Chromite Deposits in the Seiad Valley and Scott Bar quadrangles, Siskiyou County, California

GEOLOGICAL SURVEY BULLETIN 1382-D

Chromite Deposits in the Seiad Valley and Scott Bar quadrangles, Siskiyou County, California

By HENRY R. CORNWALL

CONTRIBUTIONS TO ECONOMIC GEOLOGY

GEOLOGICAL SURVEY BULLETIN 1382-D

A description and economic assessment of several small chromite deposits

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1981

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, *Secretary*

GEOLOGICAL SURVEY

Doyle G. Frederick, *Acting Director*

Library of Congress Cataloging in Publication Data

Cornwall, Henry Rowland, 1913-
Chromite deposits in the Seiad Valley and Scott Bar quadrangles, Siskiyou County, California.

(Contributions to economic geology) (Geological Survey bulletin ; 1382-D)
Bibliography: p. D17
Supt. of Docs. no.: I 19.3:1382-D
1. Chromite--California--Siskiyou County. I. Title. II. Series: United States. Geological Survey. Contributions to economic geology. III. Series: United States. Geological Survey. Bulletin 1382-D.
QE75.B9 no. 1382-D 557.3s 80-606881
[TN490.C4] [553.4'643]

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington, D. C. 20402

CONTENTS

ILLUSTRATIONS

TABLE

CONTRIBUTIONS TO ECONOMIC GEOLOGY

Chromite deposits in the Seiad Valley and Scott Bar quadrangles, Siskiyou County, California

By HENRY R. CORNWALL

ABSTRACT

Chromite deposits in the Seiad Creek and McGuffy Creek districts and the Ladd mine, Siskiyou County, Calif., occur in dunite-peridotite bodies that are part of an ophiolitic sequence, the western Paleozoic and Triassic belt of the Klamath Mountains. The deposits are estimated to contain nearly 300,000 metric tons of rock containing an average of about 8 percent Cr_2O_3. Individual deposits range in size from 200 to 135,000 metric tons of rock and consist of thin parallel layers and linear lenses of chromite in dunite. The rocks are foliated and in part tightly folded, with gently plunging lineations indicated by fold axes, parallel pencil-shaped seams of chromite, and rods of dunite.

Representative chromite analyses of the deposits indicate a range of Cr_2O_3 content from 54 to 59 percent and in Cr:Fe ratio from 2.2 to 2.8. Al_2O_3 ranges from 5 to 9 weight percent, MgO 11 to 16 weight percent, total Fe as Fe_2O_3 17 to 25 weight percent, and NiO 0.06 to 0.15 weight percent. Contents of platinum-group metals in the chromite samples are low except for one sample that contains 0.13 ppm platinum and 0.069 ppm rhodium.

The outlook for economic exploitations of these deposits is not good. They are too small and low grade to meet U.S. chromite requirements for more than a very short period.

INTRODUCTION

The chromite deposits in the Seiad Valley and Scott Bar quadrangles, Siskiyou County, Calif., constitute the largest reserve of chromite in northern California. They have been described by Diller (1921), Rynearson and Smith (1940), and Wells and others (1949). I studied these deposits during the period 1977–79 in order to reappraise their size, nature, and geologic setting in the framework of current geologic concepts of the area.

GEOLOGIC SETTING

The deposits occur in the so-called western Paleozoic and Triassic belt of the Klamath Mountains (Irwin, 1964). The rocks are part of an ophiolitic terrane described by W. P. Irwin (written commun., 1978) as follows:

"The belt is 300 kilometers long from south to north and is generally between 40 and 80 kilometers wide. On the east the rocks of the belt are thrust beneath Devonian metamorphic rocks of the central Klamath Mountains, and on the west are underthrust by Upper Jurassic flysch and volcanic rocks (Galice Formation). The belt consists of both melange and coherent slabs of ophiolite and associated oceanic rocks as well as andesitic volcanic rocks.

In the Seiad Valley-Scott Bar area, the ophiolitic rocks of the western Paleozoic and Triassic belt consist of slablike bodies of dunite and peridotite containing the chromite deposits described here enclosed in amphibolite and metasedimentary rocks. The amphibolite was probably derived from basaltic and andesitic flows, tuffs, and tuffaceous sediments and possibly also gabbros. Intrusive diorite, quartz diorite, and granodiorite of presumable Jurassic age also occur in the area.

The rocks of the western Paleozoic and Triassic belt are bounded on the east by a high-angle fault separating them from a large window of the Upper Jurassic Condrey Mountain Schist composed of quartz-muscovite schist, commonly graphitic, and actinolite-chlorite schist. Hotz states (1971, p. 13) that: "their lithology suggests that they were derived from a sequence of pelitic sedimentary rocks with some interbedded mafic volcanic rocks." These schists are surrounded and overlain structurally along a thrust fault by rocks of the western Paleozoic and Triassic belt, including the ultramafic rocks of the Seiad Valley-Scott Bar area. Klein (1977) reports that at Happy Camp, 20 km west of the Condrey Mountain area, the Upper Jurassic Galice Formation with lithology similar to the Condrey Mountain Schist is structurally overlain along a thrust fault by amphibolite and other rocks of the western Paleozoic and Triassic belt. He suggests that the Condrey Mountain Schist is correlative with the Galice Formation with a slightly higher metamorphic grade.

SEIAD CREEK CHROMITE DEPOSITS

LOCAL GEOLOGY

The Seiad Creek chromite deposits in the northwest quarter of the Seiad Valley quadrangle occur in two tabular ultramafic bodies, one a dunite, the other an harzburgite. The two bodies are separated by a thin screen of metasedimentary rocks, marble, quartzite, and quartz-mica schist and are surrounded by a large area of amphibolite (figs. 1 and 2).

The dunite body, called the West Fork dunite by Medaris (1966, p. 106), extends north-northwest for 6.4 km; it has a maximum thickness of 3.2 km and tapers at both ends. The greatest concentrations of chromite in the district occur in this body, one near its south end at the Seiad Creek mine and the other near the middle at the Emma Bell mine (fig. 2). An ultramafic body of harzburgite, the

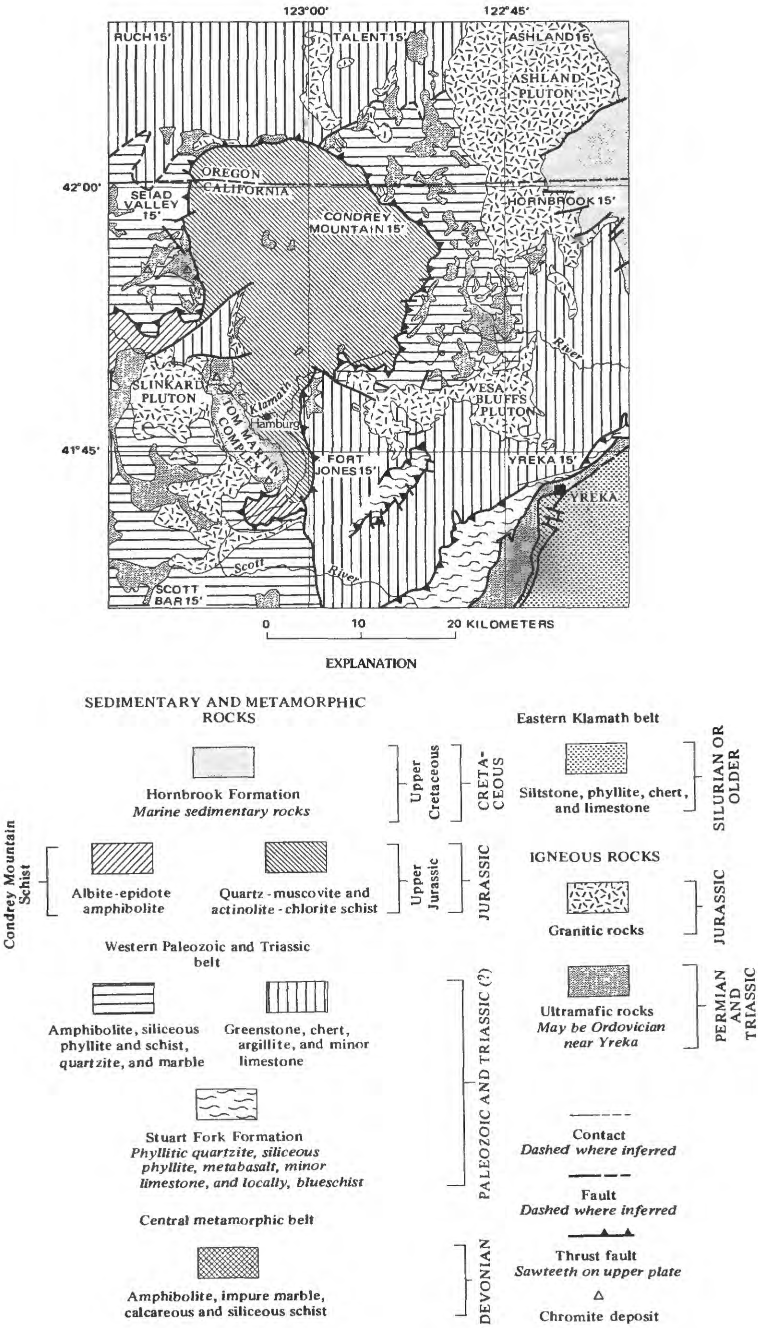

FIGURE 1.—Generalized geology of the Seiad Valley and adjacent quadrangles showing locations of chromite deposits described here (from Hotz, 1979).

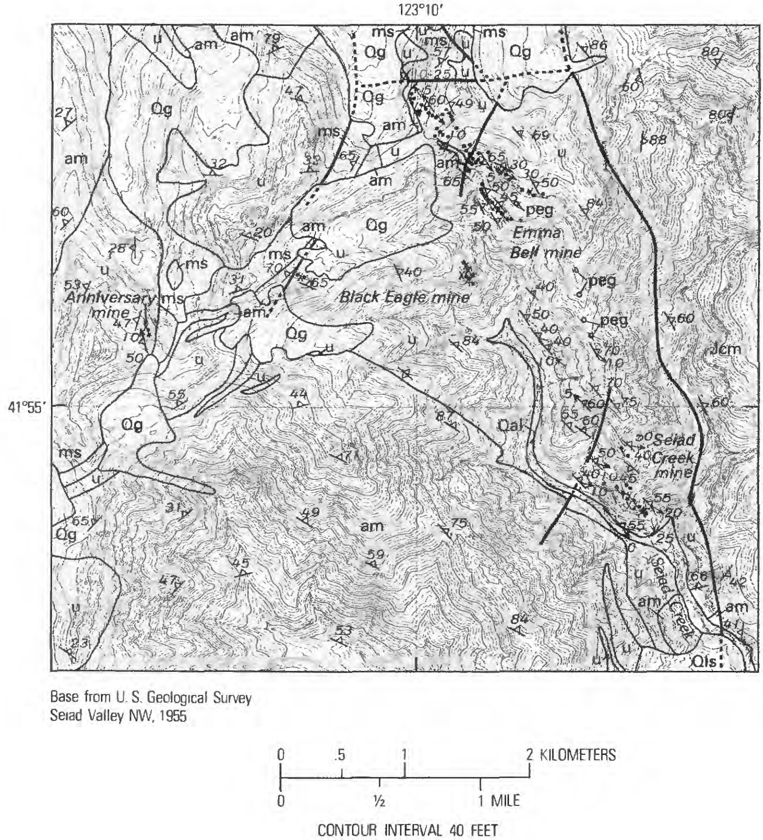

FIGURE 2.—Geology and chromite deposits of the Seiad Creek area (modified from Medaris, 1966).

Kangaroo peridotite of Medaris (1966, p. 106), extends southwest from near the middle of the dunite for 4.8 km with a width of 0.8–1.2 km. It is separated from the dunite by a thin screen of metasedimentary rocks. The small Anniversary chromite deposit occurs in this harzburgite body just west of the metasedimentary screen. The dunite and harzburgite locally contain scattered lenses and irregular dikes of lherzolite, pyroxenite, and amphibolite (pargasite), most 1–40 cm thick but a few as thick as 25 m. The pyroxenite consists of enstatite, augite, or both. These rocks are fresh except locally near the margins of the body where serpentinization may be pronounced.

The olivine of the dunite and harzburgite is xenoblastic, the individual grains ranging from 0.15 to 1.4 mm in diameter and averaging about 0.4 mm. The subhedral chromite grains range

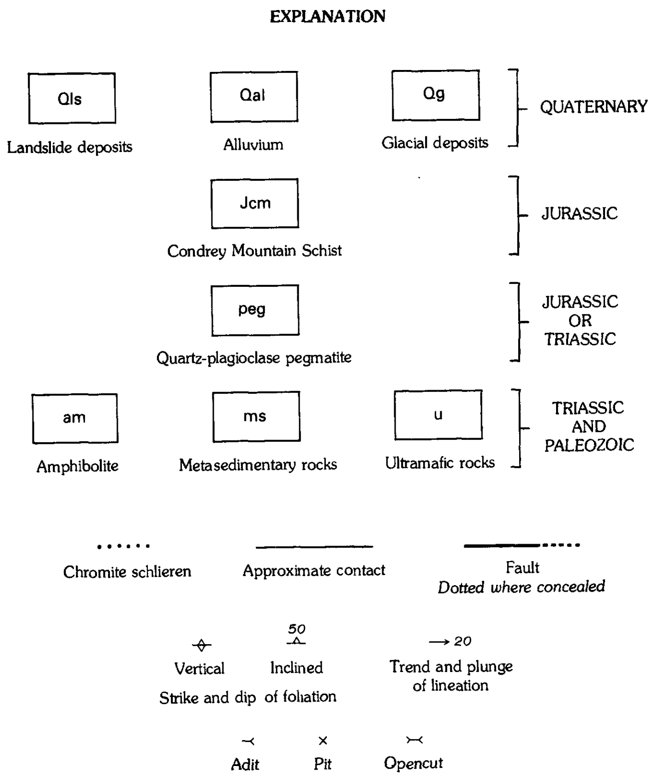

FIGURE 2.—Continued.

from 0.07 to 0.34 mm in diameter and average 0.14 mm. In nearly massive chromite schlieren, the individual crystals are larger and reach a maximum diameter of 3.5 mm. The specific gravity of 16 specimens of the dunite ranges from 3.08 to 4.02; the increase in density is due mainly to increased proportions of chromite.

Using the X-ray method of Hotz and Jackson (1963) the composition of the olivine was found to range from $fo_{91.0}$ to $fo_{95.7}$. Most of the samples tested fall in the range fo_{91-94}. The olivine is optically positive, $2V^{+}$ 85°–90°. Serpentinization consists mostly of narrow (<1 mm) veins of chrysotile plus a little replacement of olivine grains by lizardite. Olivine interstitial to chromite is partly replaced by purple kaemmererite (chrome-bearing chlorite) and green fuchsite (chrome-bearing mica).

The lherzolite and pyroxenite lenses and dikes contain varying proportions of enstatite, augite, and locally pargasite. The textures are mostly xenoblastic and partly porphyritic. Augite is more common than enstatite. The grain size ranges from 0.05 to 0.3 mm, averaging 0.2 mm with phenocrysts as much as 1.0 mm long. Very little, or no, chromite is found in these lenses and dikes.

The sparse amphibolite lenses in the dunite and harzburgite are mostly colorless pargasite. Layers and lenses of green hornblende or pargasite occur near and parallel to the borders of the dunite and harzburgite bodies (Medaris, 1966, p. 120). A typical amphibolite layer consists of pargasite that is hypidiomorphic porphyritic; crystals in the groundmass average 0.25 mm in length, and phenocrysts are as long as 2 mm, tending to clustei along the margins of the layers.

The dunite and harzburgite are foliated and lineated. In the dunite, foliation is visible only where schlieren and lenses of chromite, harzburgite, or pyroxenite are present. The lineation, however, is commonly pronounced, even in the dunite. It consists of pencils of chromite and rods of dunite several centimeters to 1 m thick. Locally, particularly at the Emma Bell mine, chromite schlieren are tightly folded, and the fold axes are parallel to the other lineations.

Foliation in the dunite strikes northwest and dips 40°-70° northeast. Lineation in the foliation plane dips from gently southeast to gently northwest. In the harzburgite in the area of the Anniversary mine, the foliation strikes north-northeast and dips 30°-55° W. Lineation is nearly horizontal.

Foliation and lineation in the peridotite bodies are concordant to foliation and lineation in the surrounding amphibolite, and the tabular peridotite bodies are themselves oriented parallel to the foliation (Medaris, 1966, p. 41, 60-63). The foliation pattern describes an antiform (fig. 2); foliation in the east body, the dunite, strikes northwest and dips northeast; that in the harzburgite to the west strikes northeast and dips northwest. It is clear that the deformation of the peridotite bodies, which probably were derived from the mantle, must have occurred after their juxtaposition with the amphibolites and metasedimentary rocks, which probably were originally deposited in an island-arc environment at or near the margin of the North American continental plate.

CHROMITE DEPOSITS

The principal chromite deposits in the Seiad Creek district, in order of relative size, are the Seiad Creek (Mountain View), Emma Bell, Anniversary (Kangaroo Mountain), and Black Eagle. All deposits except the Anniversary occur in the dunite; the Anniversary occurs in the harzburgite just west of the dunite.

The Seiad Creek mine, the largest of this group, was mined during World War I and again during World War II. Production amounted to 715 metric tons in 1918 and 2,093 metric tons during 1943-44. The U.S. Bureau of Mines explored the deposit by channel sampling and diamond drilling in 1941, and the U.S. Geological Survey made detailed geologic studies at that time. The chromite occurs as layers and linear lenses of chromite within which are parallel, pencil-shaped seams of chromite. The layers strike northwest-southeast and dip about 50° NE. The lineations plunge about 10° SE. According to Wells and others (1949, p. 51, p. 20), five bodies of chromite occur in a zone 400 m long parallel to the foliation. Individual deposits are 60-150 m long, 10-21 m wide, and 15-60 m deep. Wells and others (1949) have estimated the indicated reserves of this deposit at 241,000 metric tons averaging 6 percent or more of Cr_2O_3.

The Emma Bell deposit consists of discontinuous zones of chromite schlieren and disseminated chromite grains in dunite extending northwest-southeast for 1,220 m and as much as 60 m wide. The overall grade is low, probably 1-3 percent Cr_2O_3, but individual zones, 5-50 m long and 0.5-3 m wide, of concentrated chromite lenses contain 5-15 percent Cr_2O_3. Individual lenses strike northwest-southeast and dip mostly 45°-85° E. The lensoidal layers are tightly folded locally. Fold axes plunge gently either southeast or northwest as do linear seams of chromite. Three diamond drill holes were drilled by the U.S. Chrome Company in 1978 to depths ranging from 96 to 132 m beneath well-mineralized zones. Mineralization was found to be similar to that seen on the surface.

The amount of chromite in the Emma Bell deposit is probably second only to that in the Seiad Creek deposit described above, but individual concentrations of chromite are so widely scattered that economic exploitation is probably not possible. I estimate an inferred tonnage of 10,000 metric tons at 5 percent Cr_2O_3 in the Emma Bell deposit.

The Anniversary (Kangaroo Mountain) deposit occurs in the harzburgite body on the west wall of a northward-draining cirque (fig. 2). The chromite occurs as lenses and linear streaks in a zone 55 × 13 × 13 m elongated parallel to the foliation which strikes N. 15° W. and dips 50° SW. The lineations plunge 5°-15° NW. The peridotite is dunitic in the area of chromite mineralization. Wells and others (1949, p. 45) estimate that the deposit contains 4,760 metric tons of indicated and inferred rock containing about 5 percent Cr_2O_3.

The Black Eagle deposit, located about 600 m south-southwest of the Emma Bell in the dunite body, has been explored by several pits and an opencut in an area 150 × 60 m elongated in a northwest-southeast direction. The deposit consists of layers, lenses, and disseminations of chromite elongated parallel to the foliation which is variable but in general strikes N. 45° W. and dips 70° SW. Linear streaks of chromite plunge about 10° NW. Purple kaemmererite (Allen, 1941, p. 124) and green amphibole are associated with some of the high-grade chromite layers. I estimate that the deposit may contain 2,700 metric tons of rock that averages 5 percent Cr_2O_3.

A small pit containing layered chromite in fresh dunite is located 1.3 km west of the Black Eagle deposit, at the west edge of the dunite; it is separated by a fault from amphibolite and metasedimentary rocks to the west. This is a small deposit containing possibly 200–500 tons of chromite with a grade of 10 percent Cr_2O_3.

LADD-McGUFFY CREEK CHROMITE DEPOSITS

LOCAL GEOLOGY

The Ladd mine is located in the southeast quarter of the Seiad Valley quadrangle (figs. 1, 3), and the McGuffy Creek deposits are in the northeast quarter of the Scott Bar quadrangle (figs. 1, 4). The deposits occur in an ultramafic complex called the Ladd and Tom Martin ultramafic bodies, respectively, by Barrows (1969). The complex extends southeast for 16 km, 3 km west of Hamburg. It straddles the Klamath River at its north end and is 2.4–4 km wide (figs. 1, 3, 4). The ultramafic complex is tabular and flat lying to moderately westward dipping. The Ladd ultramafic body has an areal extent of 7.8 km^2, the Tom Martin 39 km^2 (Barrows, 1969).

The Ladd ultramafic body (fig. 3) is distinguished from the Tom Martin body (fig. 4) by an abundance of clinopyroxene. Except for a half square mile of dunite surrounding the Ladd chromite deposit, the body is composed of clinopyroxenite, wehrlite, and lherzolite. The olivine of dunite in the vicinity of the Ladd chromite mine has a composition of fo_{93} as determined for this study using the X-ray method of Hotz and Jackson (1963). Barrows (1969) reports a composition of fo_{91}. The dunite is 50–100 percent serpentinized. According to Barrows (1969), the clinopyroxene in the pyroxene-bearing part of the body is diopside, which is partly serpentinized. These rocks also contain some amphibole. Barrows (1969) states that, in contrast to the Tom Martin body, the rocks of the Ladd body are not foliated, but I observed moderate foliation of the dunite at the Ladd chromite deposit. Layers and tabular schlieren of chromite strike northwest and dip steeply northeast and southwest. Olivine crystals are elongated parallel to chromite schlieren in the foliation plane. The dunite is xenoblastic with olivine grains 0.3–1.3 mm across, averaging 0.6 mm, and subhedral chromite grains 0.05–0.35 mm, averaging 0.1 mm.

The Tom Martin ultramafic body is, according to Barrows (1969), a tabular body more than 1,500 m thick composed mainly of hornblende-bearing harzburgite. The hornblende is pargasitic. At the top and bottom of the body are relatively thin complex zones of foliated hornblende harzburgite, hornblende websterite, hornblende orthopyroxenite, hornblende wehrlite, hornblende lherzolite, hornblendite, and gabbro. Dunite, which rarely contains amphibole, is common near the margins of the Tom Martin body.

The chromite deposits of the McGuffy Creek area occur in dunite near the south end of the body. This dunite is xenoblastic with olivine grains 0.05–1.0 mm across, averaging 0.6 mm, and disseminated chromite grains 0.05–0.3 mm across, averaging 0.2 mm. The chromite grains average 0.6 mm in diameter in the massive schlieren. The compositional range of olivine is fo_{91-96} according to my X-ray determinations. Barrows (1969) reports a range of fo_{88-93} using the same X-ray method. I observed clinopyroxenite (augite) dikes in the vicinity of the chromite deposits.

The hornblende harzburgite zone makes up the major interior part of the Tom Martin ultramafic body. Some harzburgite exists near the center of the body, but most of it has been modified to hornblende harzburgite with more than 5 percent pargasitic hornblende. Barrows (1969) states that the hornblende harzburgite normally contains 25–34 percent hornblende. Phenocrysts of orthopyroxene and hornblende, 1–5 mm long, occurring both in the harzburgite and in the hornblende harzburgite, are commonly oriented parallel owing to a moderate foliation of the body. According to Barrows (1969), the range of forsterite content of the olivine in the harzburgite and hornblende harzburgite is fo_{89-95}. Disseminated chromite is ubiquitous in the harzburgite and hornblende harzburgite. Magnetite and aluminous spinel are also present in parts of the body. Amphibole-clinopyroxene dikes also occur locally.

At the south end of the Tom Martin ultramafic body in the area of the McGuffy Creek chromite deposits, the dunite is foliated. Tabular schlieren and layers of chromite strike northwest and dip 40°–60° SW. Lineations, indicated by mullions in dunite, and fold axes and pencillike schlieren in chromite, plunge 5°–25° NW (fig. 4).

CHROMITE DEPOSITS

LADD MINE

The Ladd chromite mine (fig. 3) is in the Ladd ultramafic body

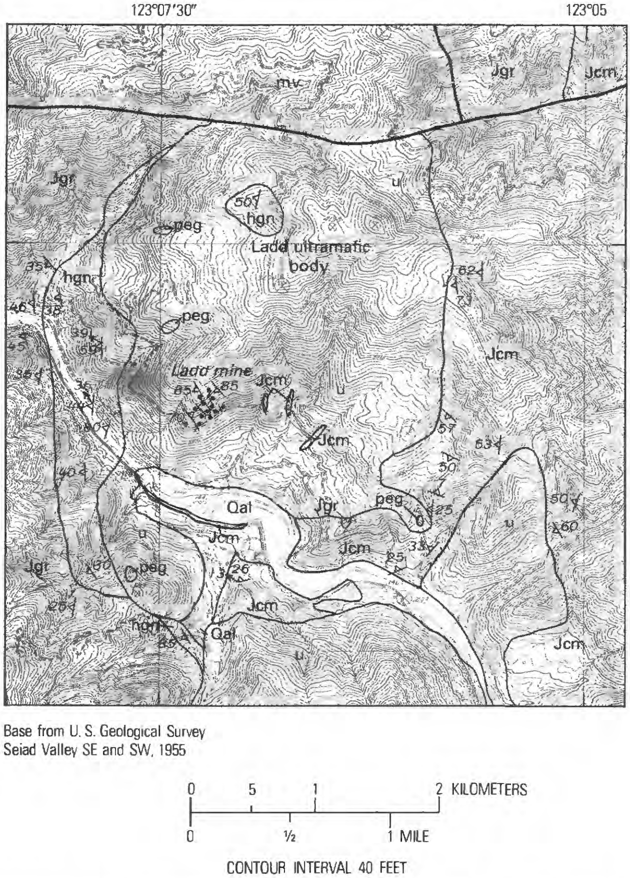

FIGURE 3.—Geology and chromite deposits of the Ladd mine and vicinity (modified from Barrows, 1969).

north of the Tom Martin ultramafic body (Barrows, 1969). The body is mainly wehrlite and lherzolite, but the chromite deposit occurs in dunite in the southwestern part of the body.

The deposit, explored by a number of pits and several short adits, consists of four separate chromite zones (Wells and others, 1949, p. 52–53). The largest zone is a flat lens 20 m long, 3–5 m wide, and of unknown depth. This lens, which strikes northwest-southeast and is nearly vertical, is elongated parallel to foliation as chromite layers indicate. The chromite lens consists of irregular stringers, indistinct bands, and high-grade disseminations of chromite. Several other similar but smaller chromite lenses occur 45–185 m south and southwest of the largest lens.

Wells and others (1949, p. 52–53) estimate that the indicated and

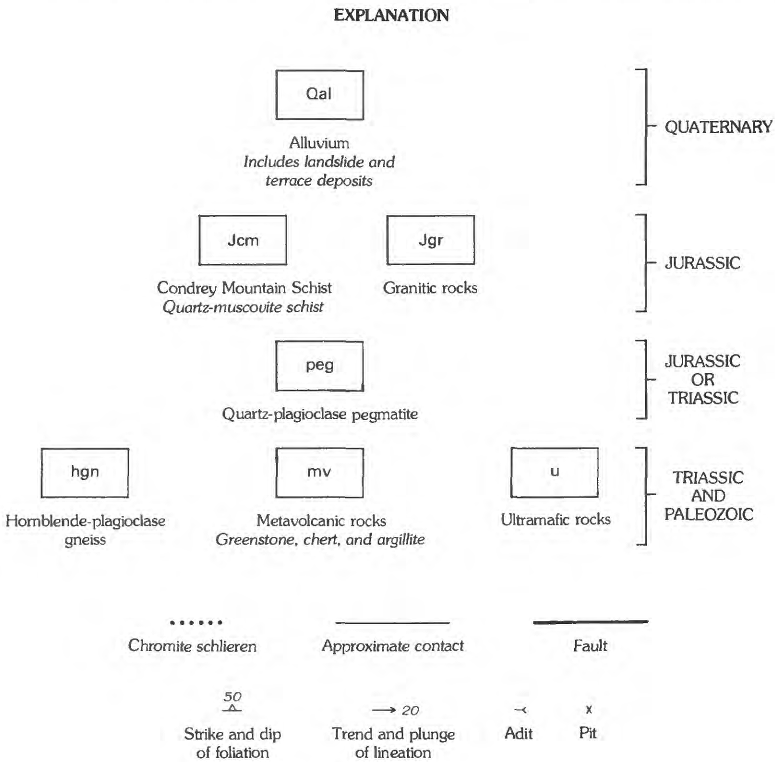

FIGURE 3.—Continued.

inferred reserves of the Ladd deposit total about 4,700 metric tons, of which about 1,800 metric tons is high-grade shipping ore and 2,900 metric tons is disseminated ore that would need to be concentrated prior to shipping. They also state that, up to 1943, 1,915 metric tons of ore had been shipped from the deposit.

McGUFFY CREEK DEPOSITS

The McGuffy Creek chromite deposits (fig. 4), studied and mapped in detail by Wells and others (1949, p. 55–62), occur on the south side of McGuffy Creek. The deposits occur in an area of dunite near the south end of the Tom Martin complex (fig. 1). The deposits consist of concentrations of layers, lenses, and schlieren up to 20 cm thick of chromite with intervening disseminated chromite in dunite. The layers strike northwest and dip moderately southwest (fig. 4) and are isoclinally folded. Lineation is commonly prominent and is best indicated by fold axes and parallelly oriented rods and schlieren of chromite. The lineation plunges

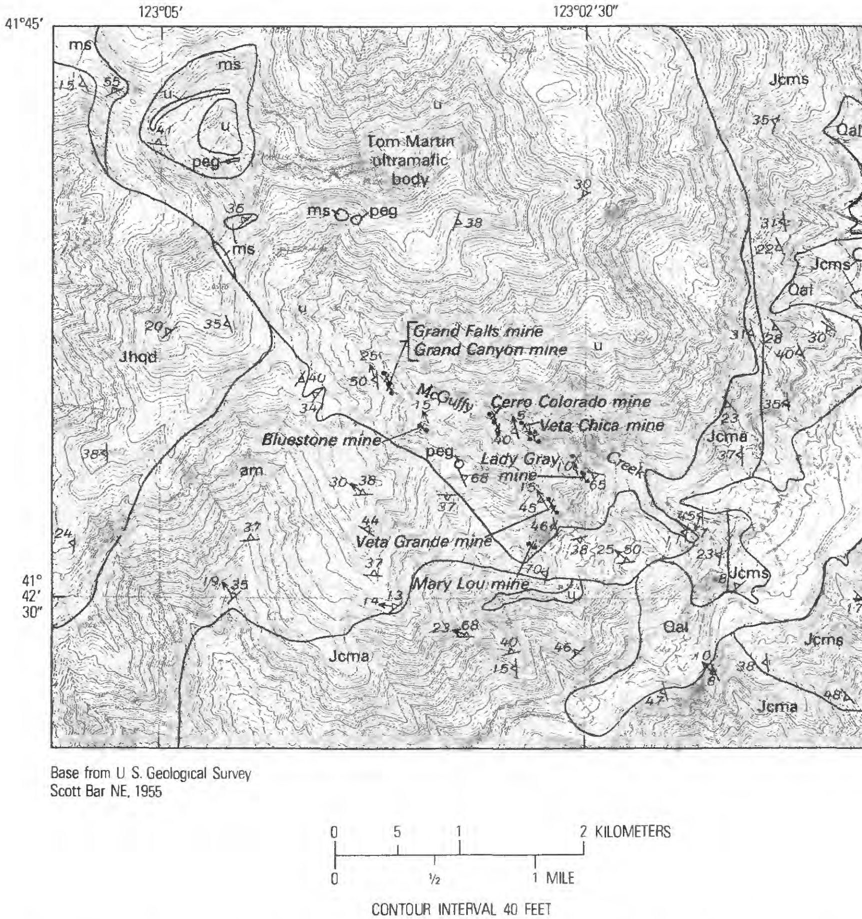

FIGURE 4.—Geology and chromite deposits of the McGuffy Creek area (modified from Barrows, 1969).

5°-25° NW. Foliation and lineation are best displayed in the Veta Chica deposit, but they are also present in the other deposits. The quality of the chromite is good. Five samples analyzed for Wells and others (1949, p. 41) ranged from 56.83 to 58.58 percent Cr_2O_3, and Cr:Fe ratio from 2.29 to 2.83.

Production from the McGuffy Creek deposits amounted to 517 metric tons during World War I and 46 metric tons during World War II. The deposits were intensively explored during World War II by the owners with assistance by the U.S. Bureau of Mines and the U.S. Geological Survey. As a result of this exploration, Wells and others (1949, p. 62) give the following statement of indicated reserves: "It is indicated that approximately 22,860 metric tons of

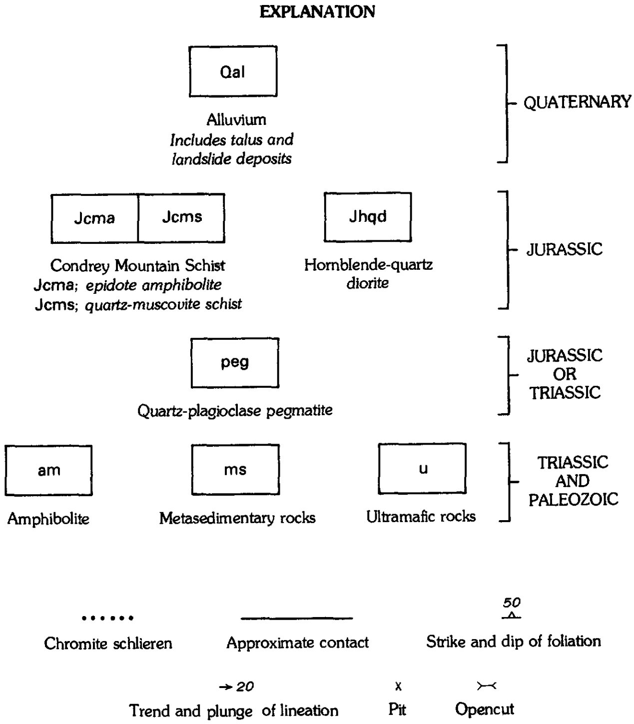

FIGURE 4.—Continued.

ore that will average about 18 percent of Cr_2O_3 can be mined by large-scale selective methods from the claims in the area." Reserves given for individual claims are:

Claim	*Metric tons*
Veta Chica	12,360
Cerro Colorado	8,165
Veta Grande	907
Grand Falls and Grand Canyon	907
Mary Lou	340
Lady Gray	181
Total	22,860

CHEMICAL COMPOSITION

Chemical data for 11 samples of nearly pure chromite are given in table 1. SiO_2 contents ranging from 1.4 to 2.6 weight percent indicate that small amounts of silicates are present in the samples. Six samples are from the Seiad Creek area, one from the Ladd mine, and four from McGuffy Creek deposits. The Cr_2O_3 content

TABLE 1.—*Chemical data for chromite from deposits in the Seiad Valley and Scott Bar quadrangles, Siskiyou County, California*

[Weight percent determinations of oxides: Cr_2O_3 and NiO determined volumetrically and by atomic absorption, respectively, by A. Neuville and P. Aruscavage. SiO_2, Al_2O_3, total Fe as Fe_2O_3, and MgO determined by rapid-rock analysis by Z. A. Hamlin. Platinum metals determined by Joseph Haffty and A. W. Haubert using method of Haffty and Riley (1968). Semiquantitive six-step spectrographic analyses determined by Leon A. Bradley. Values reported are midpoints of arbitrary brackets. G = greater than 10 percent. L = detected but below limit of determination. --- = below limit of determination]

Sample No. [1]	S1-4	S1-5	S1-7	S1-8	S44	S46-1	L7-2	M2	M2-5	M7-1	M8-1
Oxide analyses (weight percent)											
Cr_2O_3	54.6	55.5	54.4	55.8	57.1	58.9	54.3	49.7	56.8	55.2	56.8
NiO	.11	.11	.09	.10	.06	.08	.11	.15	.11	.09	.10
SiO_2	2.6	1.4	2.1	1.9	1.8	2.3	2.4	1.5	1.6	2.1	1.7
Al_2O_3	6.9	7.0	5.4	6.5	8.8	5.0	6.7	16.3	6.6	5.5	6.4
Fe_2O_3 [2]	21.9	21.2	24.6	22.4	21.4	23.0	21.1	17.4	20.5	23.3	20.6
MgO	14.3	13.3	12.6	13.2	11.9	11.1	13.9	15.5	13.8	12.7	13.4
Platinum metals (ppm)											
Pd	<.004	<.004	<.004	<.004	.019	.004	.005	<.004	<.004	<.004	<.004
Pt	<.010	<.010	<.010	<.010	.044	.13	<.010	.014	<.010	<.010	<.010
Rh	.018	.019	.010	.022	.027	.069	.024	.020	.013	.013	.021
Semiquantitative spectrographic analyses (weight percent)											
Si	3.	3.	10.	5.	3.	3.	3.	3.	1.5	3.	3.
Al	7.	7.	3.	3.	5.	5.	7.	G	7.	3.	7.
Fe	7.	10.	7.	7.	7.	10.	7.	7.	7.	7.	7.
Mg	10.	10.	G	10.	10.	7.	G	G	10.	10.	10.
Ca	.15	.15	.07	.15	.07	.07	.07	.005	.005	.007	.03
Ti	.07	.1	.05	.07	.07	.03	.07	.07	.1	.07	.07

(ppm)											
Mn	300	300	500	300	500	700	300	300	300	300	700
Ba	......	......	......	......	......	15	......	......	......	......	......
Co	200	200	150	200	200	500	300	200	300	150	150
Cr	G	G	G	G	G	G	G	G	G	G	G
Cu	3	7	5	5	7	L	50	2	7	15	7
Ni	1,500	1,000	1,500	1,500	700	700	1,500	1,500	1,000	1,500	1,500
Pb	15	......	......	......	......	......	......	......	......	......	......
Sc	10	10	7	10	7	10	15	7	10	7	10
V	500	500	200	500	700	700	700	700	700	300	700
Ga	15	15	15	15	15	15	15	15	15	15	15
Ratio Cr:Fe											
Cr	37.4	38.0	37.2	38.2	39.1	40.3	37.1	34.0	38.9	37.8	38.9
Fe	15.3	14.8	17.2	15.7	15.0	16.1	14.8	12.2	14.3	16.3	14.4
Cr/Fe	2.44	2.56	2.16	2.44	2.61	2.50	2.52	2.79	2.71	2.32	2.70

[1]Sample No.: S1-4, -5, -7, -8, Seiad Creek mine; S44, Black Eagle deposit; S46-1, Anniversary deposit; L7-2, Ladd mine; M2, ,M2-5, M8-1, Veta Chica deposit; M7-1, Bluestone deposit.
[2]Total Fe calculated as Fe_2O_3.

ranges from 54.4 to 58.9 weight percent except for one McGuffy Creek sample (M2) that contains only 49.7 weight percent. This sample contains about twice as much Al_2O_3 (16.3 weight percent) as the other samples; the Al_2O_3 must be in the chromite rather than from included silicates, because the SiO_2 content is only 1.5 weight percent. NiO ranges from 0.06 to 0.15 weight percent; MgO ranges from 11.1 to 15.5 weight percent. Total iron calculated as Fe_2O_3 ranges 17.4 to 24.6 percent. The Cr/Fe ratio ranges from 2.16 to 2.79 and is mostly greater than 2.4.

The assays for platinum-group metals are all low and not noteworthy except for sample S46-1 from the Anniversary deposit, Seiad Creek area. This sample contains 0.13 ppm platinum and 0.069 ppm rhodium; these high contents suggest that other chromite deposits in the Seiad district may have anomalous amounts of platinum-group metals.

ECONOMIC SIGNIFICANCE

The outlook for economically feasible exploitation of the chromite deposits discussed here in the Seiad Valley and Scott Bar quadrangles is not good for the foreseeable future. The deposits are too small and low grade to meet the U.S. chromite requirements for more than a very short period (Thayer, 1973). The largest single deposit, located at Seiad Creek, is 135,000 metric tons containing about 6 percent Cr_2O_3. The McGuffy Creek and the Ladd deposits range from 200 to 12,000 metric tons each; the grade is higher than at Seiad Creek, probably 15-20 percent Cr_2O_3. The Cr/Fe ratio for all of the deposits would probably average close to 2.5.

The deposits described here are disseminated; the chromite would have to be concentrated to be economically recovered. A deposit consists of a number of layers and schlieren 1-5 cm thick, of massive or abundant chromite separated by similar or greater thicknesses of dunite, which is barren or contains scattered chromite grains. Although the largest disseminated deposit found thus far by exploration contains about 135,000 metric tons of mineralized rock, most are less than 15,000 metric tons. The total tonnage is probably close to 300,000 metric tons averaging about 8 percent Cr_2O_3.

The economically minable chromite deposits found elsewhere contain pods and layers of massive chromite thick enough so that nearly pure chromite can be mined from them. Most of the high-grade, high Cr/Fe chromite reserves are in Rhodesia and South Africa. An average deposit there contains at least 1,000,000 metric tons (Cotterill, 1969, p. 174) of ore with Cr/Fe of 3.0 or more

(Cotterill, 1969, p. 171-172; Anhaeusser, 1974, p. 18). Substantial reserves, 1-5 million metric tons of high-grade ore, also occur in Turkey, the Phillippines, Malagasy, India, Iran, and Brazil (Thayer, 1973, p. 117-118).

REFERENCES CITED

Allen, J. E., 1941, Geological investigation of the chromite deposits of California: California Journal of Mines and Geology, v. 37, no. 1, p. 101-167.

Anhaeusser, C. R., 1974, Archean metallogeny in southern Africa: Economic Geology Research Unit, University of Witwatersrand, Johannesburg, Information Circular 91, 38 p.

Barrows, A. G., Jr., 1969, Geology of the Hamburg-McGuffy Creek area, Siskiyou County, California, and petrology of the Tom Martin ultramafic complex: Los Angeles, University of California, Ph. D. thesis, 301 p.

Cotterill, P., 1969, The chromite deposits of Selukiwe, Rhodesia, *in* Wilson, H. D. B., ed., Magmatic ore deposits: Economic Geology, Monograph 4, p. 154-186.

Diller, J. S., 1921, Chromite in the Klamath Mountains, California and Oregon: U.S. Geological Survey Bulletin 725, p. 1-84.

Haffty, Joseph, and Riley, L. B., 1968, Determination of palladium, platinum, and rhodium in geologic materials by fire assay and emission spectrography: Talanta, v. 15, p. 111-117.

Hotz, P. E., 1971, Geology of lode gold districts in the Klamath Mountains, California and Oregon: U.S. Geological Survey Bulletin 1290, 91 p.

———1979, Regional metamorphism in the Condrey Mountain quadrangle, north-central Klamath Mountains, California: U.S. Geological Survey Professional Paper 1086, 25 p.

Hotz, P. E., and Jackson, E. D., 1963, X-ray determinative curve for olivines of composition $Fo_{80\text{-}95}$ from stratiform and alpine-type peridotites, *in* Geological Survey research 1962: U.S. Geological Survey Professional Paper 450-E, p. E101-102.

Irwin, W. P., 1964, Late Mesozoic orogenies in the ultramafic belts of northwestern California and southwestern Oregon: U.S. Geological Survey Professional Paper 501-C, p. C1-C9.

Klein, C. W., 1977, Thrust plates of the north-central Klamath Mountains near Happy Camp, California: Short contributions to California Geology, California Division of Mines and Geology Special Report 129, p. 23-26.

Medaris, L. G., Jr., 1966, Geology of the Seiad Valley area, Siskiyou County, California, and petrology of the Seiad ultramafic complex: Los Angeles, University of California, Ph. D. thesis, 333 p.

Rynearson, G. A., and Smith, C. T., 1940, Chromite deposits in the Seiad quadrangle, Siskiyou County, California: U.S. Geological Survey Bulletin 922-J, p. J281-J306.

Thayer, T. P., 1973, Chromium, *in* Brobst, D. A., and Pratt, W. P., eds., United States mineral resources: U.S. Geological Survey Professional Paper 820, p. 111-121.

Wells, F. G., Smith, C. T., Rynearson, G. H., and Livermore, J. S., 1949, Chromite deposits near Seiad and McGuffy Creeks, Siskiyou County, California: U.S. Geological Survey Bulletin 948-B, p. B19-B62.