red Mountain chromite ores (50, p. 2). Rutledge (43, p. 9) found that most chromite from Red Mountain has Cr:Fe ratios between 2.5 and 3.3. Metallurgical testing of composite samples from Red Mountain stringer zones by ALRC (13) indicates chromite with Cr:Fe ratios ranging from 2.3 to 3.1.

TABLE 7. - Published chromite reserves (96,700 tons Cr_2O_3) at Red Mountain[1]

Deposit	Shipping ore[2]		Concentrating ore[3]		Contained Cr_2O_3,[4] 10^3 tons
	Amount, 10^3 tons	Chromite content, pct	Amount, 10^3 tons	Chromite content, pct	
2......	90.0	⩾40	80.0	⩽40	39.4
3......	5.0	⩾40	25.0	⩽40	7.0
4......	NR	NR	5.0	30	.9
5......	.2	⩾40	1.5	⩽40	.4
6......	.2	⩾40	2.0	30	.6
8......	10.5	⩾40	6.0	42	3.9
9......	12.5	⩾40	5.0	⩽40	2.3
10.....	8.0	⩾40	5.0	60	3.6
11.....	7.0	⩾40	16.0	50	6.2
12.....	NR	NR	10.0	⩽40	2.3
13.....	NR	NR	22.0	30	3.8
14.....	1.0	40	14.0	30	2.7
17.....	1.0	⩾40	16.0	⩽40	1.6
18.....	NR	NR	3.0	60	1.1
19.....	NR	NR	30.0	40	7.0
20.....	NR	NR	6.5	49	1.9
24.....	8.4	⩾40	10.1	56	5.2
25.....	NR	NR	4.5	38	1.0
27.....	.6	⩾40	.7	46	.4
28.....	NR	NR	9.5	33	1.8

NR No reserve estimate.

[1]Deposits were described by Gill (16) and Guild (17). Deposits for which no reserves were published are not listed.

[2]Contains at least 40 pct Cr_2O_3 (16, p. 28; 17, p. 155).

[3]Gill (16, p. 28) and Guild (17, p. 155).

[4]Cr_2O_3 (10^3 tons) = chromite (10^3 tons × 0.58 on the basis of data in Guild (17, p. 150).

NOTE.--See figure 19 for deposit locations.

The locations of chromite deposits at Red Mountain are shown in figure 19. Because Gill (16) failed to show a location for deposit 19, the location labeled 19 in figure 19 is based on his verbal description, and some doubt exists regarding the accuracy of this location.

Bulk channel samples RM3M and RM4M were collected by the Bureau at deposit 9, which was described by Gill (16). These samples were collected 15 ft apart, from a 3-ft-thick layer of coalescent to massive chromite which strikes N 20° W and dips 30° SW. This is the thickest of several chromite layers at deposit 9 (17, pp. 169-170). Heads from RM3M contained 39.6 pct Cr_2O_3, and a concentrate containing 56.8 pct Cr_2O_3 with a Cr:Fe ratio of 3.0 was produced. Heads from RM4M contained 21.9 pct Cr_2O_3, and a concentrate containing 56.8 pct Cr_2O_3 with a Cr:Fe ratio of 2.8 was produced. Gill (16) estimated deposit 9 contains 5,000 tons of shipping-grade ore and 5,000 tons of chromite in concentrating ore. If an average grade of 40 pct chromite is assumed for both ores, reserves equivalent to 2,300 tons of contained Cr_2O_3 are inferred (table 7).

TABLE 8. - Inferred chromite reserves and estimated chromite development potential in low-grade deposits at Red Mountain (1,487,000 tons)

Deposit[1]	Weight, 10^3 tons	Cr_2O_3 content, pct	Contained Cr_2O_3, 10^3 tons
Turner[2,3].	22,322	5.6	1,250
Star[2].....	3,020	6.9	208
Horseshoe[4]	632	4.6	29
Tram Road[2]	5,798	2-3	NC
Richards..	NC	7-15	NC
Tom[2]......	791	3-4	<1

NC Existing data do not warrant calculation.

[1]Stringer zones described by Anaconda Minerals Co.

[2]Inferred reserve estimates based on trench sampling or drill and trench data from Anaconda Minerals Co. (1).

[3]Bulk sample RM1M had the following Cr_2O_3 content analysis, in percent: head, 8.3; concentrate, 55.0; Cr:Fe ratio of 2.3. No bulk samples taken for other deposits.

[4]Estimated chromite development potential by Anaconda Minerals Co.

NOTE.--See figure 19 for deposit locations.

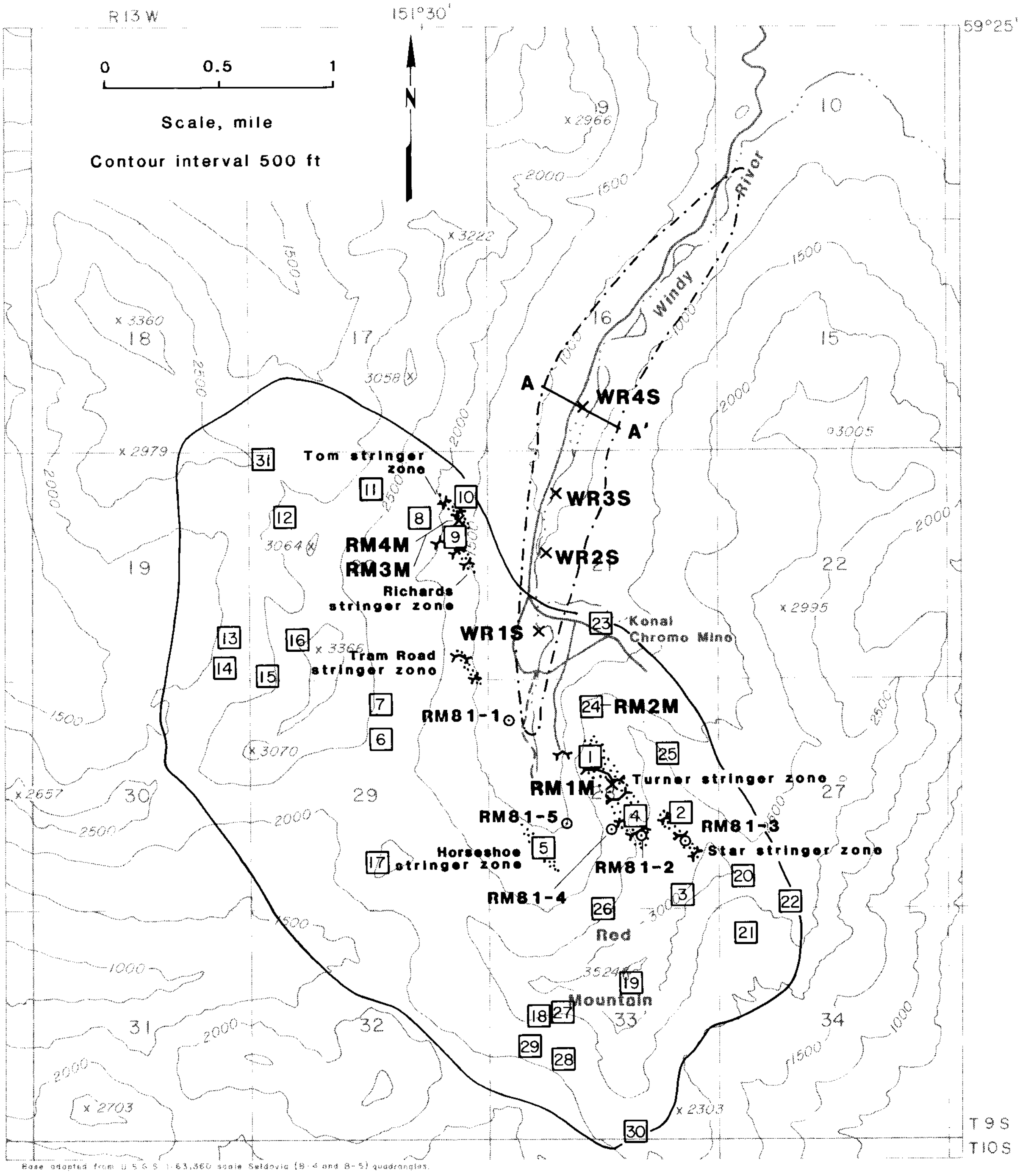
Bulk sample RM2M is a channel sample collected from two sets of multiple, parallel chromite layers at deposit 24, which was described by Guild (17, p. 173). The widest of these layers is 18 in across and consists of disseminated and coalescent chromite grains in dunite gangue. The total thickness of chromite bands sampled is 52 in. These bands, however, occur in a larger section totaling 105 in wide. The two parallel, mineralized intervals strike N 35° W, are exposed for 130 and 300 ft, and dip 30° SW. Sample RM2M was collected across both mineralized intervals; heads contained 29.1 pct Cr_2O_3, and the concentrate contained 54.9 pct Cr_2O_3 with a Cr:Fe ratio of 2.6. Guild (17) estimated chromite reserves of 18,500 tons in deposit 24. This is equivalent to about 5,200 tons of contained Cr_2O_3.

Low-grade chromite deposits that have not been previously described, but that meet the criteria outlined earlier in this report, also exist at Red Mountain. The following descriptions of these deposits are based on data gathered by Anaconda Minerals Co. in 1980 and 1981 (1). These deposits are referred to as stringer zones and consist of generally discontinuous concentrations of chromite in larger, definable zones (fig. 19). The chromite concentrations occur as segregations and layers of disseminated to massive chromite. Because stringer-zone-type mineralization frequently persists over thousands of feet through stratigraphically equivalent rocks at Red Mountain, these intermittently exposed deposits may be continuous with one another. In two cases, the larger, lower grade zones include previously described, high-grade deposits (nos. 4 and 5 in table 7). Both of the high-grade deposits contain less than 1,000 tons of Cr_2O_3 (table 7). Additional stringer zones for which no tonnage estimates were made because of their small size, low chromite content, or insufficient data are listed in table 8 and shown in figure 19.

The Turner stringer zone (figs. 19 and 20) is a large, low-grade deposit that strikes from N 25° W to N 30° W and is intermittently exposed for about 2,500 ft along strike. The deposit dips 45° SW, and is exposed for about 2,000 ft down a dip slope, and averages 75 ft wide.

The Turner stringer zone was sampled in four trenches at the surface and at one in the Carbide Adit. The deposit was intersected by three diamond-drill holes. Average grade for the deposit is estimated at 5.6 pct Cr_2O_3, based on assays of core, channel, and trench samples. Heads from a 1,000-lb trench sample (RM1M) contained 8.3 pct Cr_2O_3. A concentrate beneficiated from this sample contained 54.5 pct Cr_2O_3 with a Cr:Fe ratio of 2.3.

Based on trench sample and drill core analyses, Anaconda Minerals Co. (1),



LEGEND

[3]	Chromite locations described by Gill (16) & Guild (17)	≻—≺	Trench sample location (approximate)
	Stringer zone described in text (see table 8).	×	Sample location
	Outline of ultramafic complex		Suffix S denotes screened alluvial sample
	Area of potential placer chromite reserve		Suffix M denotes metallurgical bulk sample
⊙	Diamond drill hole (approximate location)		
A—A'	Trace of drill-hole profile in figure 22		

FIGURE 19. - Map of Red Mountain and Windy River areas showing sample locations and chromite deposits. (After Guild (17, plate 26))

FIGURE 20. - Chromite bands in the Turner stringer zone. The narrow dark bands are chromite segregations.

using three cutoff grades, estimated Cr_2O_3 contained in the Turner stringer zone. At a 3.5-pct cutoff, 1.25 million tons of contained Cr_2O_3 with an average grade of 5.6 pct was inferred (table 8). Medium-grade reserves were estimated using a 7.5-pct-Cr_2O_3 cutoff. These equal about 1 million tons of contained Cr_2O_3 at an average grade of 7.9 pct. Based on a 10-pct-Cr_2O_3 cutoff, higher grade reserves equivalent to 813,000 tons at an average grade of about 14 pct were inferred.

The Star stringer zone is about 250 ft west of deposit 2, also called the Star No. 4 deposit by Gill (16) and Guild (17). This stringer zone strikes N 17° W for over 90 ft and dips 45° W. The average width is 13 ft. It extends for about 1,200 ft down dip to the west. The deposit was intersected by two diamond-drill holes and was trenched at the surface. Based on a 4.5-pct cutoff, 208,000 tons of contained Cr_2O_3 with an average grade of 6.9 pct is inferred in the Star stringer zone (table 8). Based on a 10-pct-Cr_2O_3 cutoff, reserves inferred in the Star stringer zone equal 26,000 tons of contained Cr_2O_3 with an average grade of about 14 pct.

The Horseshoe stringer zone, also first described by Anaconda Minerals Co. geologists, consists of numerous smaller stringer zones in stratigraphically equivalent rocks. Limited outcrop in this area and a lack of drill data prevent determination of the deposit's true extent at present. A 656- by 57-ft portion of the Horseshoe stringer zone was estimated to contain 8 pct chromite. This is equivalent to a Cr_2O_3 content of about 4.6 pct. Based on an inferred depth of 164 ft, estimated chromite development potential for this portion of the deposit is 29,000 tons of contained Cr_2O_3.

Windy River

Glaciofluvial sand and gravel deposits in the Windy River Valley (figs. 19 and 21) were investigated for chromite content. The Windy River placer deposit contains 20,920,000 yd^3 with a grade of 1.33 pct Cr_2O_3. This is equivalent to 556,000 tons of contained Cr_2O_3. A cooperative Anaconda Minerals Co.-Bureau program included mapping, bulk sampling of surficial gravel deposits, seismic traverses, drilling,[5] and beneficiation tests.[6]

Windy River heads at Red Mountain and flows northeastward through the glaciated, U-shaped valley shown in figure 21. A 2.5-mile-long segment of the upper valley forms an elongated bowl which contains gravel deposits averaging

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[5]Drilling and seismic surveys were contracted by Anaconda Minerals Co. Drill and seismic data and sample results were provided to the Bureau by Anaconda.

[6]Beneficiation and characterization tests were performed by the Bureau's Albany (OR) Research Center.

FIGURE 21. - Windy River Valley and Anaconda Minerals Co. exploration camp.

approximately 0.25 mile wide and ranging from 55 to 72 ft thick. A series of nine drill holes which crosses the valley near the midway point of the elongated bowl is shown in figures 19 and 22. The gravel deposits are bounded upstream by the prominent cirque on Red Mountain and downstream by bedrock and a valley constriction. Within the investigated segment of the valley, the Windy River flows as a perennial meandering stream with a gradient of approximately 120 ft/mi.

During World War II, Rutledge (43, pp. 17-18) investigated the placer and eluvial chromite potential for deposits at the head of Windy River in the Red Mountain area. Concentrations of chromite were observed in dunite talus covering an area approximately 2,000 ft long by 500 ft wide at the base of the steep slope underlain by the Turner stringer zone. A series of 20 test pits was excavated along the base of the talus slope. A composite bulk sample collected from the pits contained about 1.9 pct Cr_2O_3, corresponding to a chromite content of about 3.2 pct. Beneficiation studies on a composite sample containing 2.5 pct Cr_2O_3 produced a concentrate containing 46 pct Cr_2O_3 with a Cr:Fe ratio of 2.4 and a recovery of 67 pct (43, p. 24). Screen sizing studies on another sample of the same material that had been crushed to minus 3/4 in indicated chromite was principally contained in the minus 20-, plus 100-mesh fraction (43, p. 24). Rutledge (43) also considered the potential for placer chromite deposits in the valleys of Windy River, Seldovia River, and other local drainages (fig. 17). Samples of alluvium were panned, but the results were inconclusive.

In 1981 the Bureau collected and beneficiated three bulk alluvium samples from gravel bars at locations labeled WR1S, WR2S, and WR3S in figure 19. These

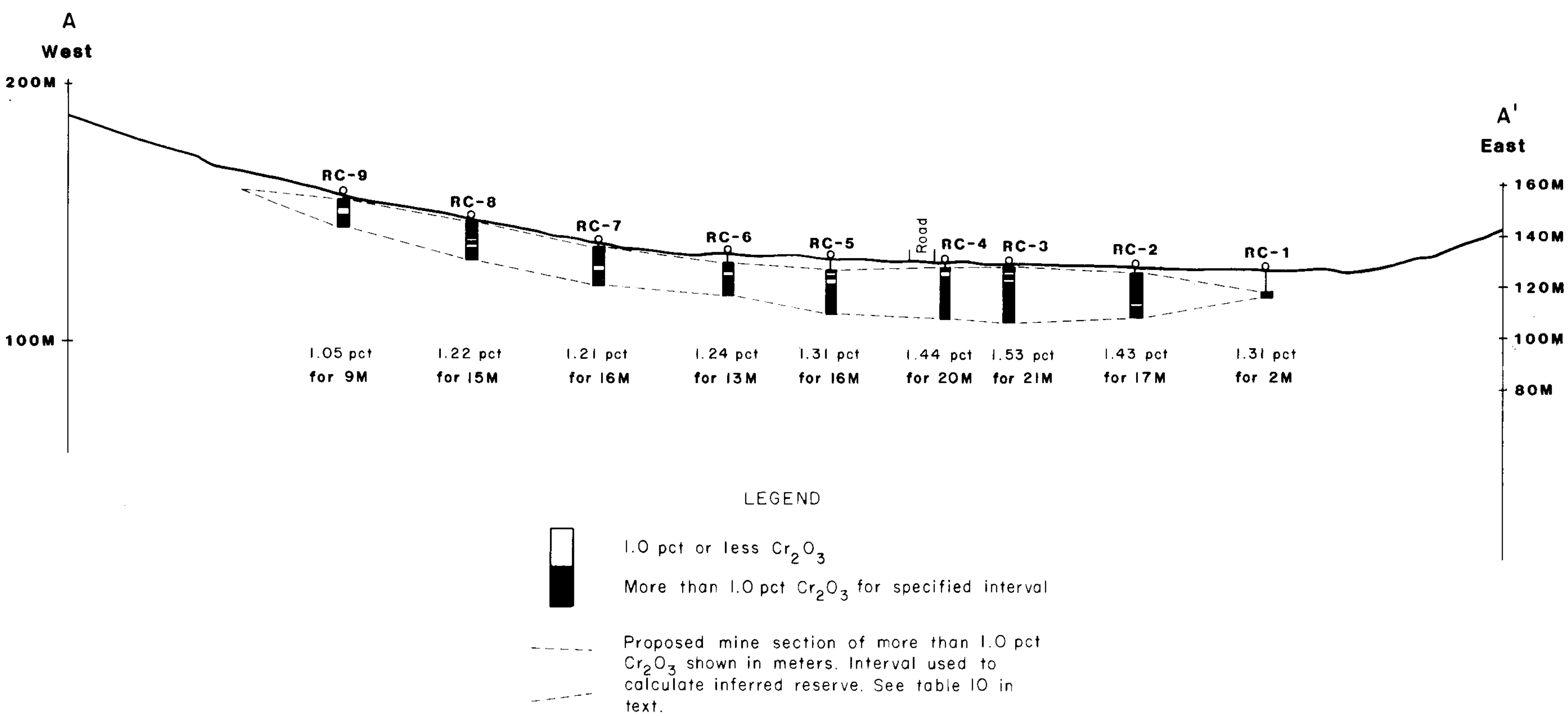

FIGURE 22. - Drill hole profile of Windy River Valley (looking north). (Adapted from Anaconda Minerals Co. data compiled by W. T. Ellis, 1983)

samples were screened on site at 2 mesh; the minus 2-mesh fraction represented about one-third to one-half of the original volume. Chemical analyses on three size fractions from these samples are listed in table 9. Head analyses for the three samples ranged from 2.1 to 4.5 pct Cr_2O_3, indicating chromite content between 3.6 and 7.7 pct.

TABLE 9. - Volume and Cr_2O_3 content of bulk gravel samples from Windy River Valley[1]

Sample	WR1S	WR2S	WR3S
Original volume of sample..........ft^3..	3.34	2.67	2.67
Approximate volume, minus 2-mesh..........	1.35	1.25	1.53
Contained Cr_2O_3, pct:			
Minus 2-mesh head....	2.7	4.5	2.1
Concentrate:			
Plus 8-mesh........	1.2	3.2	0.7
Minus 8-mesh.......	4.4	6.3	3.0

[1]Atomic absorption analyses by the Bureau's Reno (NV) Research Center.

NOTE.--See figure 19 for sample locations.

ALRC performed beneficiation tests on the minus 2-mesh fraction without grinding to determine if acceptable chromite concentrates could be produced by gravity, electrodynamic, and magnetic separation. Results (12) indicate that chromite concentrates with grades of 52.6 to 53.5 pct Cr_2O_3 and Cr:Fe ratios of 1.7 to 1.8 could be produced. During beneficiation tests only 18 to 52 pct of the chromite was recovered. An iron oxide precipitate on the chromite grains is partially responsible for the low chromite recovery. It is not known if the iron oxide precipitate persists at depth.

Based on the results of surficial sampling by the Bureau, Anaconda Minerals Co. proceeded with a limited drilling and seismic program in 1982. A series of nine drill holes was placed across the valley (figs. 19 and 22), approximately midway along the length of the Windy River Valley gravel deposit. A reverse circulation drill[7,8] with a down-hole hammer used to drill 8-in-diameter holes spaced approximately 50 yd apart. The holes were logged, and splits of cuttings from each 39.37-in (1-m) interval below overburden were analyzed for chromium. Chromium oxide values for each drill hole are presented in table 10.

Below overburden, drill holes intercepted three chromite-bearing units totaling 55 to 72 ft thick before reaching mixed chert, argillite, and graywacke bedrock. From top to bottom, these are (1) poorly sorted gravels, (2) mixed gray clay, sand, and gravel, and (3) dark sand and gravel. Abundant clay in the middle unit was readily disintegrated by the washing action of the drill system. No significant loss of chromite by agglomeration of clay balls was observed. The thickness of the gravels decreases towards the margins of the deposit, as indicated by seven seismic traverses.[9] The seismic data were verified by drilling only along the profile shown in figure 22.

Reserves of chromite-bearing gravels in the Windy River Valley were estimated by multiplying the average depth of gravels containing more than 1 pct Cr_2O_3 by the plan area of the gravel deposit. An estimated weight of 4,000 lb/yd^3 was used for the gravels. An arbitrary reduction factor of 30 pct was included in the volume calculation. A weighted assay of 1.33 pct Cr_2O_3, calculated for the drill samples for the segment of the drill hole profile containing greater than 1 pct Cr_2O_3, is assumed to be representative of the entire gravel deposit.

[7]Modified Gardiner Denver 1500, Skidmore Machine and Tool Co.

[8]Reference to specific products does not imply endorsement by the Bureau of Mines.

[9]Seismic data by Nimbus/OYO ES-1200 12-channel signal enhancement seismograph. Geophone spacing of 10 m. See footnote 5.

TABLE 10. - Chromic oxide analyses and grade calculations of drill samples from Windy River Valley

Depth range	Cr_2O_3 assay,[1] pct
Drill hole RC-1:	
8- 9 m[2]	1.15
9-10 m	1.46
10-11 m	.31
11-12 m	.28
12-13 m	.16
13-14 m	.35
14-15 m	.32
15-16 m	.29
16-17 m	.29
17-18 m	.25
18-19 m	.19
19-20 m	.25
Weighted assay	1.31
Drill hole RC-2:	
2- 3 m[2]	1.43
3- 4 m[2]	1.43
4- 5 m[2]	1.30
5- 6 m[2]	1.05
6- 7 m[2]	1.75
7- 8 m[2]	2.01
8- 9 m[2]	2.28
9-10 m[2]	2.04
10-11 m[2]	1.49
11-12 m[2]	1.28
12-13 m[2]	1.15
13-14 m[2]	1.20
14-15 m[2]	1.15
15-16 m[2]	.96
16-17 m[2]	1.43
17-18 m[2]	1.11
18-19 m[2]	1.26
19-20 m	.20
20-21 m	.25
21-22 m	.23
22-23 m	.22
Weighted assay	1.43
Drill hole RC-3:	
1- 2 m[2]	1.05
2- 3 m[2]	1.68
3- 4 m[2]	.96
4- 5 m[2]	1.20
5- 6 m[2]	1.75
6- 7 m[2]	.83
7- 8 m[2]	2.01
8- 9 m[2]	1.97
9-10 m[2]	2.04
10-11 m[2]	2.10
11-12 m[2]	1.50
Drill hole RC-3--Continued.	
12-13 m[2]	1.50
13-14 m[2]	1.42
14-15 m[2]	1.37
15-16 m[2]	1.68
16-17 m[2]	1.11
17-18 m[2]	1.27
18-19 m[2]	1.46
19-20 m[2]	1.53
20-21 m[2]	2.23
21-22 m[2]	1.56
22-23 m	.80
23-24 m	.25
Weighted assay	1.53
Drill hole RC-4:	
1- 2 m[2]	1.28
2- 3 m[2]	2.92
3- 4 m[2]	.95
4- 5 m[2]	1.40
5- 6 m[2]	1.37
6- 7 m[2]	1.04
7- 8 m[2]	1.64
8- 9 m[2]	1.64
9-10 m[2]	1.47
10-11 m[2]	1.36
11-12 m[2]	1.34
12-13 m[2]	1.26
13-14 m[2]	1.40
14-15 m[2]	1.46
15-16 m[2]	1.66
16-17 m[2]	1.14
17-18 m[2]	1.45
18-19 m[2]	1.10
19-20 m[2]	1.15
20-21 m[2]	1.78
21-22 m	.51
22-23 m	.32
Weighted assay	1.44
Drill hole RC-5:	
1- 2 m	.23
2- 3 m	.16
3- 4 m	.50
4- 5 m[2]	2.41
5- 6 m[2]	0.99
6- 7 m[2]	1.17
7- 8 m[2]	.85
8- 9 m[2]	[2].96
9-10 m[2]	[2].89
Drill hole RC-5--Continued.	
10-11 m[2]	1.11
11-12 m[2]	1.62
12-13 m[2]	1.26
13-14 m[2]	1.11
14-15 m[2]	1.40
15-16 m[2]	1.46
16-17 m[2]	1.64
17-18 m[2]	1.30
18-19 m[2]	1.50
19-20 m[2]	1.31
20-21 m	.12
Weighted assay	1.31
Drill hole RC-6:	
1- 2 m	.12
2- 3 m	.12
3- 4 m[2]	1.72
4- 5 m[2]	1.11
5- 6 m[2]	1.14
6- 7 m[2]	1.75
7- 8 m[2]	.99
8- 9 m[2]	1.05
9-10 m[2]	1.17
10-11 m[2]	1.24
11-12 m[2]	1.23
12-13 m[2]	1.24
13-14 m[2]	1.20
14-15 m[2]	1.14
15-16 m[2]	1.15
16-17 m	.13
17-18 m	.09
Weighted assay	1.24
Drill hole RC-7:	
1- 2 m[2]	1.10
2- 3 m[2]	1.24
3- 4 m[2]	1.28
4- 5 m[2]	1.24
5- 6 m[2]	1.21
6- 7 m[2]	1.39
7- 8 m[2]	1.23
8- 9 m[2]	1.42
9-10 m[2]	1.31
10-11 m[2]	1.14
11-12 m[2]	.91
12-13 m[2]	1.14
13-14 m[2]	1.23
14-15 m[2]	1.05
15-16 m	.86
Drill hole RC-7--Continued.	
16-17 m	.22
17-18 m	.12
18-19 m	.06
19-20 m	.13
20-21 m	.09
Weighted assay	1.21
Drill hole RC-8:	
0- 1 m[2]	1.30
1- 2 m[2]	1.50
2- 3 m[2]	1.23
3- 4 m[2]	1.17
4- 5 m[2]	1.61
5- 6 m[2]	1.27
6- 7 m[2]	1.58
7- 8 m[2]	1.07
8- 9 m[2]	.91
9-10 m[2]	1.08
10-11 m[2]	.95
11-12 m[2]	1.23
12-13 m[2]	1.14
13-14 m[2]	1.17
14-15 m[2]	1.07
15-16 m	.55
16-17 m	.15
17-18 m	.07
18-19 m	.09
19-20 m	.01
Weighted assay	1.22
Drill hole RC-9:	
1- 2 m	.92
2- 3 m[2]	1.30
3- 4 m[2]	.88
4- 5 m[2]	.95
5- 6 m[2]	.99
6- 7 m[2]	.96
7- 8 m[2]	.91
8- 9 m[2]	1.28
9-10 m[2]	1.10
10-11 m[2]	1.05
11-12 m	.77
12-13 m	.09
13-14 m	.18
14-15 m	.06
15-16 m	.01
16-17 m	.01
Weighted assay	1.05

[1]Calculated from Cr assay. Weight percent Cr_2O_3 = 1.46 × weight percent Cr.
[2]Interval used for reserve calculation. Drill-hole weighted assay values include portions of drill hole containing greater than 1.00 pct Cr_2O_3.

NOTE.--See figure 22 for drill hole profile.

Claim Point

Fourteen hard-rock chromite deposits at Claim Point were described by Gill in 1922 (16) and Guild in 1942 (17). A 15th deposit was located but not described by Sanford and Cole (44) A 16th deposit is described in this report. The locations of chromite deposits at Claim Point are shown in figure 23.

The present investigation revised the estimate of total contained Cr_2O_3 in Claim Point deposits to 90,000 tons. Most of these are indicated reserves based on trench and drill data. Earlier, Gill (16) had estimated reserves in nine deposits at Claim Point to contain about 25,000 tons of Cr_2O_3 (table 11). Chromium-to-iron ratios reported by Guild (17) range from 2.6 to 4.1. On the basis of trenching and drilling by the Bureau in 1943, an additional 40,000 tons of contained Cr_2O_3 was inferred at a grade of 14.22 pct Cr_2O_3 for deposits 7, 8, and 10. As a result of the present investigation, additional reserves were calculated for deposits 8b and 10 (table 12).

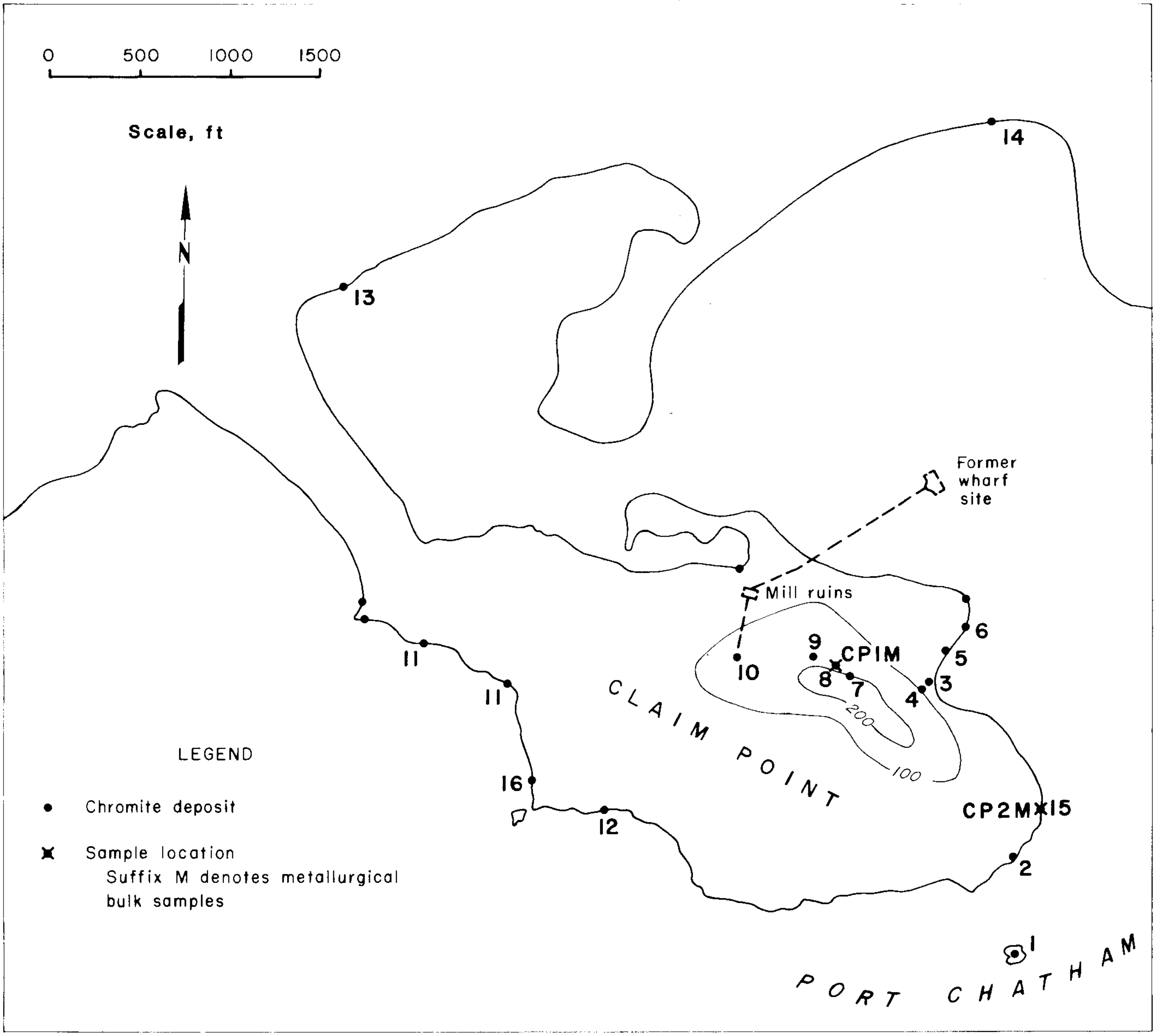

FIGURE 23. - Chromite deposits and sample locations at Claim Point. (After Guild (17, plate III) and Sanford and Cole (44, fig. 3))

TABLE 11. - Published chromite reserves (65,500 tons Cr_2O_3) at Claim Point

Deposit[1]	Shipping ore[2]		Concentrating ore[3]		Contained Cr_2O_3
	Amount, 10^3 tons	Chromite content, pct	Amount, 10^3 tons	Chromite content, pct	10^3 tons
1	11.3	≥40	5.4	52	4.2
3 and 4	NRE	NRE	1.0	35	.2
5	NRE	NRE	.3	33	.1
7	NRE	NRE	2.3	33	.4
8a,b	NRE	NRE	20.0	30	3.4
10	10.0	≥40	60.0	≥40	16.2
11	NRE	NRE	6.0	20	.7
12	NRE	NRE	1.0	20	.1
Total	NAp	NAp	NAp	NAp	25.3
8b and 10	NAp	NAp	NAp	NAp	[4]40.2

NAp Not applicable. NRE No reserve estimate.

[1]Deposits were described by Gill (16) and Guild (17). Additional reserves were calculated in 1943 for deposits 8a,b and 10 on the basis of trenching and drilling by the Bureau. Deposits for which no reserves were published are not listed.

[2]Contains at least 40 pct Cr_2O_3 (16, p. 28; 17, p. 155).

[3]Gill (16, p. 28) and Guild (17, p. 155).

[4]Includes additional reserves noted in footnote 1.

NOTE.--See figure 23 for deposit locations.

TABLE 12. - Identified chromite resources and indicated reserves in deposits (84,000 tons Cr_2O_3) at Claim Point

Deposit	Resources, 10^3 tons	Cr_2O_3 content, pct	Contained Cr_2O_3, 10^3 tons	
			([3])	([4])
2[1]	0.7	20.0	<1	NA
8b:[2]				
Upper	30.8	16.6	5.1	NA
Middle	74.2	5.96	4.4	NA
Lower	99.2	3.48	3.5	NA
Total	NAp	NAp	13.0	7.0
10:[2]				
Upper	68.0	20.3	13.8	NA
Middle	304.0	9.2	28.0	NA
Lower	426.0	6.9	29.5	NA
Total	NAp	NAp	71.3	17.7
15[1]	1.7	2.9	NC	NA
16[1]	2.6	4.0	NC	NA

NA Not available. NAp Not applicable.

NC Existing data do not warrant calculation.

[1]Based on visual observations or descriptions by Gill (16) and Guild (17).

[2]Indicated reserves based on drill and trench data.

[3]Total resources.

[4]Total resources minus previously published reserves.

NOTE.--See figure 23 for deposit locations.

The Reef Mine, or deposit 1, was the source of chromite produced at Claim Point. The deposit was described by Gill (16) amd Guild (17). Unmined chromite still exists at intertidal level and underwater at that deposit (fig. 18). Data are insufficient to accurately assess the amount, but it is possible that reserves are greater than inferred by Gill (16).

Low-grade chromite is also contained in deposit 2 at Claim Point, which was described by Gill (16). Deposit 2 is 15 to 20 in wide and is exposed for over 20 ft along strike. The chromite content was estimated at 20 pct during this investigation. Based on an inferred strike length of 30 ft and an inferred depth of 8 ft, about 4 tons of contained Cr_2O_3 were calculated for deposit 2.

Based on trench sample and drill-core analyses by the Bureau, deposit 8b was divided into three zones during this investigation. The deposit contains 12,900 tons of Cr_2O_3 with an average grade of 9.3 pct (table 12).

Deposit 10, the largest at Claim Point, consists of two parallel, high-grade lenses of banded chromite which strike northeast for at least 400 ft and dip nearly vertically. In plan view these lenses widen at their centers to the extent that they are almost in contact at their midpoints. Maximum width of the deposit, as indicated by drill data, is about 250 ft (44). The entire deposit pinches out to the southwest and thickens and plunges to the northeast. Drill data indicate a decrease in grade with depth (44). Maximum inferred depth of this deposit is 180 ft. Low-grade reserves were recalculated for deposit 10 during this investigation. These reserves average 8.9 pct Cr_2O_3 versus 14.7 pct Cr_2O_3 contained in the 1943 reserves.

The deposit was divided into three zones because drill core and trench sample assay data exist for three separate, inclined horizons in the deposit (table 12). The grade of the upper horizon was calculated on the basis of sample assays from 16 trenches excavated across the deposit (44). A weighted grade of 20.33 pct Cr_2O_3 was determined for this portion of the deposit. The middle zone is defined on the basis of assays from intersections in 10 diamond-drill holes (44). A grade of 9.20 pct Cr_2O_3 was determined for this zone. A grade of 6.93 pct Cr_2O_3 was similarly determined for the lower zone. At these grades a total of 71,300 tons of contained Cr_2O_3 is calculated for deposit 10. It is important to note that calculation of indicated and inferred reserves in this manner changes the configuration of the deposit from one consisting of two separate lenses to a single larger, lower grade deposit.

Deposit 15 is exposed in a sea cliff and was examined during this investigation. A 20-ft-wide zone with an exposed depth of 15 ft contains sparse to dense concentrations of chromite bands. The chromite bands average between 0.25 and 0.5 in thick. These bands strike east, normal to the cliff, and dip steeply to the north. The chromite content was visually estimated at 5 pct for the 20-ft-wide zone. The deposit increases in grade at its southern margin, where a high-angle fault forms the contact with barren dunite. Grab sample CP2M was collected from a 1-ft-wide portion of this higher grade interval. Heads from this sample contained 31 pct Cr_2O_3, and a concentrate contained 54.2 pct Cr_2O_3 with a Cr:Fe ratio of 2.6. An inferred strike length of 75 ft, not measured owing to vegetation cover at the top of the sea cliff, was four times the inferred depth of 19 ft. Based on the preceding observations, 146 tons of chromite with 85 tons of contained Cr_2O_3 was inferred in deposit 15.

At deposit 16, a zone averaging 25 ft wide with about a 50-ft strike length contained about 4 pct chromite. Bands of chromite up to 0.5 in thick strike N to NE and dip vertically. A strike length of 62 ft and a depth of 16 ft were inferred, but because of the low chromite content, no reserves were calculated for this deposit.

KODIAK ISLAND AREA

The Bureau investigated chromite in six mafic-ultramafic complexes on the northwestern portions of Kodiak Island, Afognak Island, and adjacent smaller islands. Of these six--the Middle Cape complex (subdivided into Gurney Bay, Halibut Bay, Sturgeon River, and Grant Lagoon) (fig. 24), Saddle Bay complex, and Miners Point complex--Halibut Bay was sampled in the greatest detail. Identified rserves for eight Halibut Bay deposits total 210,000 tons contained Cr_2O_3 (table 13). No reserves are indicated in the other complexes. Two smaller complexes, Karluk and Ban Islands, were not investigated because they are less than 0.5 mi^2 in area.

TABLE 13. - Identified chromite in deposits (201,000 tons Cr_2O_3) at the Halibut Bay complex

Deposit	41	42	43	44	45	46
Dimensions, ft:						
Length	250	10	90	225	30	750
Width	50	43	20	3	3	35
Depth	62	ND	22	56	8	187
Weight ..10^3 tons	80	NC	4	2	<1	43
Estimated chromite content ..pct	5	NC	6	20	10	7
Contained Cr_2O_3 ..10^3 tons	3	NC	<1	<1	<1	NC
Bulk sample:						
Number	HB1M	HB2M	([1])	HB3M	([1])	HB4M
Cr_2O_3 content, pct:						
Heads	22.4	16.7	NAp	47.5	NAp	7.7
Concentrate	50.6	40.0	NAp	65.5	NAp	34.6
Cr:Fe ratio	2.1	1.3	NAp	2.8	NAp	1.1
Deposit	**47**	**48**	**49**	**50**	**51**	
Dimensions, ft:						
Length	ND	150	ND	450	1,250	
Width	ND	6	ND	5	150	
Depth	ND	38	ND	112	312	
Weight ..10^3 tons	NC	4	NC	26	6,031	
Estimated chromite content ..pct	NC	6	NC	6	5	
Contained Cr_2O_3 ..10^3 tons	NC	<1	NC	2	196	
Bulk sample:						
Number	([1])	([1])	([1])	HB6M	HB7M HB8M HB9M	
Cr_2O_3 content, pct:						
Heads	NAp	NAp	NAp	21.2	[2]23.2 [3]38.6 [4]42.1	
Concentrate	NAp	NAp	NAp	53.5	[2]53.5 [3]51.6 [4]56.1	
Cr:Fe ratio	NAp	NAp	NAp	2.6	[2]2.1 [3]2.5 [4]3.0	

NAp Not applicable. NC Existing data do not warrant calculation.
ND Not determined.
[1]No bulk sample. [2]HB7M. [3]HB8M. [4]HB9M.

NOTE.--See figure 25 for deposit locations.

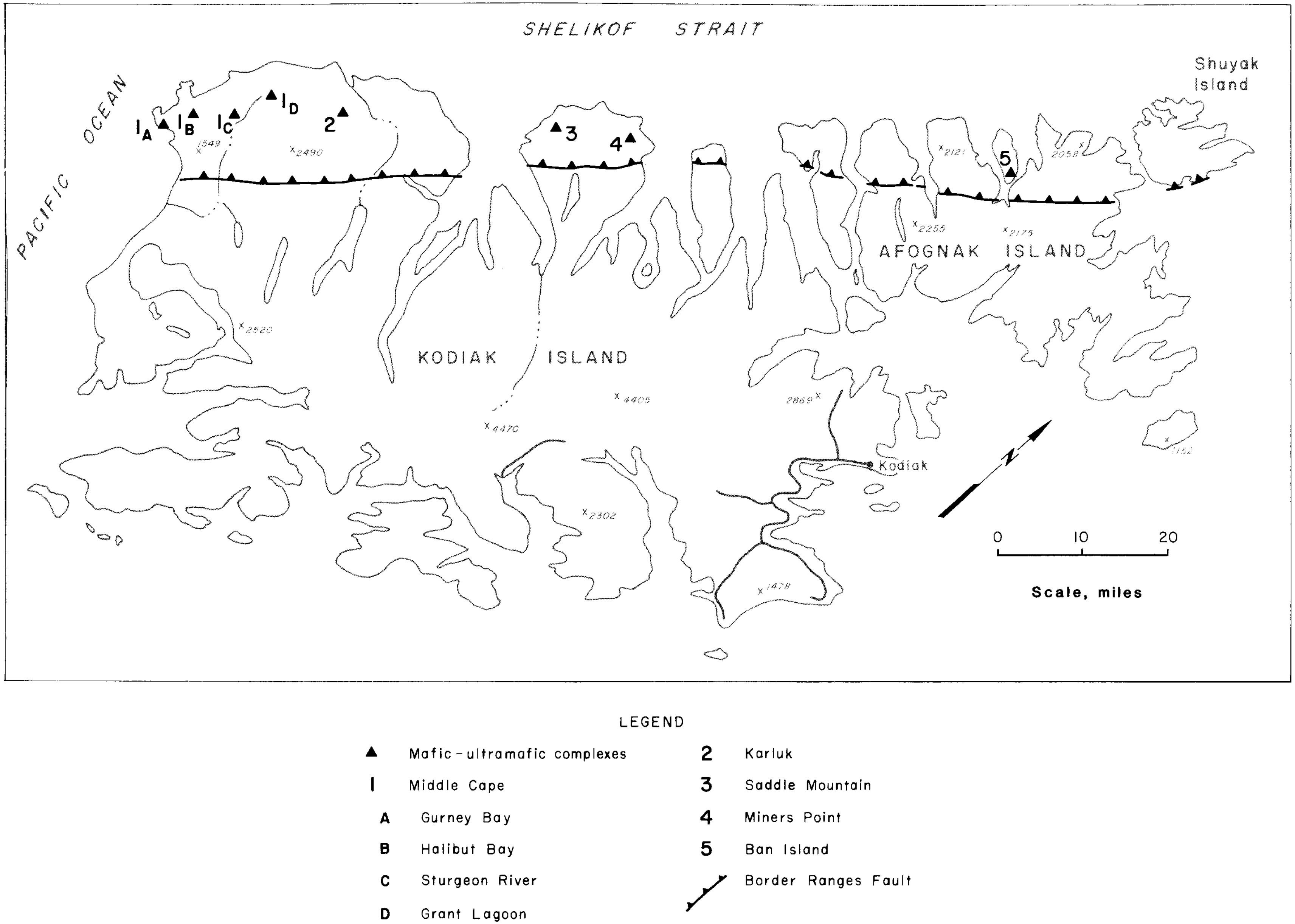

FIGURE 24. - Mafic-ultramafic complexes on Kodiak and adjacent islands. (After Beyer (3, fig. 2.1) and Connelly (11, fig. 1))

The complexes occur in the southwestern end of the Peninsular terrane, which is bounded to the southeast by the Border Ranges Fault, on islands separated from the Kenai Peninsula by 100 miles of sea. Ports and bays are ice free, and coastal habitations on Kodiak Island are accessible year round by ferry or barge. None of the complexes are more than 5 miles from tidewater.

Along the northwest side of the islands, the terrain consists of broad valleys and rolling hills covered with grass and shrubs. Trees grow in only a few low sheltered areas. Climate is milder than on the Kenai Peninsula, with intermittent snowfall during the winter. Precipitation is noticeably less on the west side of Kodiak Island than on the east side, where the city of Kodiak receives about 60 in of precipitation annually (6, p. 122).

Exposed bedrock is limited primarily to coastal cliffs and a few inland ridges. Elsewhere, bedrock is mantled by vegetation and extensive air-fall ash deposits that overlie ancient and uplifted beach deposits, till deposits, and glaciofuvial gravel deposits. Abundant evidence exists for previous extensive glaciation (6, pp. 160-168).

Areas examined during this investigation are within the Kodiak National Wildlife Refuge and are administered by the U.S. Fish and Wildlife Service in Kodiak. There have been some recent land selections within the Refuge by the Koniag Native Corporation; however, conveyance of title is still in progress.

Five mafic-ultramafic complexes on Kodiak, Ban, and Afognak Islands have been described by Connelly (10), Beyer (3), and Connelly and Moore (11), who mapped the northwest side of Kodiak and adjacent islands. The mineral resources and the geology of Kodiak and adjacent islands have been investigated by Martin (28), Maddren (27), McGee (29), and Capps (6-7). Although Beyer (3) and Capps (6-7) mentioned chromite, there are no previous descriptions of chromite deposits on Kodiak Island.

Gurney Bay, Saddle Mountain, and Sturgeon River Complexes

Minor chromite was observed during brief investigations of the Gurney Bay and Saddle Mountain complexes. These comprise complexly layered gabbro and pyroxenite with minor, serpentinized pyroxene peridotite and dunite. The Sturgeon River complex contains sill-form pyroxene peridotite bodies with dunite segregations and minor, disseminated chromite. Wispy segregations of disseminated chromite do not exceed 1 in in longest dimension.

Halibut Bay

Locations of 11 hard-rock chromite deposits (41-51) in the Halibut Bay complex are shown in figure 25. Identified resources were calculated for eight of these on the basis of data presented in table 13. Sample locations are shown in figure 26, and the corresponding geochemical sample analyses, assay results, and sample descriptions are presented in table 14. Placer chromite was not investigated in detail, but two bulk gravel samples were analyzed (fig. 26, table 15).

At deposit 41, elongated lenses of disseminated to massive chromite in serpentinized dunite dip steeply to the west. The zone is 50 ft wide and is exposed for 250 ft along a strike of N 10° E. The chromite content was estimated at 5 pct. Bulk sample HB1M consisted of hand-sorted massive and coalescent chromite in dunite, and the concentrate contained 50.3 pct Cr_2O_3 with a Cr:Fe ratio of 2.0. A depth of 62 ft was inferred for this deposit (table 13).

TABLE 14. - Analytical results and descriptions of rock samples from the Halibut Bay complex[1]

Sample	Ag, ppm	Au, tr oz/ton	Co, ppm	Cr, pct	Cu, ppm	Ni, ppm	Pd, tr oz/ton	Pt, tr oz/ton	Description
HB10G	NA	<0.0002	NA	NA	NA	NA	[2]0.002	[2]0.002	Gabbro with disseminated pyrrhotite.
HB11G	NA	<.0002	56	NA	1,500	76	<.001	[2].001	Do.
HB12G	NA	<.0002	30	NA	NA	23	.001	[2].002	Amphibolite pods in foliated gabbro.
HB13G	NA	NA	49	NA	NA	NA	[2].002	[2].001	4-ft-thick stringer zone.
HB14G	0.2	<.0002	112	NA	3	1,390	[2].001	[2].001	Fresh dunite with chromite.
HB15G	.4	.0002	25	NA	1,700	420	[2].002	.004	Chalcopyrite and pyrrhotite in 3-ft-thick gabbro layer between hobnail peridotite and pyroxenite.
HB16G	NA	<.0002	NA	NA	2,000	NA	[2].002	[2].002	3-ft-wide pyroxenite zone with pyrrhotite and chalcopyrite.
HB17G	NA	NA	120	3.8	640	120	[2].002	[2].002	Chip sample across 6-ft-wide stringer zone.
HB18G	NA	<.0002	NA	14.84	NA	NA	<.0003	<.0003	Channel sample across a 3-ft-wide stringer zone.
HB19G	.2	.002	109	NA	3	1,250	<.0003	<.0003	Unweathered dunite.
HB20G	.2	.002	54	NA	13	372	<.0003	<.0003	Pyroxenite dike cutting dunite.
HB21G	.2	<.0002	64	NA	328	117	<.0003	<.0003	Coarse-grained olivine pyroxenite with trace pyrrhotite.
HB22G	.5	<.0002	28	NA	45	7	<.0003	<.0003	Altered gabbro with pyrrhotite and trace chalcopyrite.
HB23G	.5	<.0002	20	NA	18	34	<.0003	<.0003	Foliated gabbro.

NA Not analyzed.

[1]Ag, Co, Cr, Cu, and Ni were analyzed by Bondar-Clegg, Inc., Lakewood, CO, by atomic absorption. Au, Pd, and Pt were preconcentrated by fire-assay procedures; beads were analyzed by inductively coupled plasma techniques at the Bureau's Reno (NV) Research Center.

[2]Analyses are closed to detection limits and data should be evaluated accordingly.

NOTE.--See figure 26 for sample locations.

TABLE 15. - Analytical results of heavy mineral concentrates from stream gravels at Halibut Bay[1]

Sample	HB24P	HB25P
Original volume of sample[2] ... ft^3	1.27	1.27
Weight of black sand ... g	44.24	22.47
Au ... tr oz/ton	0.01	0.073
Cr ... pct	25	NA
Pd ... tr oz/ton	<0.0003	<0.0003
Pt ... tr oz/ton	0.002	<0.0003

NA Not analyzed.

[1]Cr analyses by Bondar-Clegg, Inc., Lakewood, CO, using atomic absorption. Other elements analyzed at the Bureau's Reno (NV) Research Center by fire assay-inductively coupled plasma techniques.

[2]Original sample volumes were calculated on the basis of measured, loose volumes minus a 25-pct swell factor.

NOTE.--See figure 26 for sample locations.

FIGURE 25. - Simplified geologic map and locations of chromite deposits at the Halibut Bay complex.

LEGEND

D	Dunite with minor, interlayered clinopyroxenite and plagioclase peridotite
C	Clinopyroxenite with minor dunite and olivine clinopyroxenite
U	Undifferentiated, complexly interlayered dunite, clinopyroxenite, and plagioclase peridotite
g	Gabbro with minor, interlayered clinopyroxenite
CA	Chert and argillite
	Stringer zone
	Approximate extent of bedrock unit
	Contact between bedrock units, dashed where inferred
	Fault trace
	Serpentinized shear zone
	Strike of vertically dipping layers
40°	Strike and dip of inclined layers
45°	Strike and dip of inclined joint set
(42)	Location of chromite deposit. See text for description

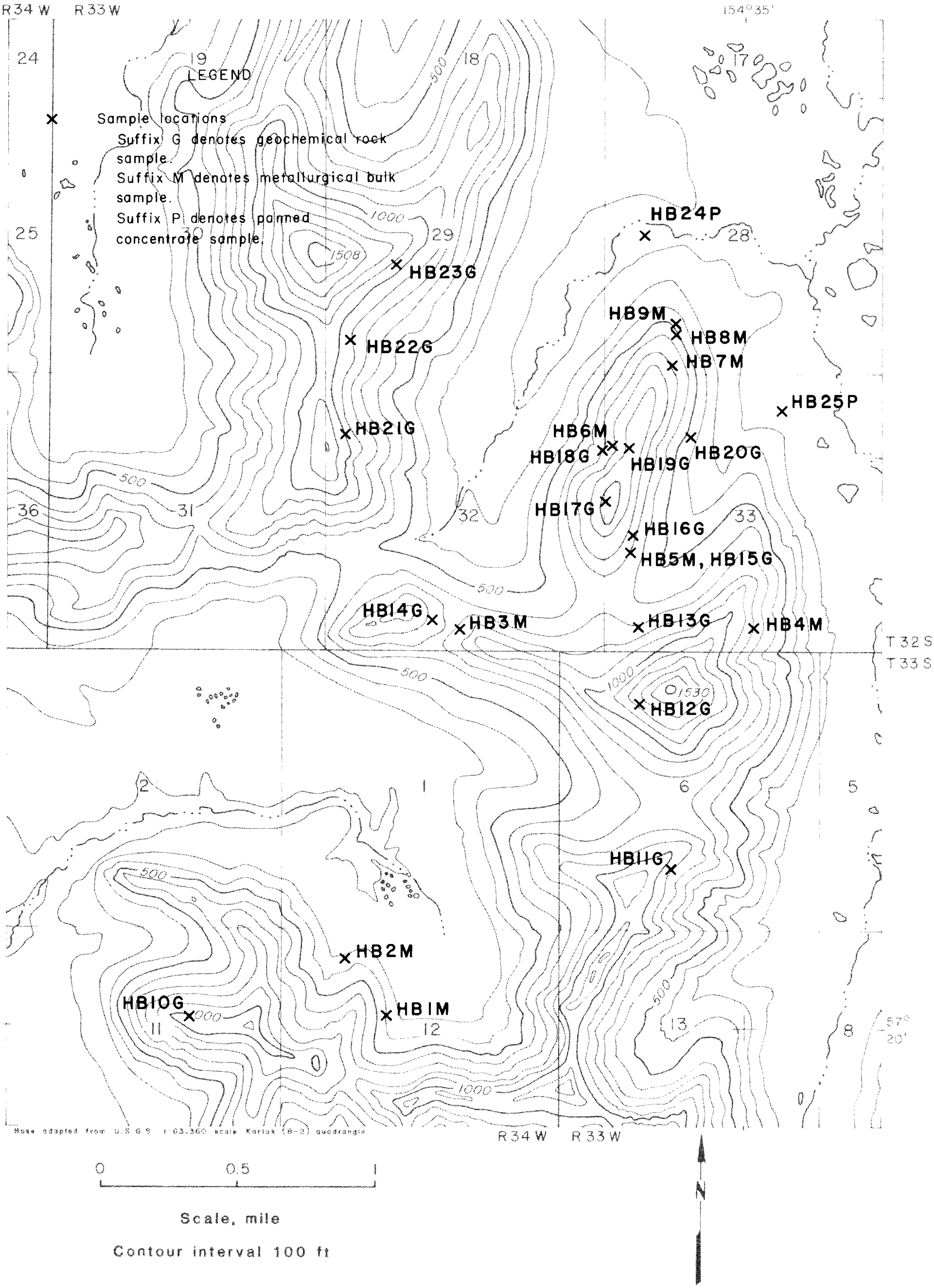

FIGURE 26. - Sample locations at the Halibut Bay complex.

Narrow bands of chromite, each less than 2 in thick and striking N 5° E, were observed in a 3-ft-wide zone of undetermined strike length at deposit 42. The chromite bands dip 70° to the west and are located about 1,000 ft northwest of deposit 41. Chromite content in the 3-ft zone was estimated to be 10 pct. For 20 ft on either side of this narrow zone, an estimated 3 pct of the rock contained disseminated chromite. The combined grade of the zone and the adjacent rock does not exceed 4 pct. No recoverable chromite estimates were made for this deposit because of its low grade, its small size, and the poor concentration results of bulk sample HB2M (table 13).

At deposit 43, discontinuous bands and irregular segregations of chromite in dunite strike N 35° W and dip steeply to the southwest. No bulk samples were collected. The chromite content in this 90- by 20-ft zone was visually estimated to be 6 pct. A depth of 22 ft was inferred for this deposit (table 13).

Massive, sheared chromite was observed in rubble at deposit 44. Bedrock is composed of complexly interlayered, serpentinized dunite, clinopyroxenite, and anorthosite. Individual layers, ranging in thickness from several inches to several feet, strike eastward and dip vertically. A shallow 150-ft trench was excavated parallel to the strike of the chromite rubble, and bulk sample HB3M was collected from a 3-ft-wide zone in frost-fractured bedrock. A concentrate containing 51.9 pct Cr_2O_3 with a Cr:Fe ratio of 3.1 was obtained from this sample. The grade of this zone was estimated to be 20 pct chromite. A strike length of 225 ft and a depth of 56 ft were inferred for this zone (table 13).

Deposit 45 contains chromite seams less than 1 in thick in a 30-ft-long by 3-ft-wide zone. The chromite content was estimated to be 10 pct, but no samples were collected. A depth of 8 ft was inferred for this deposit.

At deposit 46, irregularly shaped segregations and disseminations of chromite were conspicuously magnetic. Chromite constitutes an estimated 7 pct of a 35-ft-thick dunite unit. The dunite layer is bounded on two sides by clinopyroxenite layers and strikes N 10° W across a low saddle. The deposit is covered on both ends by tundra and scree. An inferred length of 750 ft and a depth of 187 ft were inferred for this deposit. Bulk sample HB4M was collected from rubble and bedrock along 100 ft of exposed strike length. The sample contained 7.7 pct Cr_2O_3, and a concentrate was obtained containing 29.8 pct Cr_2O_3 with a Cr:Fe ratio of 0.8. Because of the inferior quality of the concentrate from this sample, no recoverable chromite estimates were made.

Deposits 47 through 51 are located on a north-striking ridge at the northern end of the Halibut Bay complex. This ridge is underlain by serpentinized dunite and is barren of vegetation (fig. 27).

North-striking bands of chromite less than 1 in thick were observed in an area of undetermined extent at deposit 47. No samples were collected, and the chromite content was not determined because of poor exposure. Excavation is required to better describe this deposit.

Deposit 48 contains disseminated chromite and bands of more concentrated, disseminated chromite grains. The zone is 6 ft wide and is indicated by float to have at least 100 ft of strike length. The chromite bands strike N 30° E and dip steeply to the southeast. Chip sample HB17G was collected here and contained 3.8 pct Cr (table 14), which is equivalent to about 5.6 pct Cr_2O_3, or a chromite content of 9.6 pct. Traces of platinum and palladium were also detected in the sample. A strike length of 150 ft and a depth of 38 ft were inferred for this deposit (table 13).

Massive chromite segregations were observed in dunite rubble in proximity to a small shear zone at deposit 49. The size of the area could not be determined because of a lack of exposed bedrock.

FIGURE 27. - North-striking ridge in the Halibut Bay complex.

Narrow bands less than 1 in thick, disseminations, and massive segregations of chromite up to 6 in across occur at deposit 50. Chromite rubble and a few outcrops of dunite occur for 300 ft along a zone striking N 5° W and dipping 55° W. Exposed widths of this mineralized zone range from 3 to 6 ft, but abundant chromite, observed in float downslope from this zone, indicates the actual mineralized section is larger than that which is exposed. Chromite content was estimated to be 6 pct. Bulk sample HB6M from this location yielded a concentrate containing 47.1 pct Cr_2O_3 with a Cr:Fe ratio of 2.2. Sample HB18G (table 14) contained 14.8 pct Cr, equivalent to about 22 pct Cr_2O_3, or about 38 pct chromite. A strike length of 450 ft and a depth of 112 ft were inferred for this deposit (table 13).

Sparse chromite was also observed 70 ft upslope, and a zone of banded chromite was observed 200 ft downslope from deposit 50. Because of the apparent small size and lack of exposure, these occurrences were not further evaluated.

Deposit 51 is the largest and best exposed of the chromite deposits observed at the Halibut Bay complex. A steeply dipping, north-trending zone is irregular in width but averages about 150 ft at the surface. The deposit is wider at lower elevation at the north end of the ridge. Chromite bands and tabular, massive segregations within the zone also strike north but have variable, nearly vertical dips. The entire mineralized section consists of lenses or bands of disseminated, coalescent, and massive chromite alternating with nearly barren dunite. The deposit is exposed for 1,000 ft along strike. Estimates of the chromite present assumed an inferred strike length of 1,250 ft and an inferred depth of 312 ft (table 13). An average of 5 pct chromite was estimated for the entire deposit.

Bulk samples HB7M, HB8M, and HB9M were collected from this deposit. Channel sample HB7M was collected across a 4-ft-wide outcrop in the central portion of the deposit and contained 23.2 pct Cr_2O_3. The concentrate from HB7M contained 50.4 pct Cr_2O_3 with a Cr:Fe ratio of 2.1. Sample HB8M was collected from chromite-rich bands and massive segregations at the north end of deposit 51. Head analyses yielded 38.6 pct Cr_2O_3. A concentrate containing 46.8 pct Cr_2O_3 with a Cr:Fe ratio of 2.4 was obtained. Heads from sample HB9M contained 42.1 pct Cr_2O_3, and the concentrate contained 53.4 pct Cr_2O_3 with a Cr:Fe ratio of 3.0.

The potential for placer chromite in the Halibut Bay area was not investigated in detail, but observations made during the project suggest that the lowlands to the immediate west of the north-striking ridge shown in figure 27 might host placer chromite deposits. If these deposits exist, they would be overlain by muskeg and thick accumulations of organic silts, volcanic ash, and till.

The chromite-bearing dunite masses at the Halibut Bay complex are drained by three creeks whose broad, U-shaped valleys contain fluvial deposits with possible additional placer chromite. Two bulk samples were collected at locations shown in figure 26. Analytical results for these samples are listed in table 15. Chromium analyses were not obtained for sample HB25P, but an unconcentrated sediment sample from the same location contained 0.5 pct Cr. This is equivalent to a 1 pct chromite content. Chromite, with trace amounts of gold and possibly platinum (table 15), is present in alluvial deposits at Halibut Bay. Additional sampling is necessary to assess the potential for placer chromite deposits.

Grant Lagoon

The Grant Lagoon complex (fig. 24) is composed primarily of gabbro which underlies two parallel ridges, approximately 3 miles long. The gabbro has been intruded by small bodies of tonalite. A small hill midway between the two ridges and approximately 1,000 ft in diameter is underlain by the only dunite observed in the complex.

Disseminated chromite was observed in dunite cobbles and boulders. Because there was no bedrock exposure, the size of the occurrence was not determined. A concentrate from sample GL1M, which was collected from these boulders, contained 53.4 pct Cr_2O_3 with a Cr:Fe ratio of 2.3. The total amount of chromite in the Grant Lagoon complex is probably small, unless the dunite zone continues under the sediment- and tundra-covered areas to the north and south.

Miners Point

Sporadic bands of chromite, less than 1 in thick, and disseminated chromite not exceeding several percent were observed in a few dunite boulders on the beach at Miners Point (fig. 24). These boulders were apparently derived from one of several dunite dikes intruded into the gabbro at this location. These dikes attain maximum thicknesses of about 400 ft. No chromite production potential may be inferred on the basis of this limited distribution.

SUMMARY

About 2.7 million tons of recoverable metallurgical-grade chromite is contained in 41 subeconomic lode deposits and 1 placer deposit in mafic-ultramafic complexes along the Border Ranges Fault in southern Alaska. Data are insufficient to assess the potential for associated deposits of platinum and palladium. The Red Mountain complex on Kenai Peninsula contains about 1.5 million tons of Cr_2O_3. Deposits at Bernard Mountain near Tonsina contains 343,000 tons, and the Halibut Bay complex on Kodiak Island contains 201,000 tons. The largest hard-rock deposit is the Turner stringer zone at Red Mountain (1.250 million tons). The Windy River placer deposit on Kenai Peninsula contains 556,000 tons of Cr_2O_3.

Chromite has been produced from deposits at Red Mountain and Claim Point on Kenai Peninsula. The total tonnages indicated and inferred in these and other complexes along the Border Ranges Fault are summarized in table 16. The number and estimated size of deposits discovered in a given area reflect the amount of work previously done in that area and the extent of bedrock exposure; Red Mountain is by far the most investigated and exposed of the mafic-ultramafic complexes described in this report. With additional investigation, similar deposits may be discovered in many of the areas described in this report and elsewhere along the Border Ranges Fault.

The total amount of metallurgical-grade chromite inferred to be recoverable from the deposits investigated is sufficient to fulfill the Nation's total chromium demands for about 4 yr, or to satisfy the metallurgical industry's demands for over 5 yr, based on 1981 consumption. Additional chromite suitable for use by the chemical and refractory industries is contained in deposits not included in the compilations. None of these chromite deposits are being mined, and all are subeconomic under present market conditions.

TABLE 16. - Summary of contained Cr_2O_3 in chromite deposits (2,792,000 tons) along Border Ranges Fault, southern Alaska

Complexes	Deposits	Contained Cr_2O_3, 10^3 tons
Tonsina area:		
Bernard Mountain..	3	343
Sheep Hill........	1	26
Palmer area:		
Eklutna...........	1	1
Kenai Peninsula:		
Red Mountain......	23	1,575
Windy River.......	1	556
Claim Point.......	10	90
Kodiak Island:		
Halibut Bay area..	3	201

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APPENDIX.--SAMPLE IDENTIFICATION KEY

Location	Sample[1]	Field No.
Tonsina area:		
Chrome Creek.......	CC1P	CM20490
Bernard Mountain...	BM1M	CM20488
	BM2M	CM20495
	BM3M	CM20496
	BM4M	CM20497
	BM5M	CM20499
	BM6M	CM18678
	BM7M	CM20500
Sheep Hill.........	SH1M	CM20471
	SH2M	CM20472
	SH3M	CM20466
	SH4M	CM20467
	SH5G	CM20449
	SH6G	CM20450
	SH7G	CM20468
	SH8G	CM20470
	SH9G	CM10477
Dust Mountain......	DM1M	CM20443
	CM2M	CM20445
	DM3M	CM20446
Dust Creek.........	DC1P	CM20479P
	DC2P	CM20481P
	DC3P	CM20486P
Palmer area:		
Wolverine complex..	WC1M	CM19322
	WC2G	CM19368
	WC3G	CM19370
	WC4G	CM19371
	WC5G	CM19326
Kenai Peninsula:		
Red Mountain.......	RM1M	([2])
	RM2M	CM17675
	RM3M	CM17670A
	RM4M	CM17670B
	RM5M	([2])
	RM6M	([2])
Kenai Peninsula--Con.		
Windy River........	WR1S	CM17676
	WR2S	CM17677
	WR3S	CM17678
	WR4S	([2])
Claim Point........	CP1M	CM17679
	CP2M	CM17680
Kodiak Island:		
Halibut Bay........	HB1M	CM18635
	HB2M	CM18636
	HB3M	CM19649
	HB4M	CM20268
	HB5M	CM17953
	HB6M	CM11168
	HB7M	CM19277
	HB8M	CM18623
	HB9M	CM18624
	HB10G	CM19218
	HB11G	CM19643
	HB12G	CM19644
	HB13G	CM19273
	HB14G	CM18632
	HB15G	CM19275
	HB16G	CM19280
	HB17G	CM19276
	HB18G	CM11169
	HB19G	CM18626
	HB20G	CM18625
	HB21G	CM18630
	HB22G	CM18629
	HB23G	CM18628
	HB24P	CM18633P
	HB25P	CM18637P
Grant Lagoon.......	GL1M	CM20261
Miners Point.......	MP1M	CM19461

[1]Prefix key: CC--Chrome Creek; BM--Bernard Mountain; SH--Sheep Hill; DM--Dust Mountain; DC--Dust Creek; WC--Wolverine Complex; RM--Red Mountain; WR--Windy River; CP--Claim Point, HB--Halibut Bay; GL--Grant Lagoon; MP--Miners Point. Suffix key: M--metallurgical sample; G--geochemical rock sample; P--panned concentrate sample; S--screened alluvial sample.

[2]Composite sample provided by Anaconda Minerals Co.

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^3	cubic foot	cubic meters	.0283
ft/mi	foot/mile		
g	gram	ounces	.03527
		troy ounces	.03215
in	inch	centimeters	2.54
lb	pound	kilograms	.4535
lb/yd^3	pound per cubic yard		
m	meter	feet	3.28
	mile	kilometers	1.6093
mi^2	square mile	square kilometers	2.590
mm	millimeter	inches	.03937
oz	ounce	grams	28.3495
pct	percent		
ppm	parts per million		
ton	short ton	long tons	.8929
		metric tons	.9072
		pounds	2,000
tr oz	troy ounce	grams	31.1035
tr oz/ton	troy ounce per ton		
yd	yard	meters	.9144
yd^3	cubic yard	cubic meters	.7646
yr	year		

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