5916

MINERALOGY OF A COMPOSITE SAMPLE,

HORNBY-MENZIES ULTRAMAFIC COMPLEX

(121° 15' W; 49° 29' N)

New Westminster Mining Division

for

MOUNTAIN PASS MINES LIMITED

by

Dr. A. J. Sinclair, P. Eng.

July 12, 1976

INDEX

INTRODUCTION

Several studies have been undertaken on the so-called Hornby-Menzies property in the Coquihalla ultramafic belt just east of Hope, B. C. , to determine whether or not Ni assays in the range 0. 2 to 0. 3% Ni for scattered specimens might provide an economic source of Nickel (see references). Much of this work has been aimed at traditional milling tests and a limited amount of mineralogical work was done to aid in the interpretation and evaluation of such tests.

The aim of this study is to provide fairly detailed mineralogical information for specimens from a different part of the property than those on which the early work was done. Such a study would thus extend the detailed knowledge of the mineralogy of the ultramafic complex, with particular concern to the mode of occurrence of nickel, and would provide an independent check on the earlier work. This earlier work has been the basis for much of the recent exploration work done on the property and it is thus important to check its reliability.

One of the main results of early mineralogical work was the conclusion that as much as 65 percent of the nickel present in these ultramafic rocks was in the form of sulphides in ultramafic rocks that averaged about 0. 24% Ni.

It was for these foregoing reasons that Mr. M. Menzies requested that the writer undertake a detailed mineralogical study of a large composite sample provided by Mr. Menzies.

The composite sample weighed about 30 pounds and was made up of numerous fist-sized and smaller fragments collected from a trenched area shown in figure 1. All these spcimens were examined by the writer with a binocular microscope and 7 specimens were selected as being appropriate for mineralogical study. Both polished sections and thin sections were prepared for each of the 7 specimens which were labelled

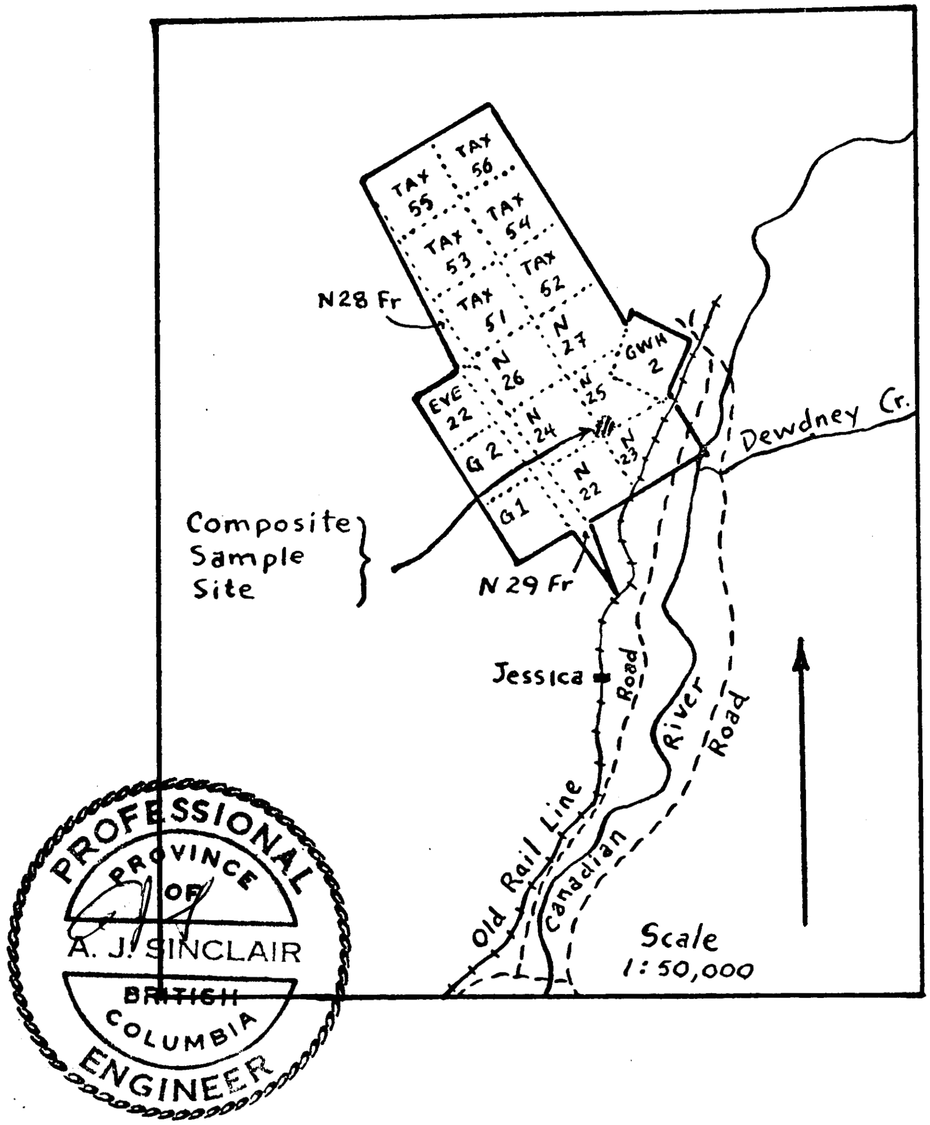

Figure 1: Claims location map on which is shown the area from which the composite sample was collected.

Department of Mines and Petroleum Resources

ASSESSMENT REPORT

NO. 5916 MAP #1

A, B, C, D, E, F and G. Traditional microscope examination was then done.

The writer has not visited the property.

GENERAL GEOLOGY

The Coquihalla ultramafite forms the southern end of a north-westerly trending belt of ultramafic rocks that Chamberlain (1970) has referred to as the Hope-Lillooet arc. For the most part this zone is about 2000 feet wide but in the Coquihalla area it widens to a maximum of about 7000 feet. Some of the areas appearing on G. S. C. maps as ultramafic bodies have been found to consist of diorite (Chamberlain, ibid). No detailed maps have been produced, however, nor has a thorough microscope investigation of the ultramafite been done. Field work by Chamberlain (1971) indicates that serpentinization is variable and is less pronounced in pyroxene-bearing rocks as opposed to those that were rich in olivine. Original rock types are thought to have ranged from dunite and peridotite to clinopyroxenite. Nearby dioritic rocks have an as yet unclear relation to the ultramafite.

PETROGRAPHY

All specimens examined in thin section are serpentite and are described in Appendix I. They are all characterized by an abundance of antigorite with what has been described here as a net texture. Most commonly the individual flakes of antigorite are about 0. 1 to 0. 2 mm. in diameter and show up in section having a lath-shape. Thicknesses of these flakes are about one-quarter the length. Two orientations more-or-less at right angles predominate to give the flakes a definite "rectangular" geometry, hence, the term net texture. However, a small proportion of flakes have somewhat different orientations. Perhaps 90 percent or more of the serpentine is antigorite with net texture. Small areas in which the net texture has one orientation are separated from other such areas with different orientation by "trains" of disseminated magnetite grains that in places form pseudoveins. It seems likely that these trains have originated by serpentinization of olivine, and that the individual areas of net texture represent individual olivine grains. The magnetite and less abundant Ni sulphides almost certainly represent Fe and Ni respectively, extracted from olivine during serpentinization.

A second variety of serpentine appears to be pseudomorphs of serpentine after individual grains of orthopyroxene. This variety has been designated coarse-grained serpentine because even under the microscope individual grains appear, at least superficially, to be single crystals replacing a single grain. In some cases, however, it appears that such grains may be a nearly parallel agglomeration of cryptocrystalline serpentine flakes, thus, the term coarse-grained serpentine might be a misnomer. Nevertheless, the texture is one that is readily recognized and easily distinguished from the net-textured serpentine and the interpretation of the two as representing different primary minerals is not unrealistic. This type of serpentine contains virtually no magnetite, nor are magnetite trains associated with them as is the case with net textured serpentine.

Late serpentine is indicated by veinlets of several types that crosscut the two aforementioned serpentine varieties. These veinlets contain picrolite, chrysotile, serpophite, antigorite and magnetite. Relations among the four types of late serpentine veinlets are not clear. Certainly all are late compared with the net and coarse-grained varieties. Magnetite is commonly associated with serpophite and antigorite veinlets and small amounts of Ni sulphides were observed in a single picrolite veinlet. The great bulk of Ni sulphieds, however, are clearly related to magnetite trains that derive from a serpentinization of olivine, and Ni and Fe are undoubtedly derived from olivine. Source of sulphur is no known but traditionally is thought to be present in hydrothermal fluids that originated outside the ultramafic rocks, perhaps related somehow to fluid flow set up by acid to intermediate plutonic rock related to the Coast Plutonic Complex.

Minute amounts of carbonate have been recognized associated with a single late serpentine veinlet and forming a nebulous small replacement mass through the veinlet and nearby wallrock. The variety of carbonate is not known but it is probably magnesite and is later than at least some of the so-called late serpentine.

In summary the petrogenetic history of the rock would appear as follows:

1. Original rock was a dunite with some specimens verging on the composition of peridotite.
2. Extensive serpentinization was effected by hydrothermal fluids derived from an extraneous source, perhaps a Coast pluton.
3. Serpentinization proceeded in stages.
   (a) serpentinization of olivine to produce net-textured antigorite.
   (b) serpentinization of pyroxene to form the so-called coarse-grained serpentine.
   (c) Late phases of serpentine that formed veinlets cross-cutting the two earlier varieties.

Of course, stages (a) and (b) may have been to some extent contemporaneous.

4. Formation of Ni sulphides was related largely to the early stages of serpentinization and was a response to release of Ni from olivine. A concommittent release of Fe resulted in the development of much magnetite that concentrated as small grains at physical discontinuities, mainly grain boundaries, and these give some indication of primary grain size in the dunite.
5. Late stage veins developed containing various forms of serpentine, variable amounts of magnetite and very minor amounts of carbonate and Ni sulphides.
6. Chromite, the only primary mineral to persist only moderately changed through serpentinization provides an independent source of information on grains size that is consistent with the cellular aspect of trains of magnetite, both indicating grains of 0. 2 to 0. 8 mm. diameter.

ECONOMIC GEOLOGY

Mineralogy:

The following opaque minerals have been recognized in polished and thin sections of rocks from the Coquihalla claims with which this report is concerned:

Chromite
Magnetite
Chalcopyrite
Millerite
Pentlandite
Pyrite
Pyrrhotite
Heazlewoodite

It is of interest to note that native metals, iron sulphides and platinum minerals have not been observed with the exception that minor disseminations of pyrite and pyrrhotite are recorded (of Chamberlain, 1971).

Details of occurrence of each mineral will be discussed in turn.

Chromite: Chromite is the dominant primary opaque mineral whose character has been retained even though complete serpentinization of silicates has occurred. The mineral forms grains from 0.3 to 0.8 mm. diameter, in rocks examined by the writer, and accounts for about 1 percent (volume) or less of the specimens examined. Texture is somewhat variable. Many grains are subhedral and show embayments indicating resorption. Crystal faces are commonly present although not necessarily forming a high prop rtion of grain perimeters. Inclusions of gangue, now serpentine, are common, about 2 to 5 per chromite grain. In some cases these inclusions were overgrown by the developing chromite crystal as shown by the occurrence of crystal faces (see figure 2). In one polished section a definite relict mesh texture was observed as illustrated in stylilized fashion in figure 2. Note that the indicated grain size of primary olivine, now serpentine, as shown by areas enclosed by the chromite mesh, is about 0.3 mm. which is comparable to the grain size of much of the chromite.

In some cases chromite is veined and/or rimmed by magnetite, although many grains observed by the writer in polished sections contain no evidence of magnetite. The rim and veins do not exceed 15 percent (by volume) of the opaque grains.

Magnetite: Magnetite commonly forms 2 to 3 volume percent of the serpentinite although the total range is much wider and locally magnetite makes up 20% with an average of 4-5% (cf. Chamberlain, 1971).

Up to 6 percent magnetite has been recorded by Britton, 1971. Large roughly equidimensional masses with irregular borders occur,

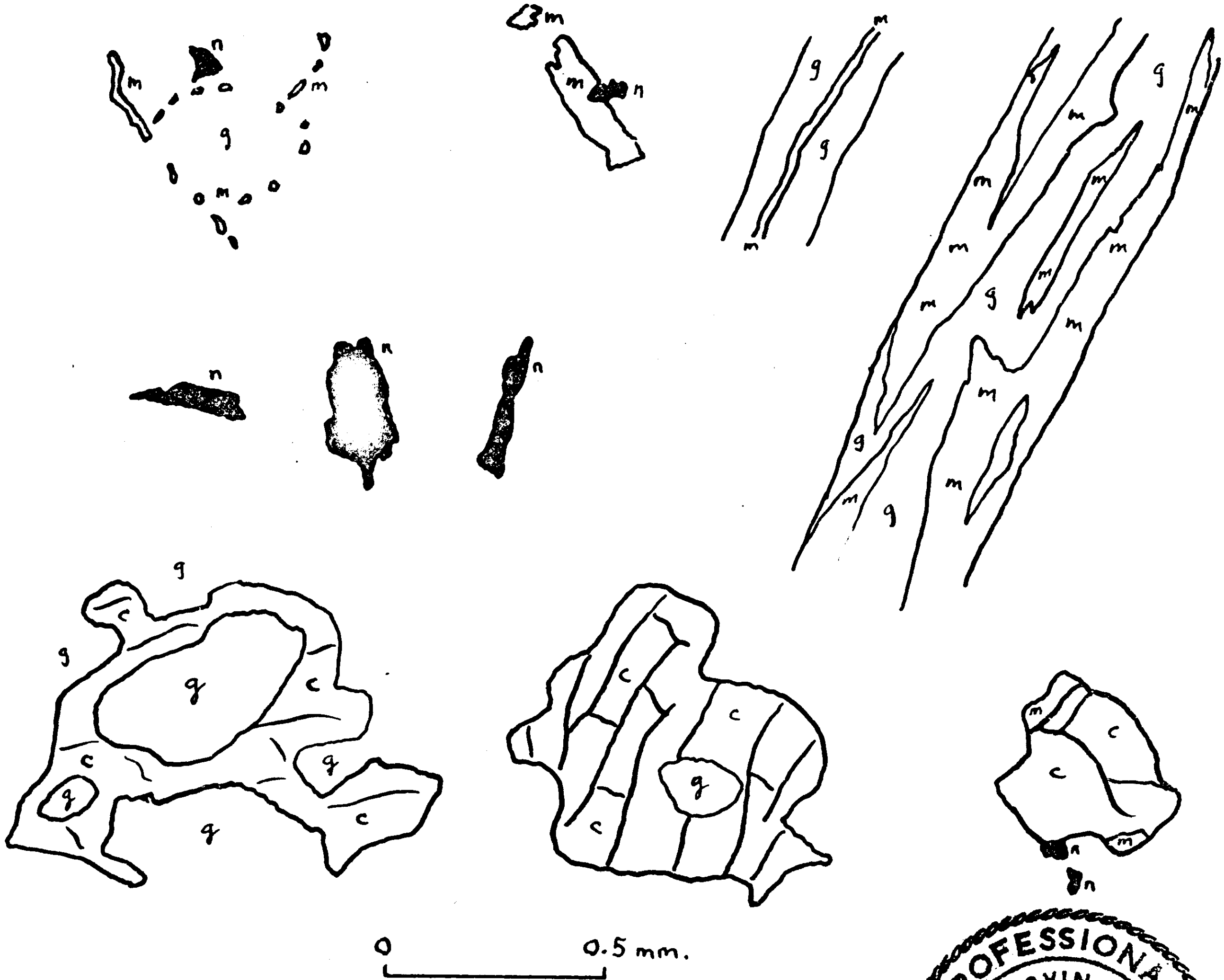

Figure 2: Characteristic examples illustrating textures of opaque minerals. n-Ni sulphides, c-chromite, m-magnetite, and g-gangue (serpentine). Note scale. Also note that "trains" of magnetite, two varieties of veins of magnetite and serpentine, Ni sulphide grains, and several forms of chromite grains (including fracturing, partial magnetite rims and relict intergranular textures) are all illustrated.

but rarely, and are about 0. 2 mm. in diameter, i. e. about the same size as much of the chromite. The origin of these large grains of magnetite is not clear. One might conclude that they were primary to which some secondary magnetite was added during serpentinization, or they might be entirely secondary. The writer leans towards the latter interpretation mainly due to the negative evidence that no crystal faces are apparent -- it seems likely that either some well-developed crystal faces or mesh texture would be preserved were the magnetite grains primary!

A second important mode of occurrence of magnetite is as thin rims and veinlets associated with chromite grains. Quantitatively this is not a main mode of occurrence, but it has serious economic implications for it probably rules out any reason for evaluating chromite, at least for metallurgical purposes, because of the probable high Fe:Cr ratio. The possibility that a chromite-magnetite concentrate might be used as a heavy aggregate or for sand casting should be considered, however.

The greatest amount of magnetite, perhaps 80 percent or more of the total present in the serpentinite occurs in forms that are distinctly related to processes of serpentinization. Three dominant forms are apparent:

(1) Vein-form

(2) Single disseminated grains

(3) Linear patterns or trains of single grains.

Veinform magnetite seems to be most commonly associated with a late phase of serpentinization that in some cases produced serpentine with the character of serpophite and in other cases produced what is clearly antigorite. In rare cases chrysotile has been observed in hand specimen as thin veinlets but it has not been recognized in thin or polished sections and the relation of chrysotile to vein magnetite is not known. Either magnetite or serpentine can predominate in a given vein, or in different parts of the same vein. In its greatest concentration of veins, magnetite practically fills the entire vein for widths of up to 0. 2 mm. but more commonly 0. 05 mm. Lengths of such concentrations are commonly up to 2 mm. or more. This form has been called "bladed" by the writer in the appended descriptions of polished sections.

An equally common form of magnetite is as small individual grains disseminated in serpentine masses, and showing no particular orientation or structure. Almost certainly these grains arose by release of iron from primary silicates (olivine and pyroxene) during serpentinization.

The third common form of magnetite, probably a modification of the last mode of occurrence, is as trains of small grains 0. 01 to 0. 03 mm. diameter concentrated in sinuous, linear patterns that probably represent physical discontinuities in the rock prior to serpentinization -- in particular they probably represent grain boundaries and fractures.

It is the writer's opinion that virtually all of the magnetite present in the serpentinite has formed during the process of serpentinization, rather than representing primary magnetite. This interpretation is consistent with all textures observed although there is a possibility that some of the magnetite rimming chromite is primary.

Pentlandite: Pentlandite has been recognized by Von Hahn (1969) and Chamberlain (Chamberlain and Campbell, 1969) in specimens submitted to him by Mr. G. W. Hornby. The exact location of these specimens is uncertain but they are thought to have been taken from outcrops along the rail line through the claim group and east of Jessica Station. Grains as large as 0. 15 mm. in diameter are documented although such large grains are rare. They are extensively fractured along cleavage directions. The pendlandite is probably secondary in origin because only a very limited compositional range would be stable at the high temperatures of formation of the original rock. A few grains are intergrown with chalcopyrite.

Heazlewoodite: Heazlewoodite has been identified in tailings obtained from beneficiation tests done by Britton (1971) and has been recognized in rock specimens by Chamberlain (1970-1971). The mineral has not been identified by the writer, and its mode of occurrence is not known.

Chalcopyrite: Chalcopyrite has been observed in specimens from outcrops along the rail line where it occurs either as minute grains a few microns in diameter or intergrown with millerite and/or pentlandite (cf. Chamberlain and Campbell, 1969). About one in fifteen grains observed locally was chalcopyrite indicating a very minor copper content. If average Ni content of 0. 24% is entirely in the sulphide form then the ratio 1. 15 chalcopyrite to nickel sulphide grains gives a copper content of the order of 0. 01% Cu. No chalcopyrite was identified with certainty by the writer although one minute grain is considered tentatively to be chalcopyrite. This may indicate that chalcopyrite distribution is sporadic. Origin of the chalcopyrite is secondary, related to serpentinization, as indicated by its occurrence as intergrowths in millerite needles. The Cu may have been present in lattice positions in orthopyroxene, and since orthopyroxene was an accessory mineral, copper can be expected to be a very minor constituent of the serpentinite.

SIZE DISTRIBUTION OF Ni SULPHIDES

Mineralographic work done on specimens indicates that there are two principal size ranges of approximately equidimensional Ni sulphide grains (ignore needle-shaped grains for the present). These have approximate mean diameters of 0. 15 mm. and 0. 025 mm. respectively. There is little question that the smaller grainsize population is numerically much more abundant than is the coarser grained population. However, an interesting calculation can be done to illustrate that a high proportion of sulphide nickel exists in the coarser grained population. The volume ratio for the two mean grain sizes can be estimated as follows:

$$\frac{V_1}{V_2} = \frac{4/3\ (r_1 3)}{4/3\ (r_2^{\ 3})} = \frac{r_1^{\ 3}}{r_2^{\ 3}} = \frac{.012^3}{.075^3} = .0041$$

This result indicates that the volume of a large grain is about 250 times the volume of a small grain. In other words, grains in the small size range must be 250 times as abundant as grains in the larger size range in order for Ni to be present in equal weight amounts in the two size ranges. There are three important assumptions implicit in this statement if it is to be applied meaningfully to the Coquihalla samples: (1) the mean estimates for each population are adequately representative of each population, (2) mineralogy of the grains in both size populations are identical or nearly so, and (3) grains are more-or-less equidimensional. Although there is uncertainty attached to each of these assumptions they are met to a sufficient extent in the writer's estimation that they provide useful information. There is little question that the volume ratio is an order of magnitude too low according to specimens viewed by the writer. In other words, there are substantially more coarser grains than are necessary to partition sulphide nickel equally between the two size populations. The implication is that a high proportion of sulphide nickel in equidimensional grains occurs in the coarser grained population!

Now consider the effect on this result of the presence of needle-like crystals of Ni sulphides that characteristically have lengths of 0. 15 to 0. 2 mm and widths of about 0. 02 to 0. 05 mm. This group represents a third populations of Ni sulphide grains. A subjective evaluation shows that such needles would contribute most to the larger sized population of equidimensional grains rather than to the finer sized population.

CONCLUSIONS

1. Average grades of 0.24% Ni in serpentine can be accounted for as consisting of about 65% Sulphide nickel and 35% silicate nickel.
2. Principal Ni mineral is millerite although pentlandite and heazlewoodite have been identified, as have small amounts of chalcopyrite. Only minor quantities of iron sulphides have been recognized in the area.
3. Grain size of Ni sulphides is variable but commonly is in the range 0.01 to 0.03 mm. diameter. Millerite commonly has a needle-like form with needles about 0.1 to 0.2 mm. long. Limited needle-like form to pentlandite has been reported also.
4. All Ni sulphides and both chalcopyrite and magnetite originated during serpentinization.
5. Chromite is the only primary opaque mineral present in quantity and makes up about 1 percent or less of most specimens examined. A limited amount of ulvospinel has also been reported and is undoubtedly primary.
6. Ni sulphides are almost entirely physically separated from magnetite even though the two are related genetically to serpentinization. Thus, benefication techniques that separate the two might be expected to be relatively efficient separators, barring effects of small particle size.
7. Dioritic rocks associated with serpentinite have been found to contain pyrrhotite and chalcopyrite but not in amounts that seem to be of economic significance (Chamberlain, 1970).

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PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — A. J. SINCLAIR

Dr. A. J. Sinclair, P. Eng.
July 12, 1976.

CERTIFICATE

I, Alastair J. Sinclair, of the City of Vancouver,

Province of British Columbia, hereby certify:

1. That I am a Geological Engineer residing at 2972 W. 44th Ave., Vancouver, British Columbia.

2. That I obtained a B. A. Sc. Degree in Applied Geology from the University of Toronto in 1957, an M. A. Sc. Degree in Geological Engineering from the University of Toronto in 1958, and a Ph. D. in Geology from the University of British Columbia in 1964.

3. That I am a registered Professional Engineer in the Province of Ontario in the Mining Division, and in the Province of British Columbia in the Geology Division.

4. That I have practiced my profession for nineteen years.

5. That I have no interest directly or indirectly, nor do I expect to have any direct or indirect interest in the properties or securities of Mountain Pass Mines Ltd.

6. That the accompanying report is based upon my studies of thin sections and polished sections made on specimens provided by Mr. M. Menzies.

Dated at Vancouver in the Province of British

Columbia, this 12th day of July, 1976.

A. J. Sinclair, P. Eng.

APPENDIX I

THIN SECTION DESCRIPTIONS

Specimens A, B, C, D, E, F and G are prefixed by T S in this appendix to indicate "thin section" description.

TS-A

The section consists almost entirely of serpentine with about 3 percent opaque minerals. Small scattered grains of yellow sulphides are visible megascopically and trace amounts of limonite are also apparent. In thin section the rock is seen to consist of three forms of serpentine. The first is a dominant network of sheets oriented principally in two directions more-or-less at right angles to which the term "network" texture will be applied. Individual grains in this texture are about 0. 2 mm. or less in length. This variety appears characteristic of olivine and the preferred orientation of serpentine grains (antigorite) may be a reflection of structural control by olivine or, perhaps, by fractures in the olivine. Large isolated anhedral grains of serpentine form another characteristic textural variety. These masses have the appearance of single grains although in detail they are seen to be an ultrafine mesh of sheets with almost the same orientation. They are distinctly different from the much more abundant network antigorite although they are also antigorite. The writer interprets these masses as representing serpentinized orthopyroxene on the basis of their texture. If this is true they indicate a grain size of 0. 3 to 0. 8 mm. diameter for the original orthopyroxene. Many of these grains are deformed by kink bands and by shears to give them wavy extinction. Vein type serpentine is not abundant but is found in numerous thin veinlets with magnetite. The nature of the serpentine varies considerably although much of it has the characteristics of serpophite. In other cases it is antigorite and in rare cases it has a crossfibre texture and may be chrysotile.

Several minute grains could not be identified. One single grain about 0. 1 mm. long with a rectangular form has the general characterstics of epidote but this could not be verified. Many masses of serpentine that presumably altered from olivine have small, nondescript cores of low birefreingent material with granular form and high relief.

The great majority of opaque minerals are magnetite occurring in two principal forms. Vein form is most obvious but disseminated form is the most abundant, particularly as "trains" of disseminated grains. Small amounts of yellow opaques, probably nickel minerals, are present but only as disseminated grains that are anhedral in form with diameters of about 0. 1 mm. or less. Millerite can be identified with certainty but many of the grains are too small for positive identification and other pale yellow sulphides could be present. Magnetite has a wide range of grain sizes. Many disseminated grains are minute, about 0. 01 to 0. 03 mm. diameter or less. Another common size is about 0. 1 mm. which is also a common width of vein magnetite. Rare grains up to 0. 3 mm. have been observed. Locally magnetite is limonitized. Chromite is also present but only as a few grains about the same size as the large magnetite masses.

The rock appears to have been a dunite with perhaps 5 percent orthopyroxene and 1 percent chromite, that has now been completely altered to serpentinite with a few grains of chromite representing the only relict of primary minerals and textures.

TS-B

The specimen is a serpentinite with about 3 percent opaque minerals. Minor disseminated yellow sulphides are apparent megascopically. Serpentine is the principal mineral in the thin section with textures identical to those found in TS-A. Proportions of different forms of serpentine differ, however, from TS-A. Large patches of serpentine that appear to have altered from orthopyroxene are common and are up to 2 mm. in diameter. These are set in a mass of fibrous serpentine of the "network" variety. As a rule opaque grains are absent from the orthopyroxene pseudomorphs but are common in olivine pseudomorphs.

Large opaque grains are about 0. 6 mm. diameter and appear to represent original grains prior to serpentinization. Some contain very small inclusions of gangue, now serpentine. Other opaques are associated with serpentine and probably originate by serpentinization. Locally, this latter group has associated with it small yellow sulphide grains both adjacent to and within magnetite. Most grains are subhedral and rare grains show well defined triangular and cubic cross sections.

The rock is a serpentinite. Originally it appears to have been a peridotite but was close to the arbitrary boundary between dunite and peridotote. Only chromite remains of the original constituents.

TS-C

The large patches of coarse serpentine with grains 1 to 3 mm. diameter are set in a matrix of net-textured antigorite. Amorphous serpentine occurs in a few veinlets with magnetite and is later than the bulk of the serpentinization.

Opaque grains of chromite are up to 3 mm. diameter with rounded edges, and embayments indicating partial resorption. Some chromite is coated with a thin rim of magnetite and most grains contain a few gangue inclusions that are now serpentine. Veinform opaques are magnetite which forms small grains about 0. 1 mm. in diameter or less, commonly strung out in trains that provably represent physical discontinuities in the original rock (i. e. grain boundaries and fractures). Magnetite also forms thin veinlets that cut grains of chromite in rectangular pattern. In other cases magnetite bearing serpentine veinlets cross cut chromite and where they do magnetite has been precipitated. This is fairly good evidence for the secondary origin of most, if not all the magnetite associated with chromite.

The rock is a completely serpentinized dunite.

TS-D

The rock consists of about 95 percent serpentine and 5 percent opaque grains. Serpentine is principally of the network type but with significant amounts of the coarse masses and veinform. The textures and mineralogy of these have been described under other sections.

Opaque minerals are about 1 percent chromite and 4 percent others. The chromite grains are from 0. 4 to 1. 2 mm. diameter and contain small inclusions of gangue. Veinform magnetite has a pronounced "bladed" texture in which for sections the vein is completely filled with magnetite and this zone feathers out into serpentine at both ends. Lengths of such masses of magnetite are commonly 2 to 3 mm. and vein widths range up to 0. 1 or 0. 2 mm. In other cases thin seams of magnetite form a more-or-less centrally disposed zone in late serpentine veinlets although, in detail, the magnetite is seen to change position relative to serpentine within the vein.

The rock is a serpentinite and was originally a dunite. Only chromite remains as a vestige of the original rock. Small specks of Ni sulphides are visible megascopically.

TS-E

The specimen consists entirely of about 97 percent serpentine and 3 percent opaque minerals. Serpentine is in two distinct forms, the network variety and large masses of apparently single crystals. These forms represent pseudomorphs of olivine and orthopyroxene respectively, and have been described in detail in previous thin section descriptions.

One grain of chromite is 1.0 mm. long with rounded edges and small gangue inclusions. Another of comparable size is veined by serpentine. The remainder of the opaque grains are mostly less than 0.1 mm. in diameter and occur as disseminated grains or as trains of disseminated grains. Some magnetite also occurs in late cross-cutting serpentine veinlets about the same width as the diameter of magnetite grains or somewhat larger.

The rock is a serpentinite that was originally a dunite. Here one can see evidence in textures for a stage of magnetite development that predates the latest vein serpentinization and probably was contemporaneous with serpentinization of olivine and orthopyroxene. The dominant texture is as granules aligned intermittently in "vein-form" probably outlining physical discontinuities (mainly grain boundaries) that existed at the time of initial serpentinization. In this case the latest period of serpentinization is represented by crustiform layering in cross-cutting veinlets, a few of which also contain blades of magnetite.

TS-F

Serpentine accounts for about 95 percent of this rock, the remaining 5 percent being opaque minerals, mostly of secondary origin. Most of the serpentine is of the network textural variety with only a very small proportion of the apparently coarse-grained variety. Both of these types are cut by thin serpentine veinlets about 0. 1 mm. wide or less.

Three grains of chromite from 0. 2 to 0. 8 mm. were observed, all with rounded form and small inclusions of gangue now entirely serpentine. A few crystal faces are evident.

One bladed vein of magnetite is 0. 3 mm. wide and contains minute inclusions of gangue. Other veinform examples of magnetite are only 0. 01 to 0. 03 mm. wide. Many small subhedral grains are strung out in trains along what are probably former grain boundaries and fractures.

The rock is a serpentite that was originally a dunite.

TS-G

The rock is a serpentinite consisting mainly of network serpentine with less abundant grains of massive serpentine and veinform serpentine.

Chromite occurs as a few regular shaped crystals about 0. 5 mm. in diameter with embayments and rare inclusions of gangue. Disseminated magnetite is abundant as trains and as individual isolated grains. Magnetite in veins commonly shows a bladed appearance with feathered out ends ending in serpentine vein material.

Carbonate was observed in trace amounts but the species is unknown. The carbonate forms a rounded patch at the edge of a serpentine veinlet and replaces both the wallrock (antigorite) and the vein serpentine. A few minute opaque grains are disseminated through the carbonate patch. The carbonate is probably magnesite but no diagnostic test could be applied.

Serpentine is principally as net texture with much less coarse grains, all of which are cut by late serpentine veinlets that contain magnetite.

APPENDIX II

POLISHED SECTION DESCRIPTIONS

Specimens A, B, C, D, E, F and G are prefixed with PS in this appendix to indicate "polished section" description.

PS-A

Total opaque mineral content of this sample is less than 1 volume percent. Magnetite is significantly less abundant than in all other specimens examined but is still the most abundant opaque mineral. Much of the magnetite occurs in veinlets where it is massive and up to 0. 4 mm. wide. In such veinlets it is associated with serpentine. Most of the magnetite occurs as small elongate grains about 0. 03 mm. wide and up to 0. 2 mm. long although some such grains are more-or-less equidimensional.

Chromite is present as a few grains 0. 4 to 0. 7 mm. in diameter. The grains are slightly embayed and contain a few inclusions of gangue. All chromite grains are fractures and have a slightly rounded appearance with some indication of crystal faces.

Millerite is the only sulphide recognized and occurs as small abundant grains with angular appearance. Grains range in size from 0. 02 to 0. 1 mm. diameter. Most are small, a few are elongate 0. 02 mm. wide and 0. 1 to 0. 15 mm. long.

PS-B

The total opaque mineral content of this serpentinite is 2 to 3 volume percent. Magnetite is by far the most abundant opaque mineral and much of it is concentrated in a serpentine veinlet containing wispy "feathers" of magnetite, in places almost massive over widths of nearly 1 mm. Two picrolite veinlets in the hand specimen are about the same size. One of these picrolite veinlets cuts the magnetite veinlet and the other contains two small grains of Ni sulphide. This suggests a paragenesis but picrolite veinlets are not abundant in the specimens examined and it is thus difficult to generalize about them.

Most magnetite is present as small granules, mainly subhedral, about 0. 02 to 0. 04 mm. diameter and strung out along trains. Some such trains are made up in part of elongate grains of magnetite and form pseudo veins. These "trains" of magnetite grains probably represent primary grain boundaries.

Millerite occurs as numerous scattered grains, mainly 0. 05 to 0. 1 mm. diameter. Some thin needles are up to 0. 3 mm. long.

A few grains of chromite, poorly polished, are up to 0. 6 mm. diameter.

PS-C

The total opaque mineral content of this serpentinite specimen is about 2 percent by volume. Most of this is magnetite as disseminations, as small grains in trains and as veinlets -- comparable to other sections described.

Chromite is present in grains up to 0. 8 mm. diameter showing a crude mesh texture indicative of intergranular crystallization. Chromite grains are rounded and probably show relicts of primary texture. As such they give some indication of the grain size of accompanying primary silicates as inferred from the mesh texture i. e. about 0. 3 mm diameter. All chromite grains in this section are cut by thin serpentine veinlets.

Anhedral grains of millerite are about 0. 1 mm. in diameter. Some needles are up to 0. 15 mm. long. In its granular form it is closely associated with trains of magnetite and it is likely that the Ni and Fe in these two minerals derived from serpentinization of olivine. Ni sulphide grains are abundant if small, and many of the smaller ones cannot be identified as millerite with certainty because of their small size.

PS-D

This slide contains much less than 1 percent total opaque minerals by volume. No chromite was observed. The most abundant opaque mineral is magnetite which occurs mainly as small roughly equidimensional grains about 0. 05 mm. diameter. In some cases these grains are elongate masses whose elongation is parallel to trains of small grains of magnetite. In rare cases such grains show one or more crystal faces but the grains in general are anhedral. Less commonly disseminated grains occur within masses of serpentine. Small amounts of magnetite also occur along vei nlets of late serpentine.

Millerite is the only sulphide recognized. It is in part disseminated in early serpentine and in part concentrated as grains, commonly elongate, in trains of magnetite. Numerous grains have a crude needle-like form. Disseminated grains, however, tend to have a more-or-less equidimensional form. Most such grains are 0. 03 to 0. 1 mm. in diameter with a few somewhat larger.

This slide shows good evidence of a textural nature linking the origin of Ni sulphide with the origin of trains of magnetite i. e. both are a product of serpentinization of olivine.

PS-E

Total opaque minerals in this serpentinite are less than 1 volume percent. Magnetite occurs as apparently disseminated grains about 0. 1 mm. in diameter or slightly smaller grains strung out along what appear to be former grain boundaries. In some veins essentially pur magnetite occurs over widths of 0. 1 mm. and for lengths up to 1 mm.

Chromite masses show some crystal faces, and grains are about 0. 3 to 0. 8 mm. in diameter. All grains are fractured with fractures 0. 02 mm. wide and now filled with serpentine.

Millerite is the only sulphide identified and appears to be related to an early phase of serpentinization. Late barren serpentine veins contain magnetite and these cut areas of disseminated millerite mineralized rock. Grain size is mostly 0. 02 to 0. 04 mm. as well as a few needles about 0. 01 mm. wide and 0. 2 mm. long.

PS-F

Opaque minerals are magnetite, chromite and millerite. All pale yellow grains appear to be millerite. They are relatively abundant with a diameter of about 0. 03 mm. and as elongate grains about 0. 15 mm. long and 0. 01 to 0. 02 mm. wide. One minute yellow grain might be chalcopyrite but identification is not certain. All these yellow opaque grains are disseminated in serpentine.

A few rounded and network (mesh texture) grains of chromite about 0. 3 mm. diameter occur surrounded by serpentine. This intergranular texture of some chromite gives a clue as to original grain size of silicates at about 0. 4 mm. diameter, consistent with the grain size of chromite.

Magnetite is common in "bladed" form in veins and as disseminated crystals about 0. 3 to 0. 5 mm. diameter. These crystals are commonly strung out along well defined linear trends, probably former grains boundaries. A very minor amount of Ni sulphides is associated with this hydrothermal magnetite. Most Ni sulphide grains are completely separated from magnetite and chromite.

PS-G

Many grains of pale yellow, equidimensional sulphides are disseminated through the specimen of serpentinite. Most are in the range 0. 1 to 0. 5 mm. diameter with the great majority of these being about 0. 02 to 0. 03 mm. diameter. A small proportion of such grains are as large as 0. 15 mm. diameter. Because of the great disparity in size of these two groups a relatively high proportion of sulphides do occur in the coarser grains. A second distinct textural form of Ni sulphide is the needle-like form in which needles are 0. 15 to 0. 2 mm. long and 0. 01 to 0. 02 mm. wide. The two distinct textural forms appear to be the same mineral i. e. millerite.

Several rounded grains of chromite about 0. 4 mm. in diameter are replaced slightly by magnetite.

Nickel sulphides bear no relationship to chromite. They undoubtedly originated during serpentinization as does magnetite. Despite the common origin for Ni sulphides and magnetite the two are not intergrown or included within each other to any significant extent.

Magnetite forms are described in the polished section description.

Total content of Ni sulphide grains is less than 1 percent.

APPENDIX III

COST AND ALLOCATION OF TIME

Mineralogy	
A. J. Sinclair, Professional Services (Petrography, Mineralography and Evaluation) May 17, 18, 19, 20, 21, 23, 25, 26, 1976 8 days at $175. 00	$1400. 00
B. Cranston, preparation of polished and thin sections. 14. x $8. 00	112. 00
Report Preparation (June 22 to July 12, 1976)	
A. J. Sinclair, 2 days at $175. 00	350. 00
Metro Secretarial	100.00
TOTAL CHARGES	$1962.00

These charges are to be applied for one years assessment work for each of Tax 51, Tax 52, Tax 53, Tax 54, Tax 56 and Eve 22 claims as indicated on "Affidavits on Application to Record Work", dated May 21 and May 26, 1976, in Vancouver, and noted on B. C. Mining Receipts No. 102208 E and No. 102266 E.

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
A. J. SINCLAIR

SUPPLEMENT TO APPENDIX III

Tax 55 was inadvertently ommitted from the last paragraph of Appendix III. The paragraph should read as follows:

> These charges are to be applied for one years assessment work for each of Tax 51, Tax 52, Tax 53, Tax 54, Tax 55, Tax 56 and Eve 22 claims as indicated on "Affidavits on Application to Record Work", dated May 21 and May 26, 1976, in Vancouver, and noted on B. C. Mining Receipts No. 102208 E and No. 102266 E.

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A. J. SINCLAIR

A. J. Sinclair

Dr. A. J. Sinclair, P. Eng.
June 16, 1976