GEOLOGY AND ORE DEPOSITS OF THE NORTHEAST QUARTER OF THE SEIAD QUADRANGLE, CALIFORNIA.

A Thesis

by

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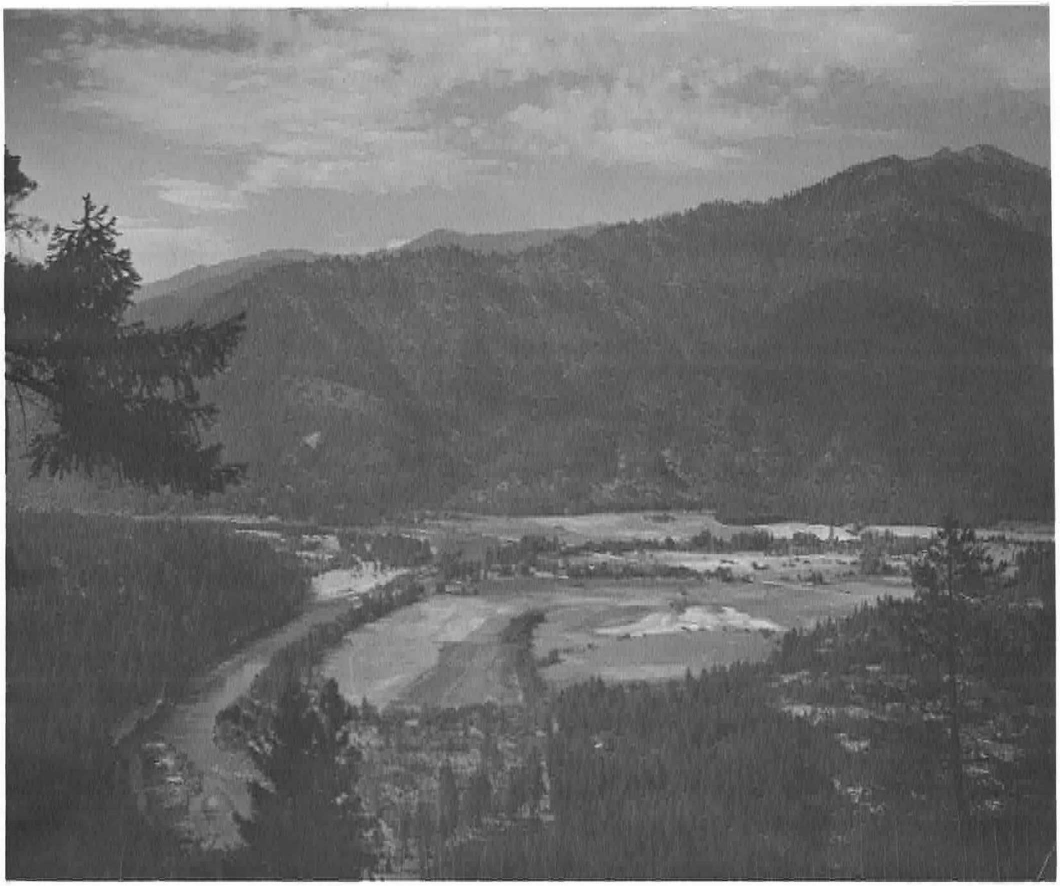
Submitted in partial fulfilment of the requirements for the degree of Master of Science in Geology, to the California Institute of Technology, June 1, 1940.

1940.



Frontespiece:--Seiad Valley, looking north from Walker Ridge road.

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AUTHOR'S NOTE.

This paper presents data which was accumulated by the joint efforts of Mr. G. A. Rynearson and the author in the field and in the laboratory from July 1938 to May 1940. This exposition is largely the work of the writer, who has revised and supplemented a joint report of which Mr. Rynearson and the writer are co-authors. The joint report, now in press, will soon appear as a chapter in the U. S. Geological Survey Bulletin titled "Strategic Mineral Investigations, 1940." Mr. Rynearson is also presenting the data written in final form by himself to Lehigh University in partial fulfillment of the requirements for the degree of Master of Science in Geology.

The maps accompanying this report are preliminary. When the final copies are drafted by the U. S. Geological Survey they will be substituted for the present copies and will include the cross sections indicated on the preliminary maps.

ABSTRACT

This paper describes the results of a field and laboratory study of the geology and ore deposits (dominantly the chromite properties) of the northeast quarter of the Seiad quadrangle, California.

The Seiad quadrangle is located in the central Klamath Mountains in a region of rugged ridges and deep canyons. The oldest rocks are schists overlain by arenites, argillites, marble and metavolcanic rocks. They are intruded and metamorphosed by quartz-diorite, chromium-bearing peridotite, and granodiorite probably representing at least two phases of intrusion. Recent alluvium and remnants of old terrace gravels are found along the Klamath and Scott Rivers.

No definite ages have been assigned to the rocks because of the lack of fossil evidence. The older rocks are probably pre-Mesozoic, while some of the terrace gravels may be of Pleistocene age.

The laboratory study of the chromite ores indicates that they are late magmatic (pneumotectic) ores whose structure is controlled by flowage, fracture-filling and replacement of the peridotite intrusions.

INTRODUCTION

Scope of the Report

This report embodies the results of an investigation of the chromite deposits in the northeast quarter of the Seiad Quadrangle, Siskiyou County, California. The investigation was made under the supervision of W. D. Johnston, Jr., as a part of the Strategic Minerals Program of the United States Geological Survey. The field and laboratory work was done by G. A. Rynearson and C. T. Smith, with the assistance of J. R. Bovyer in the detailed mapping of the Seiad Creek chromite deposit. Field work was carried on from July 25 to November 8 in 1938 and from May 22 to July 13 in 1939.

The purpose of the investigation was to determine first, the chromite resources of the northeast quarter of the Seiad quadrangle; and second, to make as complete a geologic map of the area as was possible in the time allotted. The geologic map accompanying this report was plotted on a scale of one mile to the inch using a base map enlarged from the U. S. Geological Survey topographic sheet of the Seiad quadrangle. The detailed areal mapping in parts of the area is admittedly incomplete. A detailed map of the workings and topography of the major chromite deposit has been completed on a scale of 500 feet to the inch, and a careful laboratory study of the chromite ores has been made.

Earlier Investigations

The present investigation is the first time the area has been geologically mapped. J. S. Diller[1] made a brief study of the

[1] Diller, J. S., Chromite in the Klamath Mountains, California and Oregon. U.S.G.S. Bull. 725, 1922.

chromite deposits during the period of their early development, and W. D. Johnston, Jr., spent a few days in the area examining some of the chromite properties and collecting several specimens, which he later described.[2] C. V. Averill[3] briefly described a number of the

[2] Johnston, W. D., Jr., Nodular, Orbicular and Banded Chromite from the Klamath Mountains. Econ. Geol. Vol. 31, 1936.

[3] Averill, C. V., California Journal of Mines and Geology, Report of State Mineralogist XXXI, 1931.

mines in the California Journal of Mines and Geology. J. H. Maxson[4]

[4] Maxson, J. H., Unpublished Ph.D. thesis, Calif. Inst. of Tech.

mapped the northern portions of the Preston Peak and Crescent City quadrangles to the west. The Shasta quadrangle to the east was mapped by geologists of the Southern Pacific Railway Company.[5] Mapping

[5] Averill, C. V., op. cit.

of the Medford and Grants Pass quadrangles, to the north in Oregon, has been nearly completed by U. S. Geological Survey parties and is to be finished this year.

Acknowledgments

The writers wish to express their appreciation to Mr. W. D. Johnston, Jr., of the United States Geological Survey, for his supervision of the project; and to Mr. F. G. Wells, also of the U. S. Geological Survey, for his many helpful suggestions concerning the field work. Mr. H. F. Byram and the Rustless Mining Company were very cooperative in permitting the writers to study their chromite properties and in furnishing claim maps of two of the deposits. The assistance of J. R. Bovyer in the work on the chromite deposits is gratefully acknowledged. The personnel of the U. S. Forest Service and the local inhabitants cheerfully cooperated at all times with the work of the survey. The writers are especially indebted to Dr. H. J. Fraser for his critical examination of the manuscript, and to Dr. J. H. Maxson for several of the illustrations.

GEOGRAPHY

Location and Accessibility

The region investigated in this report lies in the northeast part of the Seiad quadrangle, Siskiyou County, California (see Fig. 1). The area mapped is roughly bounded by the northern and eastern edges of the quadrangle, Portugese and Grider Creeks on the west, and by north latitude 41° 40' on the south.

Seiad Valley, Hamburg and Scott Bar are the principal settlements. Other habitations are scattered along the Klamath and Scott Rivers. Three lookout stations on the higher peaks are maintained by the U. S. Forest Service.

Of the four major chromite bearing localities, two are served by graded dirt roads and two are served only by trail. The nearest shipping point is Hornbrook, fifty-one miles up the Klamath River from Seiad Valley. Twenty-four miles of narrow, graded dirt road and twenty-seven miles of paved and oiled road make the railroad available to the deposits. Within the area mapped a network of trails and a few graded roads used for fire control make the dominant ridges and larger canyons fairly accessible, but a dense brush cover isolates many parts.

Topography

General Features

The area described in this report lies in the central part of the Klamath Mountains and is divided by the Klamath River and its

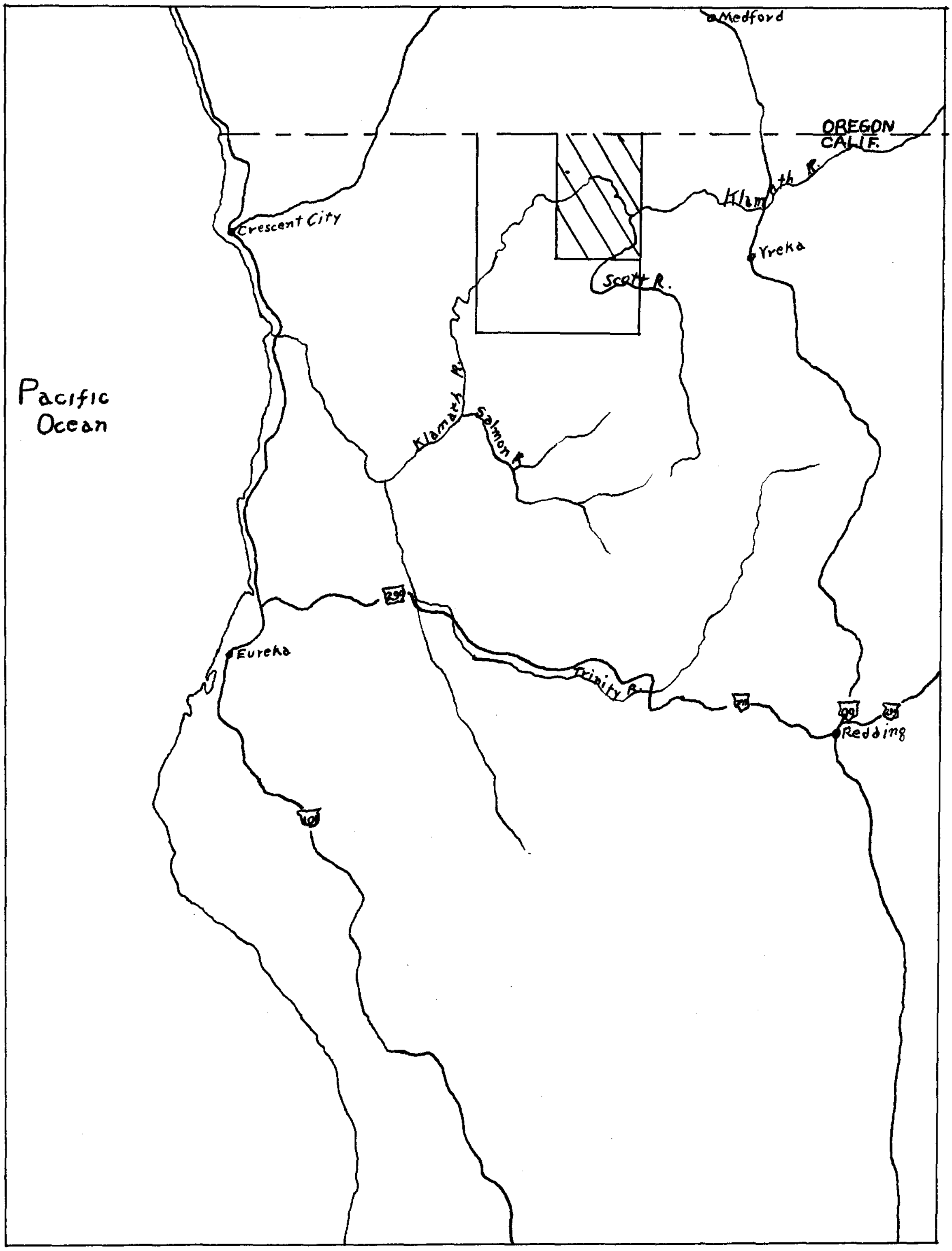

Fig. 1.--Index map showing location of the northeastern part of Seiad quadrangle.

tributary, the Scott River, into three sub-ranges—the Siskiyou Mountains, the Marble Mountains and the Scott Bar Mountains. When viewed from a distance, the main ridges of the three sub-ranges present a rather uniform outline against the sky, suggesting the remnants of a dissected plateau. This plateau, or peneplain, has been discussed in more detail by Diller,[1] Shenon[2] and Maxson[3] in earlier reports.

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[1] Diller, J. S., op. cit.

[2] Shenon, P. J., Geology and Ore Deposits of the Takilma-Waldo District, Oregon. U. S. Geol. Survey Bull. 846-B, p. 160, 1933.

[3] Maxson, J. H., op. cit.

The different rock formations have only a slight control on some of the more detailed topographic features. The broader land forms seem to be related to an earlier period of erosion and uplift than is exhibited at present. The most outstanding topographic features of the area are the canyons of the Klamath and Scott Rivers. Both of these rivers follow winding courses through deep canyons. Wide, rocky bars have been formed at many of the bends in the rivers.

Of the numerous high peaks in the region, Tom Martin Peak is the most striking because of its steepness and its rough, reddish-colored surface made more apparent by the relatively sparse vegetation it supports.

Relief

The region is characterized by extreme relief, which in places exceeds 3000 feet within a distance of one mile. Slopes with a grade of as much as 70% are common. Altitudes range from 7030 feet on Scraggy Mountain to 1300 feet along the Klamath River. Seiad Valley, the most extensive area of low relief, extends over approximately two square miles. There are a few terraces along the Klamath and Scott Rivers wide enough for small pastures and farms.

Drainage

The summit of the Siskiyou Mountains forms the watershed between the Rogue River drainage basin to the north and the Klamath River drainage basin to the south. That part of the area north of the watershed is drained by the Applegate River and its tributaries into the Rogue River, while that part of the area south of the watershed is served by the Klamath River and its tributaries. The largest of the Klamath's tributaries is the Scott River, which drains a large area farther to the southeast. The Scott River is a cold, clear stream, while the Klamath River has a greenish, murky color and is somewhat warmer. Both rivers are inhabited by "suckers" and various species of trout, and at certain seasons are visited by runs of salmon and steelhead trout.

Climate and Vegetation

The climate is characterized by warm dry summers and cooler winters. During the summer, temperatures sometimes reach 100 degrees in the valleys, but the nights are generally cool. Frost frequently forms and the Scott River has been known to freeze over. Snow falls during the winter and remains in protected places on some of the higher peaks throughout the year. During certain seasons low fogs form over the Klamath River, but these generally disappear early in the day. The following climatic data was taken from a publication of the U. S. Weather Bureau (data incomplete):

TABLE I

Scott Bar, Siskiyou County (Elevation 1800)

Precipitation 1922-1930

Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	
.15	.15	.64	1.98	4.51	4.23	
Jan.	Feb.	Mar.	Apr.	May	June	Total
3.23	4.61	1.95	1.79	.77	.68	24.64

Happy Camp, Siskiyou County (Elevation 1132)

Precipitation 1920-1930

Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	
.52	.29	.96	3.03	6.12	7.32	
Jan.	Feb.	Mar.	Apr.	May	June	Total
5.34	6.72	3.58	2.60	.93	.82	35.13

Snowfall 1920-1929

Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	
0	0	0	0.4	0.2	4.0	
Jan.	Feb.	Mar.	Apr.	May	June	Total
4.5	3.7	1.1	0	0	0	13.9

Most of the region is covered by dense growths of timber. The thickness of growth depends, to some extent, on the underlying rocks. For example, peridotite and serpentine areas usually support only a scanty growth of timber, while areas of schist are generally the most heavily covered. The larger part of the trees are conifers, represented by the commoner species of pine, fir, and cedar. Oak trees grow in profusion on the lower slopes. Undergrowth on the timbered slopes is so dense in some places as to be almost impenetrable. Some walnut, apple, pear, plum, and peach trees are cultivated along the Klamath and Scott Rivers.

GEOLOGY

General Features

The Klamath Mountains are composed of schists, meta-volcanics, and meta-sediments complexly intruded by a group of peridotites, granodiorites and other igneous rocks. Several geologic periods are thought to be represented by this rock sequence, although fossil evidence for the various ages is extremely meagre.

The oldest rocks in the area investigated are hornblende, chlorite and mica schists which are tentatively correlated with the pre-Cambrian schists of other regions of the Klamath Mountains. These are overlain by the Applegate formation, a complex series of metamorphosed volcanic and sedimentary rocks assigned tentatively to the Paleozoic period.

An exposed complex of plutonic rocks intrudes the earlier schists and Applegate rocks. This complex may be divided into a metamorphosed quartz-diorite, associated with the Applegate series, peridotite and granodiorite; the latter two appear to be related to the late Jurassic(?) invasion of granodiorite which forms the core of the Siskiyou Mountains.

Recent gravels and alluvium partially fill the larger canyons; at various points along the Klamath and Scott Rivers are found remnants of old terrace gravels, some auriferous, which lie high above the level of the present stream beds and which, in a few cases, may be Pleistocene in age.

Metamorphic Rocks

Schists

A large area of schists is exposed in the eastern part of the region mapped, and a smaller area along the Klamath River northwest of Seiad Valley. These rocks include three distinct types, i.e., mica, chlorite and hornblende schists. The types have not been differentiated on the map and the complexity of their relationships is not fully understood.

The principal exposures of the mica schist are in the northeast part of the area, north from the Klamath River. The color of the rock is pale gray to dark gray and black. This type is characterized by folia of colorless or black mica with varying amounts of quartz. Throughout the schist lenticular stringers of quartz up to several inches in thickness and a foot long occur parallel to the foliation. Pseudomorphs of hematite or limonite after well-formed crystals of pyrite are commonly found. Thin bands of nearly pure quartzite which parallel the schistosity suggest a parallelism between the original bedding and the present foliation. This schist is thought to have been derived from a series of sandy clays and shales.

The chlorite schists are best exposed along and just east of the upper part of Seiad Creek. From here, a belt extends southeast to the Scott Bar Mountains. The rocks are typically light green to dark grayish green and are well-foliated. From thin-section studies, the rocks were found to contain 35% to 80% chlorite, 10% to

45% quartz, 2% to 30% clinozoisite and varying amounts of plagioclase. Stringers of quartz paralleling the schistosity are common and along Seiad Creek lentils of coarsely crystalline calcite and quartz up to a foot long are found. On Copper Butte a narrow zone of quartz feldspar schist may be seen interbedded with the chlorite schist. Under the microscope, this particular rock shows a mosaic of quartz and feldspar, making up 95% of the rock, with biotite occurring as small flakes arranged more or less at random. The mineralogy seems to indicate an igneous origin although this is not definitely proven. The chlorite schist contains marked percentages of feldspar in contrast to the mica schist and is believed to have developed from a series of andesitic or basaltic flows. In a few places complex interfolding of the mica and the chlorite schists can be definitely proven but the broader relationships of the two rocks is not fully understood.

Hornblende schists are closely associated with the chlorite schist and are commonly found near the contacts between the schist and the later intrusives. They are dark green or gray when fresh, and brownish when weathered. The typical rock contains from 55% to 75% hornblende, 15% to 20% plagioclase, 10% to 15% quartz and 1% to 15% clinozoisite, with traces of chlorite, sphene, and limonite. The hornblende schists are believed to be contact facies of the chlorite schist, the development of the hornblende being due to the slightly higher temperatures near the intrusive masses.

Applegate Formation

A series of metamorphic rocks of unknown age is exposed in the higher parts of the Marble Mountains and at scattered points along the Siskiyou summit, finally merging into a broad band which trends northeasterly into the Grants Pass Quadrangle to the north. These rocks, collectively known as the Applegate formation, comprise a wide variety of rock types. They are dominantly a series of metamorphosed volcanic rocks, dark green in color weathering to brown or gray. Interbedded in the meta-volcanics are narrow bands of arenites, mostly tuffs or ash beds, argillites, and large bands or lenses of marble.

The volcanics exposed in the area mapped are now metamorphosed to schists and gneisses with much of the original texture and structure obliterated; mapping along the strike of the rocks to the north where the metamorphism has been less intense reveals the typical amygdules and volcanic structures. The typical rocks consist of a mosaic of quarts and feldspar, constituting 30% to 90% of the whole, with 10% to 50% hornblende and small amounts of magnetite. The feldspar is dominantly andesine but may vary from labradorite to microcline. Some specimens were found to contain 20% biotite and 30% muscovite. Small amounts of chlorite, clinozoisite, zircon, calcite, and apatite also occur. The meta-volcanics are thought to be derived from andesitic or basaltic flows and sills.

The arenites and argillites are fine-grained and have a banded appearance probably developed from the original bedding. Their color varies; when fresh, they are brown, buff, gray or green, and when weathered, all are brownish or black. The arenites represent sandstones and tuffs which by regional metamorphism have been changed to quartzites, quartz schists and gneisses. They contain from 50% to 90% quartz with small amounts of hornblende and other mafic minerals. The argillites are derived from shales and ash and may be recognized by their fissile character, very fine grain and dark color. Their composition is similar to that of the arenites although much finer grained.

The marble occurs as lenses in the arenite and argillites, sometimes several hundred feet thick. The rock is coarse-grained and is grayish-white in color. Smaller lenses of a darker color and a finer grain are sometimes found incorporated in the main mass. These are thought to represent carbonaceous material, as most of the marble gives off a fetid odor when broken. Small discontinuous chert bands and thin quartzite beds are found in various parts of the exposures suggesting the original bedding, much of which has been destroyed by metamorphism. Calcite or dolomite constitutes 90% to 100% of the rock, but one thin section showed 5% tremolite, 4% epidote, and traces of quartz, graphite, apatite and muscovite. Small amounts of tremolite and quartz could be identified in nearly every section. Contact metamorphism is slight, the principal changes being due to recrystallization under stress. This recrystallization has destroyed most of the fossils and none were found in the area mapped. It is hoped that some of the less-metamorphosed lenses to the north will yield some recognizable forms.

Igneous Rocks

Quartz-Diorite

The quartz-diorite is a medium-grained plutonic rock which intrudes the schists and the Applegate formation and is intruded by the peridotites and the granodiorite. The age of this rock is not known, but it is possibly late Paleozoic (?). The color is medium gray, sometimes with a greenish cast. The chief minerals are moderately calcic plagioclase, hornblende, quartz up to 30% and a little biotite.

A slight to well-developed gneissic structure is commonly present. This structure is mainly due to primary flow banding, but in some areas it has been developed by later deformation of the rock. In areas where gneissic quartz-diorite and highly metamorphosed volcanics are in contact it is difficult to distinguish one rock from the other. Because of this feature, no attempt was made to differentiate these two rock types on some portions of the map; i.e., a large part of the area shown on the map as Applegate formation, in the region of Canyon Creek and Devils Peak is probably quartz-diorite with the true Applegate rocks capping the higher parts of ridges and the Siskiyou summit.

Peridotite and Serpentine

The principal bodies of peridotite and serpentine are exposed in a discontinuous band, striking about N20°W from McGuffey Creek to Red Butte on the Siskiyou summit. Less extensive bodies are found along Grider Creek and at the western end of Seiad Valley; small masses are exposed on Lake Mountain, the Siskiyou summit and other high ridges in the area. The bodies are in part sill-like, but small to large dike-like bodies are more characteristic.

By far the greater part of this group of rocks is peridotite of the dunite variety. Locally the dunite grades into saxonite with an increase in the percentage of the rhombic pyroxene, enstatite. The peridotite is relatively fresh; alteration to serpentine is most pronounced along joint planes and shear zones. Small bodies of completely serpentinized rock occur in several places, but these may represent a different phase of the intrusion. The peridotite is yellowish-green to greenish-black on fresh surfaces and weathers from a brownish to brick-red color. The accessory minerals tend to be more resistant to weathering and stand out in relief on the otherwise smooth surface of the rock. The more highly serpentinized rocks weather to a light green or greenish-brown color and are characterized by slick, curved surfaces with a waxy luster. As a rule, areas of peridotite and serpentine may be recognized from other rocks in the field by their reddish colored surface and soil and by the sparse vegetation they support.

The mineral composition of the peridotite varies only slightly. Olivine is the chief constituent, forming as much as 95% of the rock. Chromite and magnetite occur as accessory minerals, usually as sparsely disseminated grains, but sometimes in masses large enough to be of economic importance. Tremolite, talc, anthophyllite, chlorite, magnetite, and serpentine minerals occur as products of metamorphism and hydrothermal alterations.

Only the relative age of the peridotite and serpentine may be determined in this area. They intrude all of the metamorphic rocks including the quartz-diorite, and are in turn intruded by the granodiorite and associated pegmatites. Their age is tentatively classified as late Jurassic or early Cretaceous based on observations[1] in other parts of the Klamath Mountains.

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[1] Diller, J. S., U. S. Geol. Survey Geol. Atlas. Port Orford Folio (No. 89), p. 4, 1903.
Diller, J. S., U. S. Geol. Survey Geol. Atlas. Riddle Folio (No. 218), p. 4, 1924.
Shenon, P. J., Geology and Ore Deposits of the Takilma-Waldo District, Oregon. U. S. Geol. Survey Bull. 846-B, p. 160, 1933.
Maxson, J. H., Economic Geology of Portions of Del Norte and Siskiyou Counties, Northwesternmost California. Report XXIX of the State Mineralogist, Calif. State Division of Mines, p. 131, 1933.

Granodiorite

The granodiorite is a medium-grained plutonic rock, possibly a correlative of the Siskiyou granodiorite of Maxson[2]; it is exposed east of Seiad Valley and between Walker and Grider Creeks. It is light-colored and usually weathers to a friable mass. The principal minerals are quartz, plagioclase, orthoclase, muscovite and biotite. Considerable variations in the percentages of the different minerals produce phases approaching quartz-monzonite and quartz-diorite in composition. Border facies commonly contain large inclusions of Applegate rocks

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[2] Maxson, J. H., op. cit.

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which are partly assimilated and now contain large amounts of garnet and other metamorphic minerals.

Small pegmatite phases are sometimes found in the main mass. They are composed of coarse-grained quartz and soda-plagioclase with books of muscovite and biotite and occasional well-formed garnet crystals. At many places in the area pegmatite dikes, thought to be derived from the granodiorite intrusion, are found cutting the peridotite and the rocks of the Applegate formation. The granodiorite exhibits slight effects of dynamic metamorphism.

Sedimentary Rocks

Terrace Deposits

Terrace deposits are found along the Klamath and Scott Rivers, in some cases as high as 1000 feet above the present river beds. The terraces contain boulders of peridotite, schist, quartz-diorite and granodiorite in a fairly well-consolidated sandy matrix. Some of the deposits are nearly 100 feet thick. Present-day hydraulicking operations for the recovery of gold are rapidly removing these deposits.

The age of the terrace deposits has not been completely determined. Repeated rejuvenations of the rivers, perhaps beginning as early as the Pleistocene, is indicated by the various terrace levels; no fossils were found and no measurements or correlations regarding the absolute age were attempted.

Alluvium

An unconsolidated mixture of sand and gravel with occasional boulders partially fills many of the canyon bottoms throughout the area. This alluvium is extensive enough at Seiad Valley to form a small alluvial plain, in places as much as 30 feet thick.

Structure

The complex structural features of the area have not been completely worked out. However, a number of general observations can be made. The most notable feature is the northerly trend of the rock structures.

The general strike of the schists is northeast to slightly west of north with local variations. The dip is usually moderately to rather steeply northwest, although variable in direction. Because thin bands of quartzite are found paralleling the schistosity it is inferred that the schistosity does not depart widely from the original bedding. Close infolding of the various kinds of schist suggests that isoclinal folding may be present.

The Applegate formation is relatively undeformed. The dips are generally low and are influenced by the proximity of intrusive bodies. Broad, plunging folds such as the one exposed on the north bank of the middle fork of the Applegate River may be traced in a few places although, in general, the rocks dip uniformly to the northwest and strike about N30°E.

The quartz-diorite is intruded as an elongate body trending west of north. Flow-banding is indicated by alignment of the mafic minerals. In the northern part of the area, the well-developed gneissosity is believed to be due in part to later deformation. North of Seiad Creek the quartz-diorite has permeated the schist along the contact forming a wide band of injection gneiss.

The larger bodies of peridotite also follow a north to northwest trend, closely paralleling the structure of the other rocks. Along contacts with the quartz-diorite the peridotite has been injected along planes of gneissosity of the quartz-diorite so that one commonly finds alternating bands of the two rocks over a distance of 500 feet. A well-developed schistosity is prominent in the peridotite and is best developed near the contacts. The chromite bands vary only slightly from the same trends as the schistosity. Small-scale folding in chromite bands occurs in some of the deposits.

Post-ore fracturing on a small scale is found in some of the deposits. Displacements are generally not more than a few feet. One fault zone was observed along Seiad Creek in Sec. 33, T47N, R11W, but the amount of displacement could not be measured. Some mineralization is associated with this fault and a number of gold prospects are located along it. The peridotite and serpentine in places show zones of slickensiding which simulate faulting, but which are probably due to the processes of serpentinization.

Extensive areas of landslides are found in the peridotite. The largest of these occurs on the side of Tom Martin Peak above Scott Bar. The nodular chromite of the Black Spot #1 claim is found on a landslide. Other small slides occur on the ridge between Grider and Walker Creeks and Nigger Creek where the sliding has taken place in zones of intense serpentinization. An immense slide in meta-volcanics associated with serpentine dikes is found near the mouth of the Butte Fork of the Applegate River.

Mineral Resources

Introduction

The mineral deposits of the northeast quarter of the Seiad Quadrangle are both lode and placer. The major lode deposits are chromite and copper; gold furnishes the only economic placer mineral. The major mineral production of this portion of the Seiad Quadrangle has come from the placer gold deposits with several tons of chromite and copper having been produced from lode deposits during the World War 1914-1918. Among the other minerals found in the area are, asbestos, soapstone, and several different gems. The information gained in the present investigation is concerned with the chromite and only general references will be made to the other mineral products.

Chromite

History and Production

Chromite was first discovered in America by Isaac Tyson in 1827 in Maryland. From that time until the opening of large deposits in Asia Minor in 1848, Maryland supplied the bulk of the world's chromite. In 1860 the Tysons acquired the newly discovered chromite prospects in Del Norte County, California. Sporadic production from Maryland, Pennsylvania and California continued until 1873 when competition from foreign sources became too great and all work in the United States was shut down. With the interruption of the shipments from foreign sources in 1915 domestic chromite mining was stimulated and several small lens-like deposits were discovered in the Klamath Mountains after intensive prospecting. Following the entrance of the United States into the war in 1917, mining and shipping began on a sizable scale in Montana, Oregon and California. When the price of chromite collapsed following the armistice all domestic production was shut down and has not been revived to any extent to the present day.

The production of chromite from the northeast quarter of the Seiad Quadrangle has come from four main localities of which the deposit on Seiad Creek is by far the most important. No figures are available on the amount shipped during the war from these claims.

General Features

All of the deposits investigated by the writers occur in relatively fresh peridotite (dunite), i.e., in peridotite in which 50% to 90% of the original olivine remained. This is in direct contrast to the deposits in Del Norte County which are in serpentine or meta-peridotite.[1] The ore bodies are usually tabular or vein-like and contain several distinctive types of chromite ore. Most prominent are the massive or banded ore bodies of chromite-bearing rock in the Seiad Creek and smaller deposits; the bands lense out in the direction of their greatest length and are most sharply defined in the direction of their thickness. A few of the claims contained orbicular and

[1] Maxson, J. H., op. cit.

nodular ore but only in small amounts, and the massive or banded ore comprised the main ore bodies in all of the prospects visited.

Excluding the Seiad Creek deposit, strike lengths of the individual ore shoots are limited to a few hundred feet at most, and usually to only a fraction of that distance. The bands of chromite ore are discontinuous, individual bands being only a few feet or tens of feet in length. The proven depths for the deposits are relatively small, usually less than 100 feet. The average dimensions of an individual prospect would be 100 feet long by 15 feet wide by 20 feet deep. The deposits carry on the average between 20% and 40% of the mineral chromite. The Cr_2O_3 content of the chromite concentrates averages over 50%.

The ore deposits strike approximately parallel to the strike of the peridotite but they are not confined to any particular horizon or zone within the "sill." Faulting is common but very difficult to trace and the average displacement is small.

Mineralogy

The only ore mineral found in any of the deposits is chromite, $FeO \cdot Cr_2O_3$, which, when pure, contains about 68% chromic oxide and 32% ferrous oxide. In nature this condition is seldom found and the chromium is often replaced by aluminum and ferric oxide with occasionally magnesium replacing the ferrous oxide. Thus a complete gradation is possible from pure spinel, $MgO \cdot Al_2O_3$, through picotite, $(MgFe)O \cdot (AlCr)_2O_3$, to chromite.

Olivine and serpentine are the chief gangue minerals found; olivine usually predominates. Separation and concentration of the ore is made difficult by the presence of this gangue. The usual simple gravity separation and concentration is difficult to obtain because of the small difference (i.e., about 1.0) between the specific gravities of the chromite and olivine.

Averill[1] has described the results of some metallurgical work on ore from the Seiad Creek deposit. In attempting a concentration, three types of magnetic separation, two types of flotation and a tabling concentration were tried. The best results were obtained by the U. S. Bureau of Mines Experiment Station at Rolla, Missouri. (See Fig. 2.) In this test the ore tested assayed 32.17% Cr_2O_3. An acid circuit was used on account of the olivine gangue. The chromite was floated and the olivine depressed; one cleaner, under these conditions, produced concentrates that assayed 56.35% Cr_2O_3, representing a recovery of 89.7%. Other tests were made on floating the gangue with good results, but not as good as those given above.

All of the deposits will require mechanical concentration of some sort to be profitable but with hand sorting ore may be shipped direct to the smelter from a few of them.

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[1] Averill, C. V., op. cit., p. 268.

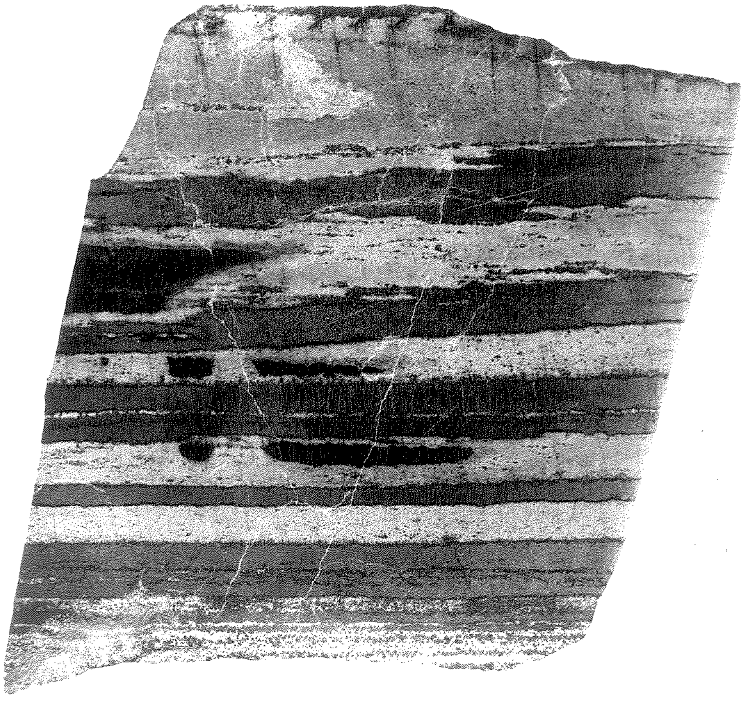
Description of the Ore

Four distinctive types of ore are found in the deposits in the quadrangle, the most important being the massive banded ore so well developed in the Seiad Creek deposit. The banded ore consists of more or less continuous alternating bands of chromite and serpentinized dunite. The chromite bands are usually about a quarter of an inch wide but may occasionally be as much as two or three inches in width. In general the bands appear to have sharp boundaries, but when studied in detail, the chromite grains are seen to crosscut the olivine grains along the edges of the bands. (See Plate II A.) Single bands are not continuous for more than fifteen or twenty feet, but pinch out as another band a few inches to one side or the other reaches a maximum width.

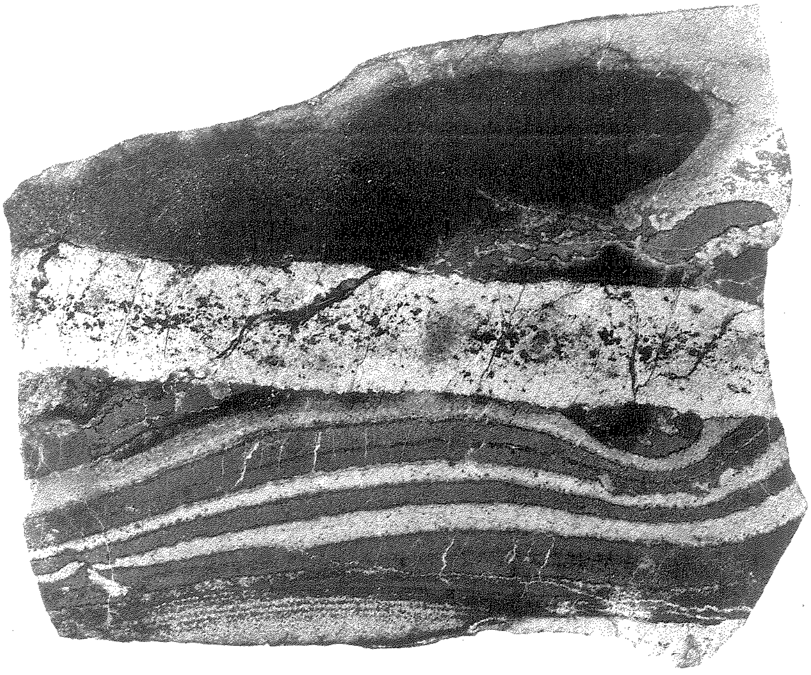
Solid massive ore averaging 60% chromite is found in several of the deposits, but only at the Seiad Creek deposit are the ore bodies of any size. The banded ore grades into the massive ore when the bands are bunched closer together and tend to lose their parallel relationships. However, a rough banding may be seen in even the most massive ore, which is indicative of its mode of formation.

On the dumps of two of the prospects a kind of "plum pudding" or nodular type of ore was found. This consisted of tubular nodules of chromite and serpentine in a partially serpentinized groundmass of olivine. As none of the ore was found in place the relations to the banding and structure of the deposits could not be determined.

Plate II.

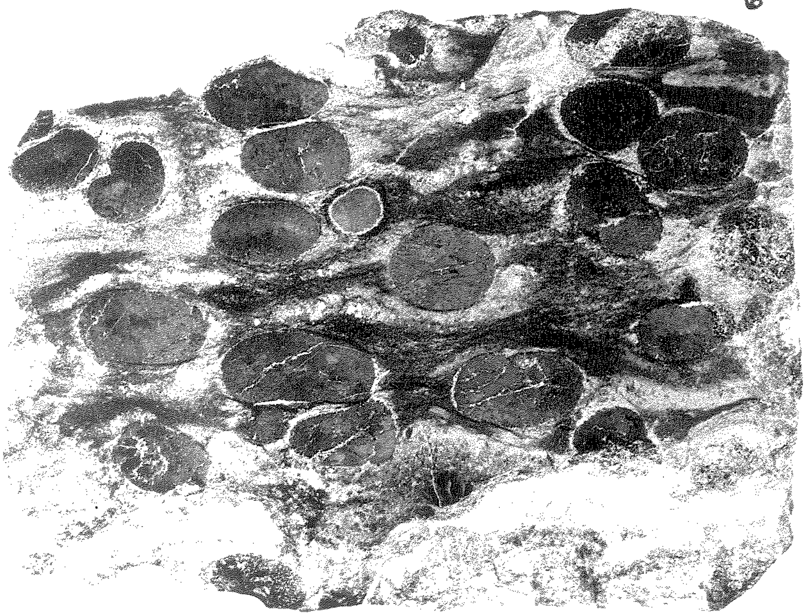


A.
Well-banded chromite ore from the Jumbo Claim.
Small black patches are unweathered peridotite.

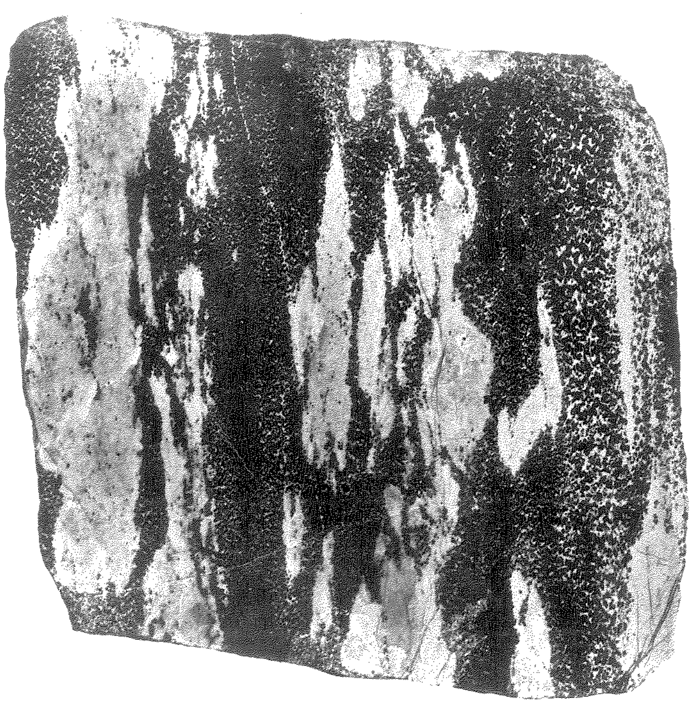


B.
Banded chromite ore (Jumbo Claim) cut by dike of olivine and pyroxene, which in turn is cut by later veinlets (black) of serpentine and carbonate. Cross-fractures in the chromite are also filled with serpentine and carbonate. The dark area in the lower part of the specimen is fresh peridotite.

Plate III.



A.
Nodular chromite from the Black Spot #1 claim.



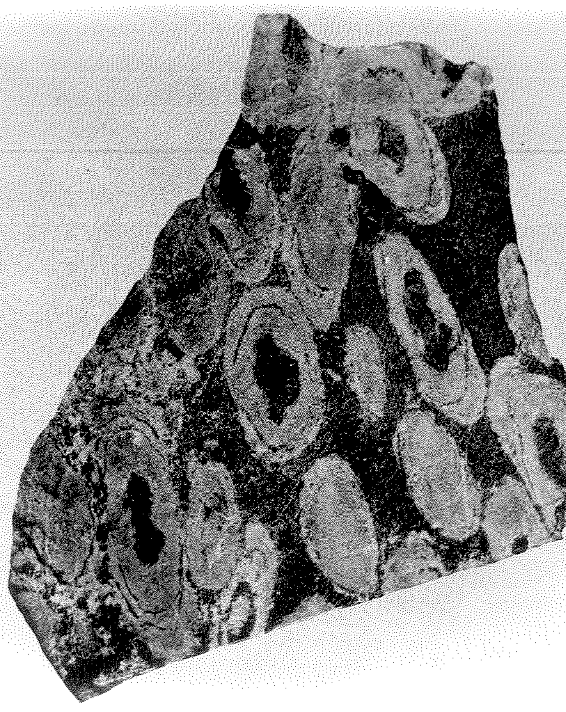
B.
Rudely-banded chromite ore from the Seiad Creek deposit.

In one deposit ore was found, in small amounts, consisting of tightly packed orbicules with a center composed of chromite crystals surrounded by a shell of olivine, imbedded in a matrix of serpentine, chromite and serpentinized olivine. One or more alternating shells of chromite and olivine are sometimes found between the center and outside of the orbicule. In some specimens the interstitial chromite is more abundant than the chromite in the centers and in these cases the orbicular rock is good ore. More often the interstitial chromite is mixed with serpentinized olivine and serpentine and is less abundant than the chromite of the centers and the ore averages only about 20% chromite. (See ~~Fig.~~ Plate IV.)

Localization

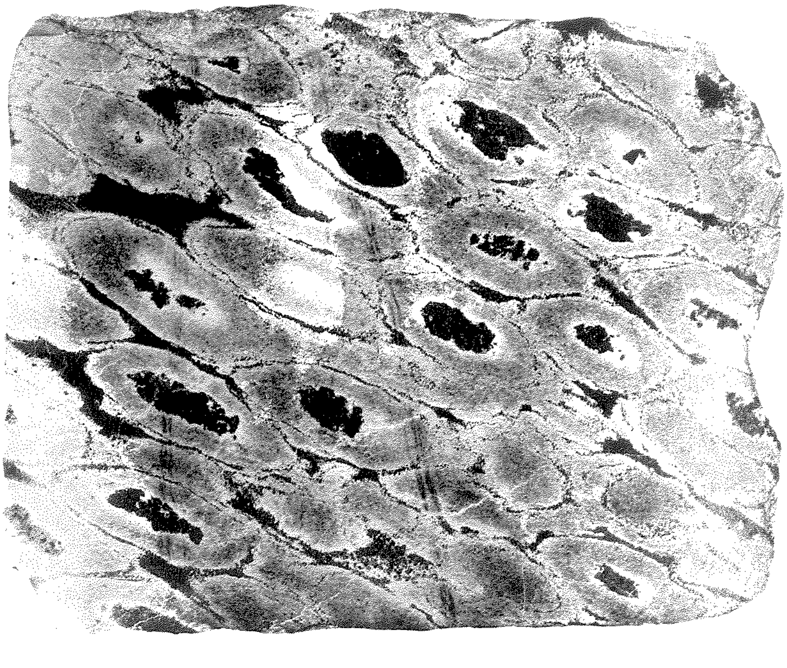
The chromite ore bodies occur in two large peridotite sills or sill-like dikes that trend about N20°-30°W. The peridotite has a well-developed schistosity that strikes N26°-64°W dipping 37°-75°SW and along which the ore bodies are localized. Two well-defined joint systems are present in places with strikes parallel and perpendicular to the strike of the schistosity and dips at approximately right angles to the dip of the schistosity. In the Seiad Creek deposit the schistosity has very nearly the same strike as in the other deposits but dips steeply to the northeast. Although the chromite deposits parallel the floor of the intrusions in a general way they are not found at any particular distance above the base; i.e., they may occur anywhere between the top and base of the "sill." There is

Plate IV.



A.

Orbicular chromite ore from the Octopus claim. Note successive sheaths of chromite and abundance of inter-orbicular chromite.



B.

Orbicular chromite ore from the Octopus claim.

no relation between the size of the deposits and their distance from contacts or their relations to the peridotite.

The larger ore bodies are found as bands more or less continuous in fresh peridotite which has been serpentinized only slightly around the ore bands. At no place in the district were chromite crystals found in direct contact with olivine crystals, they were always surrounded by a narrow sheath of serpentine. At the Seiad Creek deposit, the banded structure occurred in a zone which transected the schistosity of the peridotite, although the individual bands remained parallel to the schistosity. In the other deposits the relations were not as clear due to the small outcrop area and the poor exposures, but the individual ore bands seemed to parallel the schistosity as closely as could be measured.

None of the deposits have been sufficiently developed to prove the attitude of the ore shoots. The estimated tonnage reserves appear in a later portion of this paper. The smaller bodies seem to have a lens-like form and their length is much greater than their width or depth.

Ore varying from disseminated to massive material is random in its occurrence and generally occurs as a link or aureole of low grade material around and between the bands and lenses. It may occur as a few scattered grains throughout the mass of the dunite or it may increase in amount until it makes up fully 60% of the rock. When such concentrations occur, they are directly associated with the banded zones, being merely a zone of coalescence of the bands. No structural control could be found governing the massive ore and the locations or grades of ore bodies are difficult to predict.

The orbicular ore may be considered a mineralogical curiosity since the amounts present do not have an appreciable effect on the total tonnage. The mode of occurrence is similar to the banded ore in all respects. It is flattened parallel to the banding and elongated in the direction of strike, suggesting that the same deformations have affected it as have caused the banding and schistosity in the peridotite. The three types of ore, banded, disseminated and orbicular, grade into one another with no noticeable change in the structure or mineralogy of the peridotite, and are apparently confined to no particular zone or band in the intrusive.

Origin

Chromite deposits have long been regarded as products of magmatic segregation. The constant association of chromite deposits with ultra-basic rocks is indicative of their close genetic relationship and the character of the magma which produces them. Recent workers have questioned the magmatic segregation theory and have suggested the possibility of chromite ores being hydrothermal or at least belonging to a later magmatic phase than that previously assigned to them.[1]

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[1] Sampson, E., May Chromite Crystallize Late? Econ. Geol. Vol. 24, pp. 632-641, 1929.
Ross, C. S., Is Chromite always a Magmatic Segregation Product? Econ. Geol. Vol. 24, pp. 641-645, 1929.
Fisher, L. W., Origin of Chromite Deposits. Econ. Geol. Vol. 24, pp. 691-721, 1929.
Sampson, E., Varieties of Chromite Deposits. Econ. Geol. Vol. 26, pp. 833-839, 1931.
Eskola, P., The Copper Mine of Outokumpu. Finland Geol. Comm. Bull. 103, pp. 26-44, Aug., 1933.

The ores of the Seiad Quadrangle exhibit characteristics which are interpreted by the writers as representing chromite of the pneumotectic period. The chromite in this region everywhere replaces olivine and pyroxene, locally serpentinized near the ore bands. Inclusions of olivine and serpentine (from olivine ?) are common in chromite masses, but chromite inclusions in olivine are virtually absent, indicating the olivine of the ores had nearly completely crystallized before the formation of the chromite. The crystallization sequence is believed to have yielded aqueous, chromite-rich residual liquors which were introduced into adjacent parts of the magmatic mass, possibly by a filter-pressing process.

The banded ores of the Seiad Quadrangle strike northwest and have no apparent relation to the strikes of the surrounding gneisses or schists; they have a rough parallelism to the contacts of the peridotite intrusion. The discontinuous nature of the individual bands suggests a "schlieren" type of flow structure. The lenticular patterns of the deposits and the parallelism of the banding to the fracturing and joint systems developed in the peridotite suggests the influence of structural control on the emplacement and localization of the chromite, perhaps initiated by stresses during intrusion and during the final stages of crystallization. However, the more abundant serpentinization accompanying the chromite and the replacement texture of the bands indicates hydrothermal activity. In conclusion, the banded ore is thought to have originated by fracture filling and replacement of olivine and pyroxene along zones of weakness in a semi-competent crystalline mesh. The development of these fracture systems is believed to be due to differential stresses set up by close association of competent and incompetent portions of peridotite and influenced by flowage in the magma.

It is believed that the deformation which resulted in the injection of the chromite into the banded types of ore was also instrumental in the flattening and elongating of the orbicular and perhaps of the nodular ore. The orbicular and nodular ores have resulted from replacement of an original structure in the peridotite although the origin of the structure is not understood. The presence of rounded phenocrysts of pyroxene associated with the nodular ore suggests that the structures are due to selective replacement of such phenocrysts, but this does not fully explain the alternating shells of chromite and olivine in the orbicular ore.

Throughout the period of injection of the chromite, serpentinization of the peridotite was taking place. This represents the major period of serpentinization, although later hydrothermal activity is represented by cross cutting veinlets of serpentine, accompanied by carbonate, kaemmererite and occasionally uvarovite.

To summarize: the ores of the Seiad Quadrangle are thought to have originated as replacements of ill-defined fracture and flowage zones in peridotite. The chromite was segregated from the original peridotite by fractional crystallization and filter pressing. Stresses controlling the fracture systems caused the chromite-rich residual liquids to be injected into the crystal mesh of olivine.

The nodular and orbicular ores were developed in part, by the selective replacement of pyroxene phenocrysts, but the process is not fully understood. Large amounts of chromite are associated with the serpentinization of the olivine. The late hydrothermal dikes of serpentine carry only small amounts of ore, although they may have abundant kaemmererite or uvarovite. [illegible]

Size and Grade of Known Ore Bodies

Because of the small amount of development work which has been done on the deposits, known ore bodies in the terminology of normal mining practice are non-existent. Those ore bodies which are exposed on the surface and which are intersected by an adit beneath, although blocked on two sides only, are considered as probable ore and discussed as known ore bodies. The same procedure is used on the open cuts of banded ore or lenses with the qualification that a depth of not more than five feet is assumed unless there is reason for doing so.

There is much variation in size in the ore bodies although they are roughly of the same shape. Lenses may contain as low as 50 tons and as high as 50,000 tons of chromite-rich rock with the surface exposures of such bodies being identical. Excluding the Seiad Creek deposit, which appears to have good chances for the continuity of its ore, from the present information all of the deposits are limited to a maximum strike length of about 150 feet. The width is extremely variable, even within the confines of a single band of ore. Due to the en-echelon type of arrangement of the ore bands, the total width is seldom attained across a group of bands. The only depth estimates that can be obtained are the vertical ranges of exposures where the outcrops occur on the side of a ridge slope. Such estimates appear to be fairly accurate in the Seiad Creek deposit where continuity in depth has been proven by adits run beneath open cuts. The depths average about 20 feet although depths as high as 50 feet are known.

Assays were not available for most of the deposits. Grab samples taken across the strike of chromite-rich bands at the Seiad Creek deposit which approximated ore of minable grade averaged 38% chromite and gave a concentrate averaging 52.37% Cr_2O_3. The magnetite was believed not to exceed 5% in any of the samples and may be as low as 1%. An analysis made of the orbicular ore for W. D. Johnston, Jr.,[1]

[1] Johnston, W. D., Jr., op. cit., p. 420.

showed an average Cr_2O_3 content of 51%. These analyses come from widely separated prospects and are believed to be representative of all of the claims. The tonnage estimates which appear in a later portion of this paper are based on ore which is about 35% chromite although higher grade material could be obtained by hand sorting.

Reserves

The ore reserves of the northeast quarter of the Seiad Quadrangle may be divided into two types: (1) Sub-marginal deposits, whose size and grade permit mining only at advanced prices, and

(2) chromite-bearing rocks whose extent and size are so imperfectly known that they can scarcely be considered ore.

Sub-Marginal Ore Reserves:—

Although several occurrences of chrome ore are known in the northeast quarter of the Seiad Quadrangle, only three of these were well-enough developed to allow any sort of detailed investigation. The largest and best developed deposit, owned by the Rustless Mining Corporation, is that found at the forks of Seiad Creek about seven miles from Seiad Valley. A second locality, under lease to the Rustless Mining Corporation, consists of a series of isolated prospect pits near McGuffey Creek about five miles from Scott Bar. The least developed deposit lies approximately 2000 feet above the Klamath River about two miles downstream from Hamburg. A fourth deposit lies on the opposite side of the river from the highway about five miles downstream from Hamburg Bar, but it is so poorly exposed that accurate estimations could not be made.

Owing to the limited exposures and lack of adequate underground workings none of the ore examined by the writers can be considered as blocked out. From surface mapping and grab sampling of the exposures in the open cuts, the first three deposits mentioned above contain an estimated 44,282 short tons of rock averaging 35% chromite. This figure represents actual ore in sight but disregards any reduction due to losses during extraction. Much of the chromite averages better than 50% Cr_2O_3 and the grade of the mine product could be substantially increased by hand sorting or mechanical concentration.

The actual calculations for the individual deposits are shown in the descriptions of the various mines with the assumptions used for each calculation.

Possible Ore from Chromite-bearing Rocks:—

In the known deposits which have been partially developed there are indications of more ore both in depth and along the strike of the formations. 58,266 short tons of rock averaging 35% chromite are believed to be available in undeveloped portions of the first three mentioned deposits (see sub-marginal ore section), and an additional 2000 tons from the fourth.

In addition to the above calculated reserves the deposits of the northeast quarter of the Seiad Quadrangle are estimated to contain 200,000 short tons of rock averaging 20% chromite and 1,000,000 short tons of rock averaging 5% chromite.

Summary:—

	Short Tons of Chromite Bearing Rock	Short Tons of Chromite Available
Estimated Probable Ore (35%)	44,282	
Estimated Possible Ore (35%)	60,266	
Total Estimated 35% Ore	104,548	36,590
Estimated Possible Ore (20%)	200,000	40,000
Estimated Possible Ore (5%)	1,000,000	50,000
Total Estimated Ore Reserves in Short Tons of Chromite Available		126,590

Description of the Deposits

Seiad Creek Chromite Deposit:--

The Seiad Creek chromite deposit is the largest and most promising in the area. No ore has been shipped since 1918 because of lowered prices and prohibitive shipping costs.

The deposit is in Sec. 20, T47N, R11W, on a ridge between the forks of Seiad Creek and seven miles by mountain road from Seiad Valley. Seiad Creek flows a good stream of water the year round and the neighboring slopes are well-timbered.

According to Averill,[1] "Leroy A. Davis of Seiad and Cyrus B. Crawford originally located three claims (about 1916). During the war, 1914-1918, several thousand tons of hand-sorted chromite running about 48% were shipped, part of it by the late Dr. Reddy of Medford, Oregon, who held a lease on the property." The Reddy interests later relocated the deposit and held the claims until 1933 when H. W. Gould of San Francisco located four claims on the deposit. The Reddy and Gould interests held the claims in litigation until 1938 when the Rustless Mining Corporation bought out the litigators. The deposit is now covered by sixteen claims, four of which have been patented.

The deposit is developed by 500 feet of underground workings in two adits and by 27 open cuts and pits. Another short adit has caved. From the end of the road the adits and cuts are accessible by

[1] Averill, C. V., op. cit.

several foot trails and a sled trail. In 1938 and 1939 the present owners improved the road and trails and opened up several new cuts.

The country rock is peridotite consisting almost entirely of olivine partially altered to antigorite and talc. The peridotite has a well-developed gneissic structure striking N26° to 64°W and dipping 37° to 75° NE. A system of jointing is developed with a strike parallel and a dip approximately at right angles to the gneissic structure. The peridotite is in contact with chlorite schist along the east fork of Seiad Creek and with quartz-diorite on the west slope of the west fork of Seiad Creek. Along the contact, the peridotite has been introduced between the gneissic planes of the quartz-diorite so that a zone of alternating bands of the two rocks has been formed. Pegmatite dikes outcrop on both sides of the ridge between the forks of the creek at an elevation of about 4000 feet.

The chromite occurs as a series of elongated bodies arranged en-echelon along the strike of the gneissosity so that the chromite-bearing zone transects the structure of the peridotite. Exposures show bodies of chromite two to fifteen feet thick extending discontinuously along the strike for a distance of 3000 feet. In general, the ore is roughly banded, consisting of stringers and small lenses of chromite intermixed with olivine. The majority of the bands vary from a fraction of an inch to several inches in width, but individual bands of massive ore sometimes attain a width of two feet. Grab samples taken across chromite-rich zones in various parts of the deposit yielded rock averaging 17% to 64% chromite that concentrated to mixtures averaging 52.37% Cr_2O_3 and less than 5% Fe_2O_3. The grade of some of the zones sampled could be substantially increased by hand-sorting. Kaemmererite, antigorite and talc occur in cross-fractures of the chromite.

Minor post-chromite faulting was observed in the underground workings but the measurable displacements were not more than a few feet. Although surface indications are obscured by serpentinization and weathering, faulting has undoubtedly occurred in other parts of the deposit. Whether the faulting is of sufficient magnitude to displace chromite bodies into unexposed positions could not be definitely determined.

Minable (sub-marginal) material is exposed in the various open cuts and adits, ranging from 2 to 15 feet in width, commonly as alternating bands of "high-grade" and barren rock. Many of the bodies are pod-shaped, both in section and in plan, containing massive chromite with little or no olivine, whereas in other exposures the rock is relatively low-grade containing from 5% to 20% chromite disseminated in the olivine. Variations in shape and grade are rapid and unpredictable with ore shoots showing both lateral and vertical thinning. Chromite bodies are exposed underground which do not appear on the surface.

In calculating reserves for this deposit several assumptions were made:

1. An ore factor of 9 was assumed; i.e., 9 cubic feet of ore equals one ton.

2. Each open cut was considered to be a unit unless ore was definitely exposed on the surface between the cuts.

3. The widths assumed only approximate mining widths as considerable barren rock would be eliminated by hand-sorting.

4. Ore was assumed to extend to the depth indicated by the two adit levels unless contrary evidence required a lesser depth.

5. Probable ore is defined as ore in sight from adits, open cuts and surface exposures; depth to adit levels is proven in a few cases or assumed in most cases.

6. Possible ore is defined as ore which is not exposed on the surface nor cut by adits, but which is assumed to be present along the strike of the ore zone.

Based on the above assumptions, reserves of the Seiad Creek deposit are estimated to be:

Total probable ore	37,963 short tons
Total possible ore	51,460
Total reserves based on vertical ore shoots	89,423 short tons
Total reserves based on an average dip of 50°	116,300 short tons.

Fairview Group of Chromite Claims (Hamburg Bar Mine):—

This deposit consists of five claims located on both sides of the ridge in Sec. 34, T46N, R11W. The claims are owned by Mary F. Reddy of Medford, Oregon, and are under option to the Rustless Mining

Corporation. Two miles of graded road connect the deposit with the Klamath River highway. Workings consist of five open cuts on chromite. This deposit has not been worked since 1918.

The chromite occurs as bands and disseminated grains in zones paralleling the gneissosity of the peridotite country rock. The largest concentrations of chromite are exposed in two open cuts near the common corner of the Fiarview claims nos. 1, 2, 3 and 4. The larger cut is on the top of the ridge and exposes chromite bands in two zones (20% to 25% chromite) 2 to 3 feet wide separated by 3 to 6 feet of barren rock. The bands of chromite strike roughly N50°W and dip 40°SW. The chromite shows along the strike for nearly 75 feet. About 10 tons of 20% ore are stacked on the dump. The other open cut also exposes two zones of chromite bands which may represent the displaced extension of the bands in the upper cut. The zones in the lower cut are lower in grade and vary from 6 inches to 4 feet in width.

There are scattered outcroppings of chromite at other places on the claims but their extent is limited and the major part of the chromite appeared to be mined out.

Based on the same assumptions as before the reserves are estimated to be:

Probable ore	1,250 short tons
Possible ore	556
Total reserves	1,806 short tons.

McGuffey Creek Deposits:—

Several chromite claims, collectively known as the McGuffey Creek deposits, occur in the northern part of Sec. 25, T45N, R11W, and in the western part of Sec. 30, T45N, R10W. Ore was shipped from three of the claims during 1918. Since that time four of the claims have been resurveyed and are now leased by H. W. Gould to the Rustless Mining Corporation. A sled trail and several foot trails connect the deposits with the Scott River road. The deposits are described under their former names because in some cases it is not known whether the new claims cover the old workings. Where it is possible the new names are given in parentheses.

Octopus Claim (later relocated as the Mary Lou Claim by Gus Kehrer of Scott Bar and now known as the Chromite Claim, Rustless Mining Corporation):—Workings consist of three open cuts and a short adit which is badly caved. The chromite occurs as bands striking N38°W and dipping 50°SW and paralleling the structure of gneissic peridotite. On the western margin a small quantity of orbicular chromite is found with the orbicules elongated and flattened parallel to the gneissic planes of the peridotite. Chromite bands are exposed over a width of 20 feet with a depth of nearly 50 feet and extending at least 25 feet along the strike. More than half of the exposed width of the zone consists of barren rock. The minable (sub-marginal) portion contains 25% to 35% chromite. There are indications of much faulting and slipping in the peridotite.

Reserves are estimated to be 1,390 short tons of ore averaging 35% chromite.

Red Butte Claim (now the Veta Grande Claim, Rustless Mining Corporation):——Workings consist of two large open cuts, only one of which exposes appreciable amounts of chromite. A short adit has been driven across the chromite zone at the end of the more important cut but it is now caved. As in the Octopus Claim, the chromite occurs as bands in peridotite. Individual bands vary from a fraction of an inch to an inch in width and occur in a zone about 10 feet wide. Chromite is exposed along the strike for 150 feet in this cut, but may extend discontinuously for 300 feet to the other cut. The average grade is about 20% or more. Large and well-formed crystals of kaemmererite occur with talc and serpentine in cross-fractures in the chromite zone. Reserves are estimated to be 3,340 short tons.

Liberty Claim (now the Cerro Colorado Claim, Rustless Mining Corporation):——Workings consist of two open cuts on the west side of McGuffey Creek. The chromite occurs as bands in a contorted peridotite gneiss. The bands of chromite appear to faithfully follow the contorted gneissic structure. The structures are approximately vertical and strike N10°E into the side of the hill. Chromite is exposed over a zone 50 feet wide about 10% of which would be minable (sub-marginal). About 10 tons of 20% to 30% ore is stacked on the dump. Reserves are estimated to be 139 short tons of better than 30% chromite.

Jumbo Claim:----Workings consist of an open cut with a 15 foot adit. The chromite is the banded type and is contorted as in the Liberty Claim. No ore was shipped, but 25 or 30 tons containing about 30% chromite were mined and stacked on the dump.

Neptune or Napatama (?) Claim:----Two open cuts and several prospect holes are opened up on this claim. The chromite is banded and occurs in a zone 5 feet wide and more than 100 feet long. The zone trends N17°W and dips 60°SW. No ore was shipped and because of the discontinuous nature of the chromite in the zone the reserve is not believed to be large.

Black Spot Claims:----Two chromite claims have been located on the ridge north of McGuffey Creek by Elmer Weeks of Scott Bar. The chromite occurs as nodules in both claims. The chromite of Black Spot #1 was found in slide material and that of Black Spot #2 as a small outcrop on the top of the ridge. Reserves for both claims are negligible.

Extensive development is required to test and prove the tonnage estimates of these claims. Trenching along the side of the ridge between the Red Butte and Liberty workings has uncovered small outcroppings of chromite indicating possibilities of other chromite bodies. The ore reserves are doubled if an additional depth of 50 feet and a minable width of 5 feet is assumed for the areas under the known open pits. The total ore reserves may be summarized as follows:

Total probable ore	5,069 short tons
Total possible ore	6,250
Total estimated ore available in the Claims	11,319 short tons.

Dolbear Mine:—

This deposit is located about 800 feet above the Klamath River on the line between Secs. 16 and 21, T46N, R11W. The property is patented by the Reddy interests of Medford, Oregon. Several open cuts on chromite were badly caved and concealed the extent of the ore in the deposit. Small outcroppings were observed along the ridge to an elevation of about 3000 feet. A small amount of uvarovite was noted in cross-fractures of the chromite. Ore was shipped during 1917 and 1918 but reserves are not believed to exceed 2000 short tons of rock averaging 35% chromite.

Barton Claim:—

This claim is located near the northern edge of Sec. 9, T46N, R12W. Ore was shipped in 1918. Nearly all of the chromite has been mined from two open cuts. The chromite was apparently massive and disseminated. No reserves.

Chromite Prospects (names unknown):—

An open cut on massive chromite near the southern edge of Sec. 3, T46N, R13W was visited but nearly all of the chromite had been mined out. About one ton of ore remained on the dump. Some kaemmererite accompanied the chromite which occurs in black serpentine. No reserves.

Three open cuts on disseminated and banded chromite on the eastern edge of Sec. 19, T45N, R10W were visited. Some of the chromite bands are 2 inches wide but the total amount of chromite does not exceed a few tons.

Gold

History and Production

Gold was discovered in the sands of the Klamath River about 1853 and mining has continued steadily to the present day. As is nearly always the case, the first few years of production were the richest, and by 1865 the district was deserted except for the Chinese who worked the gravels for a few cents a day. With the introduction of hydraulic mining, activity was renewed in the area; the Quartz Hill Mine at Scott Bar was worked as early as 1860 as a placer and hydraulicking prospect. Since 1900 the gravels of the river and its tributaries have been worked by a few large hydraulic operators augmented by small leasers. The advance in the price of gold has done much to stimulate recent activity along the Klamath River.

From 1880-1934, $26,700,000 in gold was produced from Siskiyou County. Assuming an average yearly production of $400,000 there was probably an additional $8,000,000 to $10,000,000 produced from 1853 to 1880. No figures are available as to what percentage of these values has been produced by the northeast quarter of the

Seiad Quadrangle, but there are a few large operators in this area who have been producing steadily for a long period of years.

Placer Deposits:—

The placer deposits have been described in a number of the California State Mineralogist's Reports and will not be repeated in this paper.[1] Nearly every bar of the Klamath and Scott Rivers contains gold, but in such small tonnages as to make it profitable only to small-scale operators; the general average grade is about 25¢ to 50¢ per cubic yard. Along the Scott River between Scott Bar and the mouth of the river the gravels average slightly higher, probably due to the erosion of the rich quartz veins of the Quartz Hill Mine which lies just east of Scott Bar outside of the quadrangle. Rich pockets are occasionally found but in general they have been completely mined out. The older gravels found at various heights along the banks of the rivers are generally richer than the recent bars that are shifted by stream action from year to year.

[1] Averill, C. V., op. cit.

Lode Deposits:—

Numerous attempts have been made to work lode deposits in this area but the Quartz Hill Mine at Scott Bar is the only producing deposit. In this mine the gold occurs in quartz stringers in gray mica schist; to recover the values, the ore is shattered by blasting and washed over riffles by hydraulic giants. At the present time the production is sporadic.

Near the forks of Horse Creek active prospecting is developing a small series of quartz stringers in schist similar to the Quartz Hill Mine.

A massive quartz vein carrying arsenopyrite and gold has been mined on the eastern side of Seiad Valley about 3 miles from the Klamath River. More detailed information on these various lode deposits is given in the reports of the California State Mineralogist.[1]

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[1] Averill, C. V., op. cit.

Dredging:—

In the past few years dredging operations have become so efficient that it has been possible to work the very low grade alluvial plains of Seiad Creek and Horse Creek. At the present time a two cubic yard dragline dredge is taking about $9,000 per week out of the plain at the mouth of Horse Creek. As this paper is being written another dredge is being installed to work all of Seiad Valley.

Copper

Copper was discovered in the Klamath Mountains about 1853 but inadequate transportation facilities retarded the development of the mines. Production from the northeast quarter of the Seiad Quadrangle has been confined to a small tonnage mined from the Blue Ledge Mine on Elliot Creek in 1917-1918. A large tonnage of ore averaging nearly 4% copper with appreciable amounts of zinc has been proven in this mine, but the cost of transportation is prohibitive. More complete data is given by Averill.[1]

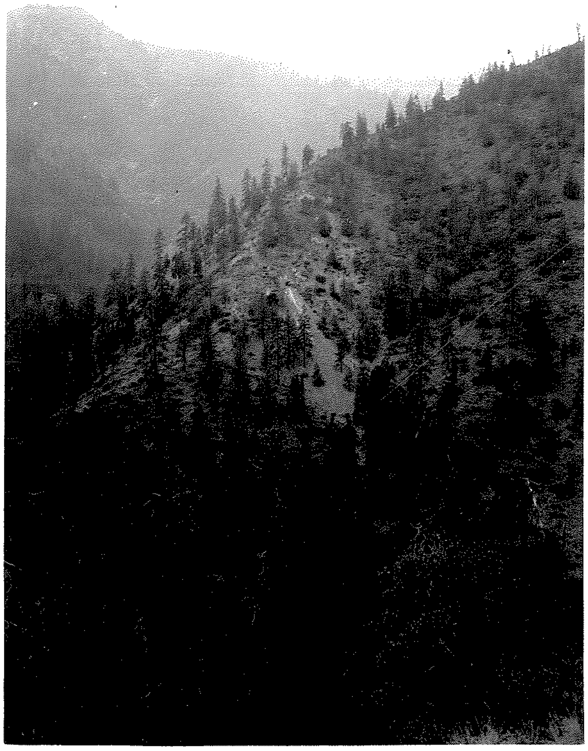
[1] Averill, C. V., op. cit.

Other Minerals

Various gems and other mineral products are found in the area but commercial production is not possible. A few asbestos claims are recorded but the material is too sparse to be exploited. Talc is mined for local use from localities near Hamburg and Scott Bar and a few diamonds were reported by Eakle[2] from the Klamath River gravels at Hamburg.

[2] Eakle, A. S., Minerals of California. California State Division of Mines, Bull. 91, 1923.

Plate V.



A.

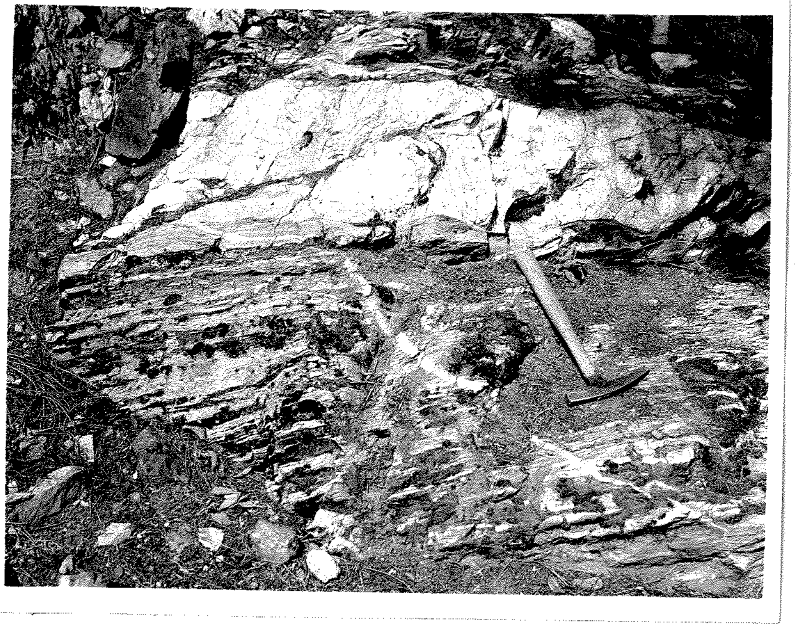
View, looking northwest, of the Seiad Creek Chromite deposit. Chromite-bearing zone extends over ridge in foreground for about half a mile.

B.

View, looking south, of the Lowden Placer workings Seiad Valley. Floor of pit is quartz-monzonite facies of the granodiorite.

Plate VI.

A.
Folded dike of pegmatite cutting Applegate meta-
sediments and volcanics.



B.
Sills and dikes of granodiorite cutting bedded
quartzites and metasediments of the Applegate series.