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CHROMITE OCCURRENCES IN THE KAIYUH HILLS, WEST-CENTRAL ALASKA

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PREFACE

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

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

ft	foot	oz	ounce
in	inch	pct	percent
kg	kilogram	tr	trace
lb	pound	wt pct	weight percent
min	minute		

CHROMITE OCCURRENCES IN THE KAIYUH HILLS, WEST-CENTRAL ALASKA

By Jeffrey Y. Foley,[1] Toni Hinderman,[2]

Donald E. Kirby,[3] and Cheryl L. Mardock[4]

ABSTRACT

Chromite occurrences in poorly exposed ultramafic rocks in the Kaiyuh Hills area, west-central Alaska, were investigated jointly by the Bureau of Mines, Alaska Field Operations Center (AFOC), Fairbanks, AK, C.C. Hawley and Associates, Anchorage, AK, and the Bureau's Albany (OR) Research Center (ALRC). This report briefly describes the local geology, the chromite occurrences, and the results of chemical analyses on 32 samples and metallurgical tests performed on four samples from the chromite occurrences.

Total estimated reserve potential for four deposits in the Kaiyuh Hills is between 17,000 and 37,000 tons of contained Cr_2O_3. One 3-ft-wide, nearly massive band that contains between 50 and 60 pct chromite is estimated to have a strike length of almost 300 ft. This deposit is estimated to contain between 2,000 and 5,000 tons of Cr_2O_3 in high-chromium chromite. Numerous other low-grade occurrences with between 3 and 10 pct chromite contain discontinuous bands up to several inches wide over areas measuring tens of feet wide and up to several hundred feet long. Three of the larger, low-grade occurrences which contain between 3 and 4 pct chromite are estimated to contain a total of between 15,000 and 32,000 tons Cr_2O_3 in high-chromium and high-iron chromite. Potential exists for additional chromite in buried occurrences and in placer deposits in streams that drain the area.

[1]Geologist, Alaska Field Operations Center, Bureau of Mines, Fairbanks, AK
[2]Geologist, C.C. Hawley and Associates, Inc., Anchorage, AK.
[3]Metallurgist, Albany Research Center, Bureau of Mines, Albany, OR.
[4]Geologist, Albany Research Center, Bureau of Mines, Albany, OR.

INTRODUCTION

The Bureau of Mines Alaska Field Operations Center (AFOC) is investigating Alaska's chromium resources. These studies are part of a long-range program to develop definitive information on Alaska's potential to produce critical and strategic minerals. To achieve this goal, the Bureau frequently works cooperatively with private industry and other government agencies. This is a jointly authored report on a cooperative investigation of chromite occurrences in the Kaiyuh Hills, west-central Alaska.

Chromite occurrences were discovered in the Kaiyuh Hills area (fig. 1) in 1980 by geologists employed by C.C. Hawley and Associates, Inc., of Anchorage, AK, while conducting mineral investigations in west-central Alaska for Armco Mineral Exploration, Ltd.[5] In June, 1982, AFOC geologists briefly examined four of the mineral occurrences, including two for which reserve potential was estimated, and collected bulk samples weighing up to 200 lb from each. The bulk samples were then forwarded to the Bureau's Albany (OR) Research Center (ALRC) where mineralogical and metallurgical tests were conducted. This report contains geologic maps of the area, describes the chromite occurrences, and presents the results of the metallurgical testing and mineralogical characterization. The Kaiyuh Hills chromite deposits are 36 miles south of Galena, between the Yuki River and the East Fork of the Yuki River. The area is best reached by helicopter. The Kaiyuh Hills are between 400 ft

[5]Data released to the Bureau in written communication from Toni Hinderman of C.C. Hawley and Associates, Inc., June, 1982, and presented herein with the permission of Armco Mineral Exploration, Ltd.

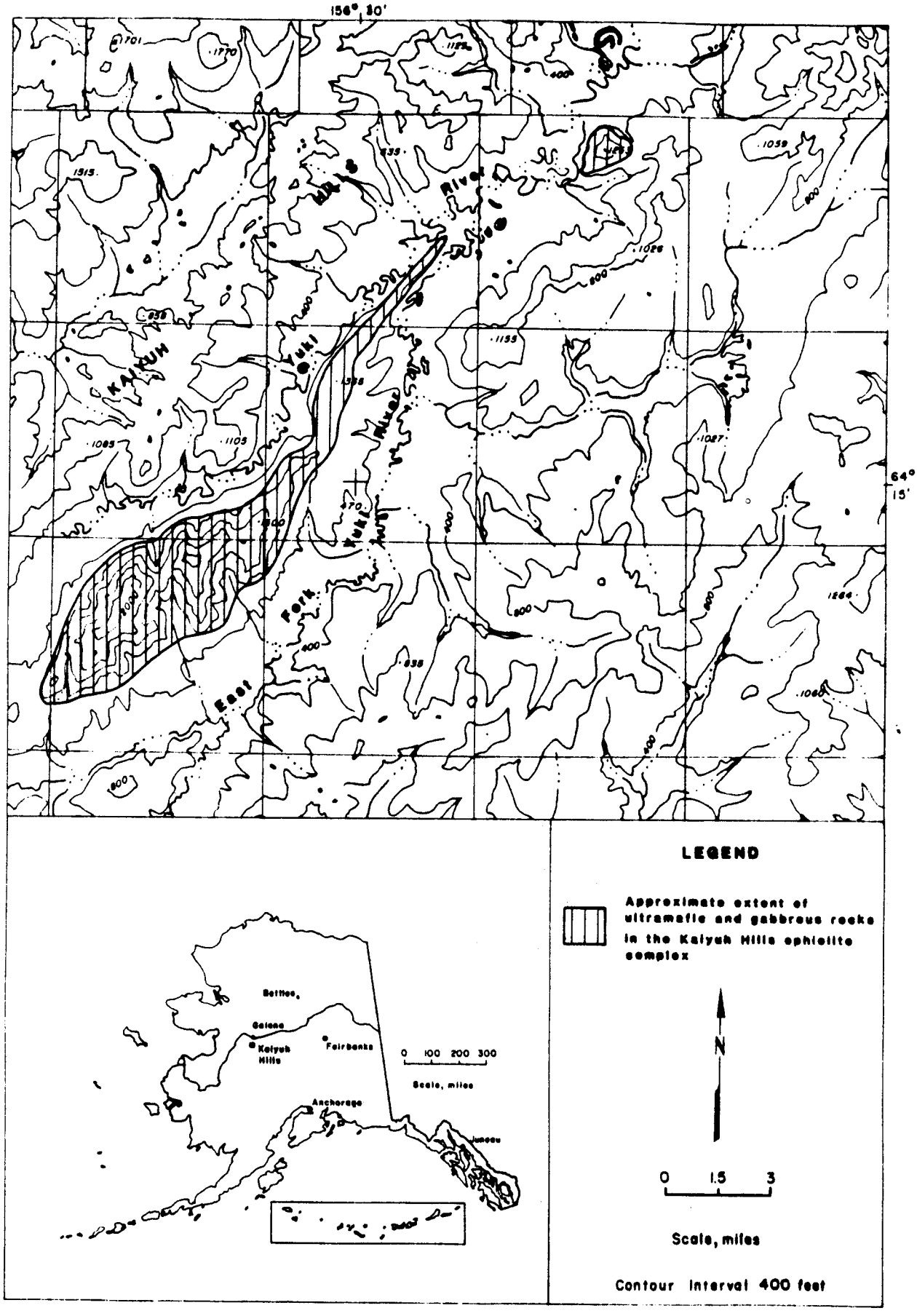

Figure 1. - Location of area investigated.

and 2,247 ft in elevation. The maturely eroded ridges are rounded and elongated northeastward between the two forks of the Yuki River (fig. 1). The hills are drained by narrow creeks, which have moderate to steep gradients and steep, V-shaped profiles. Spruce forest and alder and willow thickets cover the hillsides (fig. 2). Exposed bedrock is limited to discontinuous segments along the steeper valley walls and along ridge crests that are mostly covered by frost-heaved rubble, shrubs, sedge and moss.

The area is administered by the Alaska Department of Natural Resources, Division of Lands, and is open to mineral entry.

PREVIOUS WORK

The Kaiyuh Hills, also known as the Kaiyuh Mountains, have not previously been investigated in great detail. The geology of the area was briefly described by Mertie in 1937 (6)[6], but no mention was made of ultramafic rock or chromite deposits. A 1:250,000 scale reconnaissance geologic map of the Nulato Quadrangle was compiled by Cass in 1959 (1); the area described in this report was mapped as undifferentiated intrusive rocks of probable Cretaceous or Tertiary age. The most recent and most relevant work on the area is by Patton and others (7) who described ophiolites in northern and western Alaska. The ophiolites comprise three belts including the Yukon-Koyukuk, Western Brooks Range, and the Rampart belts. The Kaiyuh Hills ophiolite mass is in the Rampart ophiolite belt. Chromite occurrences in the Western Brooks Range and Yukon-Koyukuk ophiolite belts and at Mount Hurst, 75 miles south of the present study area, are described in other reports by the Bureau (3-5, 8)

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

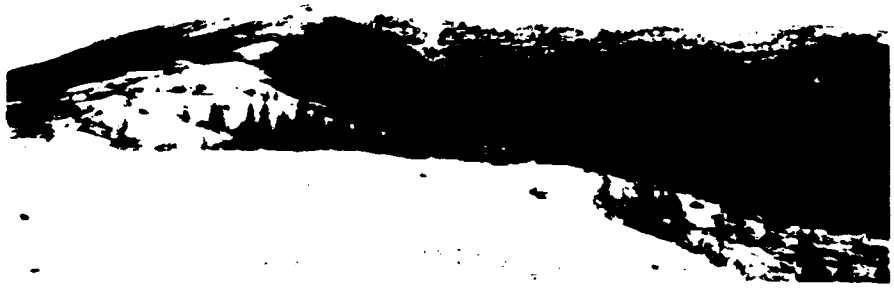

FIGURE 2. - View looking north along ridge underlain by dunite in the southwestern Kaiyuh Hills ophiolite complex. Chromite occurrence 8 (figs. 3-4) is located in left center of this photograph.

CHROMITE OCCURRENCES

GEOLOGIC SETTING

The Kaiyuh Hills are underlain by a broad synformal mass at the southwest end of the Rampart ophiolite belt. This portion of the belt is offset right-laterally along the Kaltag Fault from the remainder of the belt and comprises two tectonic units: the upper unit contains ultramafic and gabbroic rocks and the lower unit contains mafic volcanic rocks with associated diabase and chert (7). The stratigraphic position of the two tectonic units is the result of thrust faulting and is the reverse of that normally expected in better preserved ophiolites (7).

Ultramafic rocks of the upper tectonic unit, including dunite and pyroxene peridotite, are discontinuously exposed along a 24-mile, northeast-striking trend in the Kaiyuh Hills (fig. 1). The upper unit is internally faulted and has been warped into broad northeast striking anticlines and synclines. At the southwestern end of the trend is a 6-square mile body that consists mostly of dunite (fig. 3). The dunite contains greater than 90 pct olivine with accessory, disseminated chromite grains and local banded segregations of disseminated to massive chromite. Nodular chromite like that found in other ophiolite complexes was observed at one location in the dunite body. At the northeastern end of the Kaiyuh Hills complex is a large area underlain by pyroxene peridotite and interlayered dunite. Chromite bands ranging from less than an inch to 3 ft wide are locally concentrated in dunite layers that range from a few inches to several hundred feet thick. The pyroxene peridotite includes mostly harzburgite, which contains olivine and orthopyroxene, but minor wehrlite which contains olivine and clinopyroxene

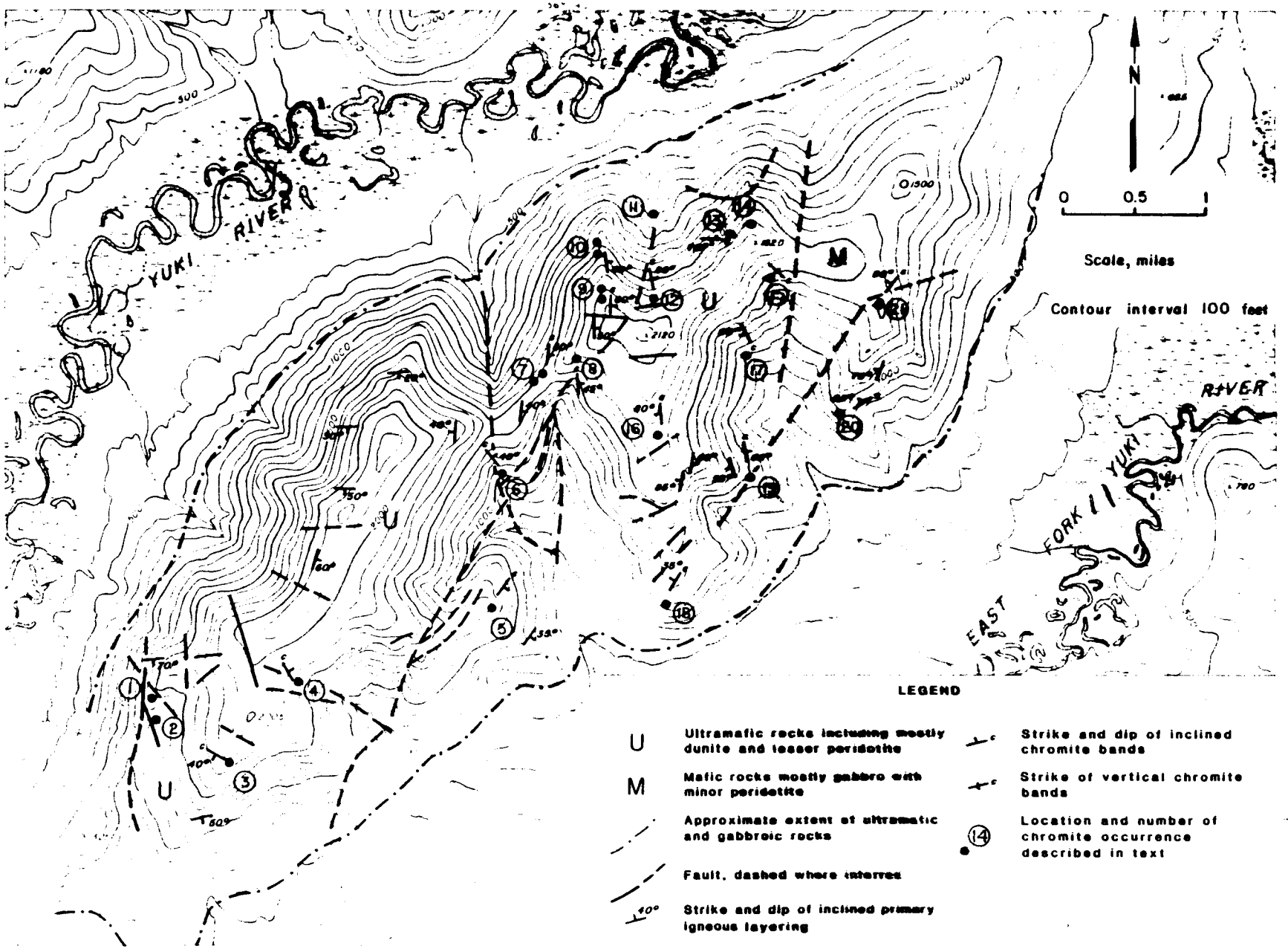

FIGURE 3. - Geologic map and chromite occurrences in the southwestern Kaiyuh Hills ophiolite complex .

and minor lherzolite, which contains olivine and both types of pyroxene are also present. Between the two ultramafic bodies, and east of the northeastern ultramafic body, are poorly exposed areas of gabbroic and mafic to felsic igneous rocks (fig. 3). These show both cumulate and plutonic textures. Based on comparison of rock types present in the Kaiyuh Hills complex to ophiolite sequences around the world (2), it appears that the uppermost stratigraphic portion of the Kaiyuh Hills complex is to the northeast.

OCCURRENCE AND SAMPLE DESCRIPTIONS

Concentrations of chromite that exceed the normal one-third to one percent disseminated chromite in dunite of the Kaiyuh Hills ophiolite complex were observed at the 21 locations shown in figure 3. The chromite at these locations occurs mostly in bands that range in thickness from less than an inch to about 3 ft (fig. 4) and contain disseminated to almost massive chromite. Less frequently, concentrations of nodular chromite and irregularly shaped chromite pods were observed.

Based on surface measurements of each occurrence and a magnetometer survey at occurrence 8, four of the occurrences are estimated to contain between 17,000 and 37,000 tons of chromic oxide (Cr_2O_3). Three of the occurrences for which reserve potential was estimated (1, 9, and 21) contain 3 to 5 pct chromite as narrow bands and disseminated grains in dunite that is exposed in areas measuring from 5 ft to tens of feet wide by tens to hundreds of feet long. Occurrence 8 consists of 3-ft-wide band of massive chromite that has an estimated strike length of 300 ft. Individual occurrences are further described in table 1. Potential exists for additional chromite in buried portions of the complex and in streams that drain the area.

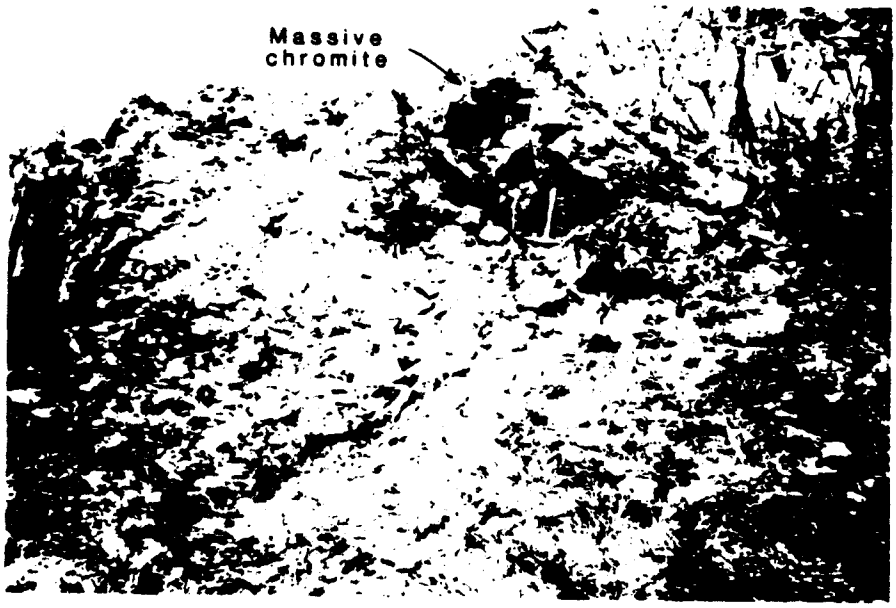

FIGURE 4. - Photograph of 3-ft-wide band of chromite at occurrence 8.

TABLE 1. - Descriptions of chromite occurrences in the Kaiyuh Hills

Map no.	Cr, pct	Description
1.....	10.0 13.3 11.0	5- by 750-ft zone containing 3 to 5 pct banded and massive chromite in float. Estimated to contain between 1,000 and 4,000 tons of Cr_2O_3.
2.....	8.0	25 pct banded chromite in sheared and brecciated dunite.
3.....	7.5	Two parallel, 3-ft-wide zones with nodular chromite and chromite bands up to 2 in wide. Zone contains up to 25 pct chromite. Maximum exposed strike length is about 15 ft. Bulk sample KW20783.
4.....	3.9 12.0	Bands of massive chromite up to 4 in wide in float.
5.....		Zones of discontinuous chromite stringers up to 3 in wide and 3 ft long. No sample
6.....		Discontinuous chromite bands up to 7 in wide in 2- by 60-ft area with 5 pct chromite. Specimen collected but not analyzed. Bulk sample KW20779.
7.....		Bands of massive chromite up to 1 in wide and bands of disseminated chromite up to 10 in wide traced for 150 ft along strike. Bands may be repeated by faulting. No sample.
8.....	24.0	3-ft-wide band of nearly massive chromite with narrow adjacent bands. Float and magnetic anomalies indicate possible 300 ft strike length. Bulk sample KW20782. Estimated to contain between 2,000 and 5,000 tons of Cr_2O_3.
9.....	2.1 20.0 9.5	30- by 900-ft zone with 3 pct chromite in scattered discontinuous bands up to 2.5 in wide. Estimated to contain between 11,000 and 22,000 tons of Cr_2O_3.
10.....	0.8 0.3 4.0 20.5	Scattered, discontinuous stringers of disseminated chromite up to 8 in wide and 15 ft long traced for several hundred ft along ridge.
11.....	7.2	Boulders up to 6 ft in diameter with discontinuous chromite bands. Boulders contain up to 10 pct chromite.
12.....	1.0 0.7	Thin stringers of disseminated chromite.
13.....		Band of massive chromite up to 8 in wide traced for 75 ft in outcrop and float. No sample.
14.....	16.0 10.0	6- by 15-ft zone with bands of massive chromite. Zone contains 10 pct chromite.
15.....	5.5	Several areas up to 30 by 50 ft contain greater than 2 pct disseminated chromite.
16.....	22.0 19.0	10- by 60-ft zone with discontinuous chromite bands and stringers.
17.....	5.0 13.6	Discontinuous chromite bands up to 3 in wide in 20- by 20-ft zone.
18.....	8.4	Massive chromite bands up to 1.5 in wide in 15- by 60-ft zone.
19.....	2.6 45.0 33.5	Stringers, bands, and lenses of massive chromite in 5- by 60-ft zone with 5 pct chromite.
20.....	9.0	Irregular bands and pods of massive chromite up to 2.5 in wide and 20 ft long.
21.....	15.5 53.0	Discontinuous chromite bands up to 2.5 in wide by 1.5 ft long in 75- by 300-ft zone containing 3 pct chromite overall. Bulk sample KW20780. Estimated to contain between 3,000 and 6,000 tons of Cr_2O_3.

[1]Chromium content (pct) of grab samples. Analyses by Rainbow Resource Labs, Inc., Anchorage, AK.

NOTE.--See figure 3 for locations.

TABLE 2. - Head analysis of chromite samples from the Kaiyuh Hills

Sample	Analysis, pct					Analysis, oz/ton			
	Cr_2O_3	Fe	MgO	Al_2O_3	SiO_2	Pt	Pd	Au	Ag
KW29779	8.3	8.4	37.8	3.2	29.6	<0.0006	<0.0006	<0.0004	<0.02
KW20780	27.3	9.5	29.7	4.1	19.2	< .0006	< .0006	< .0004	< .02
KW20782	53.6	11.1	17.0	7.4	4.8	< .0006	< .0006	< .0004	< .02
KW20783	36.0	9.6	24.8	6.5	14.1	< .0006	< .0006	< .0004	< .02

TABLE 3. - Estimated mineral composition of samples from the Kaiyuh Hills, wt pct

Sample	Chromite	Olivine	Serpentine	Chlorite[1]	Sulfides	Ferromagnesian silicates
KW20779	17	24	58	ND	ND	Tr
KW20780	39	38	21	Tr	ND	Tr
KW20782	76	ND	21	2	ND	ND
KW20783	51	5	43	1	Tr	ND

ND Not detected.
Tr Trace.
[1]The chlorite is the mineralogical variety kammererite.
[2]Contains a trace of uvarovite.

NOTE.--Totals may not add up to 100 pct due to independent rounding.

MINERALOGY AND METALLURGY

Chromite occurs in samples from four occurrences (3,6,8, and 21) as anhedral, subhedral, and euhedral crystals variously disseminated in serpentine or serpentinized dunite. Head analyses of these samples are listed in table 2 and estimated mineralogy composition is listed in table 3. Descriptions of the individual samples follow:

KW20783 from occurrence 3 consists essentially of chromite and serpentine with a small amount of olivine and a trace of chromium chlorite identified by optical means as kammerereite. The nearly massive subhedral to anhedral grains of chromite contain evenly distributed intergranular serpentine. Chromite grains are highly fractured, sheared, and elongated. Thin layers of pale green serpentine and lavender kammererite line fracture surfaces and slickensides. Most of the chromite is liberated from the gangue at 48 mesh size.

K020779 from occurrence 6 consists essentially of serpentine and olivine with some chromite. The chromite occurs in bands of closely disseminated euhedral to subhedral cyrstals in a buff colored serpentinized dunite matrix alternating with layers of an orange-brown chromite-free serpentinized dunite. The alternating bands vary from 0.2 to 0.8 in wide. A thin chalky layer of white to pale purple magnesite covers some of the fractures and weathered surfaces. Most of the chromite is liberated from gangue at 48 mesh size.

KW20782 from occurrence 8 consists essentially of chromite with some serpentine. Nearly massive subhedral to anhedral chromite grains contain evenly distributed intergranular serpentine. Also present is a small amount of kammererite lining some fractures and slickensides and trace amounts of randomly scattered uvarovite (chromium garnet). Most of the chromite is liberated from the gangue at 48 mesh size.

KW20780 from occurrence 21 consists essentially of chromite, olivine, and serpentine. Highly fractured subhedral to anhedral chromite crystals are disseminated in serpentinized dunite. The grains are concentrated in bands irregularly spaced within serpentine-rich areas of the matrix and exhibit flow textures. Fractures in the chromite are filled with pale green serpentine. Serpentine varies in color from pale green to dark olive green. Unaltered olivine is pale yellow. Chalky white to pale blue magnesite occurs on weathered surfaces. Most of the chromite is liberated from gangue at 150 mesh.

Samples were fractionated at several electromagnetic field settings on a laboratory-model Frantz Isodynamic Separator.[7] High-purity chromite concentrates were prepared, examined by optical microscopy, and submitted for chemical analysis. The grades of these concentrates are shown in table 4.

[7]Reference to specific equipment does not imply endorsement by the Bureau of Mines.

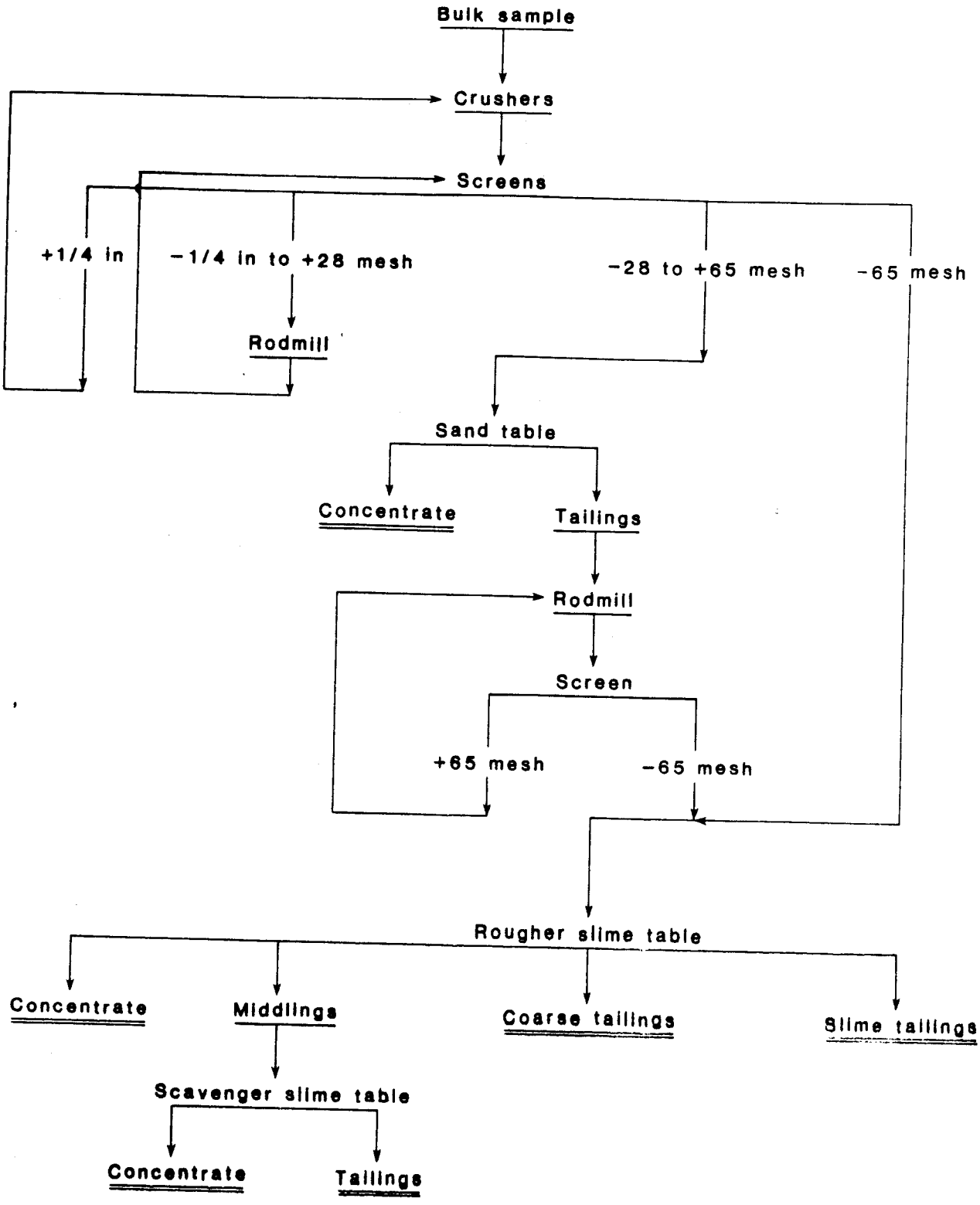

FIGURE 5. - Beneficiation procedure.

BENEFICIATION PROCEDURES

The beneficiation procedure is shown in figure 5. Minus 1/4-in material was screened on 28 and 65 mesh. The plus 28-mesh fraction was ground dry in a 13- by 25-in rodmill or a 7- by 9-in rodmill to pass 28 mesh and sized on 65 mesh. Grinding was done in stages to minimize production of fines. The plus 28-mesh fraction from a 20-lb split was ground in the large mill in one or two stages of 2 to 4 min, and then if needed, in one to two stages in the small mill to reduce it to minus 28 mesh.

The 28- by 65-mesh fraction was tabled on a sand deck of a 2- by 4-ft laboratory shaking table to produce a clean concentrate and tailings. The tailings were dried and then stage-ground to minus 65 mesh to improve liberation, and the ground product was then combined with the minus 65-mesh material from the initial grinding and tabled on a slime deck. A high-grade concentrate, middlings, coarse tailings (those that settled and banded on the table), and slime tailings (those that washed off the deck before they had a chance to settle) were collected. A scavenger table operation was done on the rougher table middlings (or the middlings and coarse tailings combined product) to produce a scavenger concentrate and tailings to improve Cr_2O_3 recovery.

BENEFICIATION RESULTS

Beneficiation results are summarized in table 5 and in the individual metallurgical balances in the appendix, tables A-1 through A-4. The composite chromite concentrates in tables A-1 through A-4 are mathematical combinations of the 28- by 65-mesh concentrate and minus 65-mesh rougher and scavenger concentrates. The concentrates may be classified in one of the following two categories:

TABLE 4. - High-purity chromite concentrates of samples from the Kaiyuh Hills

Sample	Analysis, pct					Cr:Fe ratio
	Cr_2O_3	Fe	MgO	Al_2O_3	SiO_2	
KW20779	45.2	16.2	12.7	17.0	0.4	1.9
KW20780	56.0	14.6	12.0	9.5	.6	2.6
KW20782	58.0	12.3	13.6	9.1	1.4	3.2
KW20783	55.7	12.2	4.2	10.8	1.4	3.1

TABLE 5. - Analyses of chromite concentrates from samples from the Kaiyuh Hills

Sample	Chromite concentrate classification	Analysis, pct					Cr recovery, pct	Cr:Fe ratio
		Cr_2O_3	Fe	MgO	Al_2O_3	SiO_2		
KW20779	High-iron	45.0	15.7	15.0	15.8	3.3	62.5	2.0
KW20780	High-chromium	57.4	13.6	14.3	8.4	2.1	81.9	2.9
KW20782	High-chromium	58.7	11.8	15.3	8.2	2.7	94.6	3.4
KW20783	High-chromium	55.1	11.8	16.4	9.5	3.7	89.2	3.2

(1) High-chromium (metallurgical-grade) chromite that contains a minimum of 46 pct Cr_2O_3 with a Cr:Fe ratio greater than 2.0:1.

(2) High-iron (chemical-grade) chromite that contains 40 to 46 pct Cr_2O_3 with a Cr:Fe ratio of 1.5:1 to 2.0:1.

Sample KW20779 (ME1487) yielded a high-iron chromite concentrate (table 5) that contained 45.0 pct Cr_2O_3 and a Cr:Fe ratio of 2.0:1 at 62 pct Cr recovery. The other three samples yielded high-chromium chromite concentrates that contained 55 to 59 pct Cr_2O_3 and Cr:Fe ratios of 2.9:1 to 3.4:1. Chromium recoveries of the high-chromium chromite concentrates ranged from 82 to 95 pct.

The 28- by 65-mesh concentrate and minus 65-mesh rougher concentrate from each test were submitted for precious metal analyses. None of them contained detectable amounts, in oz/ton, of 0.001 Pt, 0.001 Pd, 0.0008 Au, and 0.04 Ag.

SUMMARY

Between 17,000 and 37,000 tons of Cr_2O_3 are estimated in four podiform-type chromite deposits in the Kaiyuh Hills, west-central Alaska. One of these deposits is a 3-ft-by 300-ft band of nearly massive chromite (2,000 to 5,000 tons of Cr_2O_3). The other three contain between 3 and 5 pct chromite and would require on-site benefication prior to shipping. At least 17 smaller and less significant occurrences also exist in the area. Potential for additional tonnages exists in buried portions of the ultramafic rocks and in placer deposits in streams draining the area. Metallurgical tests indicate that high-chromium and high-iron chromite concentrates that are suitable for use by industry can be produced from these occurrences.

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APPENDIX

TABLE A-1. - Gravity table concentration of chromite sample ME1487 (KW20779) from the Kaiyuh Hills

Product[1]	Wt pct	Analysis, pct					Cr distribution, pct	Cr:Fe ratio
		Cr_2O_3	Fe	MgO	Al_2O_3	SiO_2		
28- by 65-mesh concentrate*[2]	2.3	42.9	15.6	16.0	15.5	4.3	10.9	1.9
Minus 65-mesh:								
Rougher concentrate*[2]	8.6	45.3	15.9	14.4	16.1	2.8	43.0	2.0
Rougher middlings	13.5	18.0					26.7	
Scavenger concentrate*	1.7	46.1	15.4	16.4	14.5	4.8	8.6	2.0
Scavenger tailings	11.8	13.9					18.1	
Rougher coarse tailings	55.9	1.8					11.1	
Rougher slime tailings	19.7	3.8					8.3	
Composite or total	100.0	9.1					100.0	
Calculated composite concentrate[1]	12.6	45.0	15.7	15.0	15.8	3.3	62.5	2.0

[1]Products with asterisks have been mathematically combined to give the calculated composite concentrate.

[2]Precious metals analysis, oz/ton: Pt <0.001; Pd <0.001; Au <0.0008; Ag <0.04.

NOTE.--Blank entry means data not available.

TABLE A-2. - Gravity table concentration of chromite sample ME1488 (KW20780) from the Kaiyuh Hills

Product[1]	Wt pct	Analysis, pct					Cr distribution, pct	Cr:Fe ratio
		Cr_2O_3	Fe	MgO	Al_2O_3	SiO_2		
28- by 65-mesh concentrate*[2]	7.7	56.1	13.8	14.7	8.3	2.6	15.1	2.8
Minus 65-mesh:								
Rougher concentrate*[2]	28.4	58.0	13.7	13.9	8.5	1.7	37.5	2.9
Rougher middlings	28.3	20.8					20.6	
Scavenger concentrate*	4.8	55.6	13.1	15.7	8.1	3.8	9.3	2.9
Scavenger tailings	23.5	13.8					11.3	
Rougher coarse tailings	20.7	3.3					2.4	
Rougher slime tailings	14.9	8.4					4.4	
Composite or total	100.0	28.6					100.0	
Calculated composite concentrate[1]	40.9	57.4	13.6	14.3	8.4	2.1	81.9	2.9

[1]Products with asterisks have been mathematically combined to give the calculated composite concentrate.

[2]Precious metals analysis, oz/ton: Pt <0.001; Pd <0.001; Au <0.0008; Ag <0.04.

NOTE.--Blank entry means data not available.

TABLE A-3. - Gravity table concentration of chromite sample ME1489 (KW20782) from the Kaiyuh Hills

Product[1]	Wt pct	Analysis, pct					Cr distribution, pct	Cr:Fe ratio
		Cr_2O_3	Fe	MgO	Al_2O_3	SiO_2		
28- by 65-mesh concentrate*[2]	44.3	57.4	11.6	15.9	8.2	3.6	46.6	3.4
Minus 65-mesh:								
Rougher concentrate*[2]	41.9	60.3	11.9	14.5	8.3	1.5	46.3	3.5
Rougher middlings and coarse tailings	8.1	23.4					3.4	
Scavenger concentrate*	1.8	52.8	10.8	17.7	7.6	6.6	1.7	3.4
Scavenger tailings	6.3	15.0					1.7	
Rougher slime tailings	5.7	35.0					3.7	
Composite or total	100.0						100.0	
Calculated composite concentrate[1]	88.0	58.7	11.8	15.3	8.2	2.7	94.6	3.4

[1]Products with asterisks have been mathematically combined to give the calculated composite concentrate.

[2]Precious metals analysis, oz/ton: Pt <0.001; Pd <0.001; Au <0.0008; Ag <0.04.

NOTE.--Blank entry means data not available.

TABLE A-4. - Gravity table concentration of chromite sample ME1490 (KW20783) from the Kaiyuh Hills

Product[1]	Wt pct	Analysis, pct					Cr distribution, pct	Cr:Fe ratio
		Cr_2O_3	Fe	MgO	Al_2O_3	SiO_2		
28- by 65-mesh concentrate*[2]	13.8	55.8	12.0	15.9	9.7	3.1	20.9	3.2
Minus 65-mesh:								
Rougher concentrate*[2]	37.7	56.5	11.9	15.6	9.7	2.8	57.9	3.2
Rougher middlings	14.7	34.4					13.8	
Scavenger concentrate*	8.1	47.2	10.6	21.3	8.2	9.0	10.4	3.4
Scavenger tailings	6.6	18.8					3.4	
Rougher coarse tailings	21.3	4.0					2.3	
Rougher slime tailings	12.5	15.0					5.1	
Composite or total	100.0	36.8					100.0	
Calculated composite concentrate[1]	59.6	55.1	11.8	16.4	9.5	3.7	89.2	3.2

[1]Products with asterisks have been mathematically combined to give the calculated composite concentrate.

[2]Precious metals analysis, oz/ton: Pt <0.001; Pd <0.001; Au <0.0008; Ag <0.04.

NOTE.--Blank entry means data not available.