



Ni-Cu-PGE Potential of the Giant Mascot and Cogburn Ultramafic-Mafic Bodies, Harrison-Hope Area, Southwestern British Columbia (092H)

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KEYWORDS: *Economic Geology, Cogburn Creek, Cogburn Schist, Settler Schist, Spuzzum pluton, Hut Creek pluton, Giant Mascot mine, nickel-copper showings, ultramafic cumulate, pyroxenite, peridotite, mafic cumulate, gabbro, diorite, pyrrhotite, pentlandite, chalcopyrite, nickel, copper, platinum, palladium, platinum-group elements.*

INTRODUCTION

The Giant Mascot mine, near Hope, British Columbia, was the only nickel mine in the province. It produced approximately 4 191 035 tonnes of ore averaging 0.77% Ni and 0.34% Cu, and shipped approximately 3.23 tonnes of nickel and 1.43 tonnes of copper between 1958 and 1974 (Tindall, 1987). The mine is rumoured to have produced small amounts of platinum and palladium; however, there are no records of their production or presence in the concentrate. The ore came from shoots in an ultramafic body that are acknowledged to be magmatic in origin. However, there is considerable uncertainty regarding their precise origin and age of emplacement and of the relationship of the mineralized body to other ultramafic bodies in the area, and to the nearby Spuzzum pluton.

In 2001, the British Columbia Ministry of Energy and Mines conducted mineral deposit studies, and mapping (Ash, 2002) and stream geochemical programs (Lett and Jackaman, 2002) to evaluate the potential for platinum-group elements in the ultramafic rocks in the Cogburn Creek area, east of Harrison Lake. This study compares and contrasts the geology and mineralization found at Giant Mascot with that in the Cogburn Creek area; provides geochemical data; discusses the distribution of platinum-group elements and reviews the exploration potential of the ultramafic rocks.

GEOLOGICAL SETTING

The Cogburn Creek area, located east of Harrison Lake (Figure 1), is underlain by highly deformed, and locally highly metamorphosed, meta-volcanic, meta-sedimentary and plutonic rocks. The area has attracted a considerable amount of study over the past thirty years and several theses have been written. Some, by Aho (1954), Muir (1971), McLeod (1975) and Vining (1977) specifically relate to the geology of the Giant Mascot deposit, while others, by Read (1960), Richards (1971), Lowes (1972), Gabites (1985), Bennett (1989), Hettinga (1989) and Troost (1999) are more

concerned with the tectonic and metamorphic history of the belt. Brown and Walker (1993) and Journeay and Monger (1994) discuss various aspects of this latter work and Ash (2002) provides a review of current thinking on the tectonic history of the area.

Monger and Journeay (1994) subdivide the stratabound rocks east of Harrison Lake into three units and provide the following interpretation of the tectonic relationships. The westernmost unit, Unit 1 (MSL, Slollicum Schist) is composed of greenschist facies volcanic and sedimentary strata of probable Triassic to Cretaceous age that the authors assign to the Harrison Terrane, which is stratigraphically linked to Wrangellia Terrane west of Harrison Lake. The central package, Unit 2 (PMCS, Cogburn Schist) consists of Paleozoic to Mesozoic amphibolites, meta-cherts and meta-pelites that are similar, and probably equivalent to rocks of the Hozameen and/or Bridge River Group in the Bridge River Terrane (Journeay and Monger, 1994). Cogburn Schist is intimately associated with two plutonic units, Unit 3 (Pmu, ultramafic rocks) and Unit 4 (PPY, Yellow Aster Complex meta-diorite and meta-gabbro (a.k.a. Baird meta-diorite, Gabites (1985))). The latter units appear to be part of the same rock assemblage as the Cogburn Schist. The easternmost unit, Unit 5 (MS, Settler Schist) is composed of high-grade meta-sedimentary rock of possible Cretaceous or older age that Monger and Journeay (1994) assign to the Cayoosh Assemblage; a sedimentary unit that overlies the Bridge River Terrane.

The layered units are cut by an older, mid- to Late Cretaceous (96 - 104 Ma), foliated, diorite pluton (Unit 6, Spuzzum Pluton) and a younger suite of Tertiary age, post-orogenic quartz diorite to granodiorite intrusions (Unit 7, Scuzzy Pluton, Chilliwack Batholith).

According to Journeay and Monger (1994) the central, Cogburn Schist package (Units 2, 3 and 4) is fault bounded to the northeast and southwest and is tectonically juxtaposed against Units 1 and 5 by steep, regional-scale northeasterly dipping, high-angle reverse faults. However, recent work by Ash (2002, this volume) provides a different structural interpretation. He suggests that the belt includes two tectonostratigraphic packages, an upper package consisting of Unit 2 (PMCS, Cogburn Schist), Unit 3 (Pmu, ultramafic rocks) and Unit 4 (PPY, Yellow Aster Complex) and a lower package comprised of Unit 1 (SML, Slollicum Schist) and Unit 5 (MS, Settler Schist). The rocks are highly deformed and the former is tightly infolded with the latter.

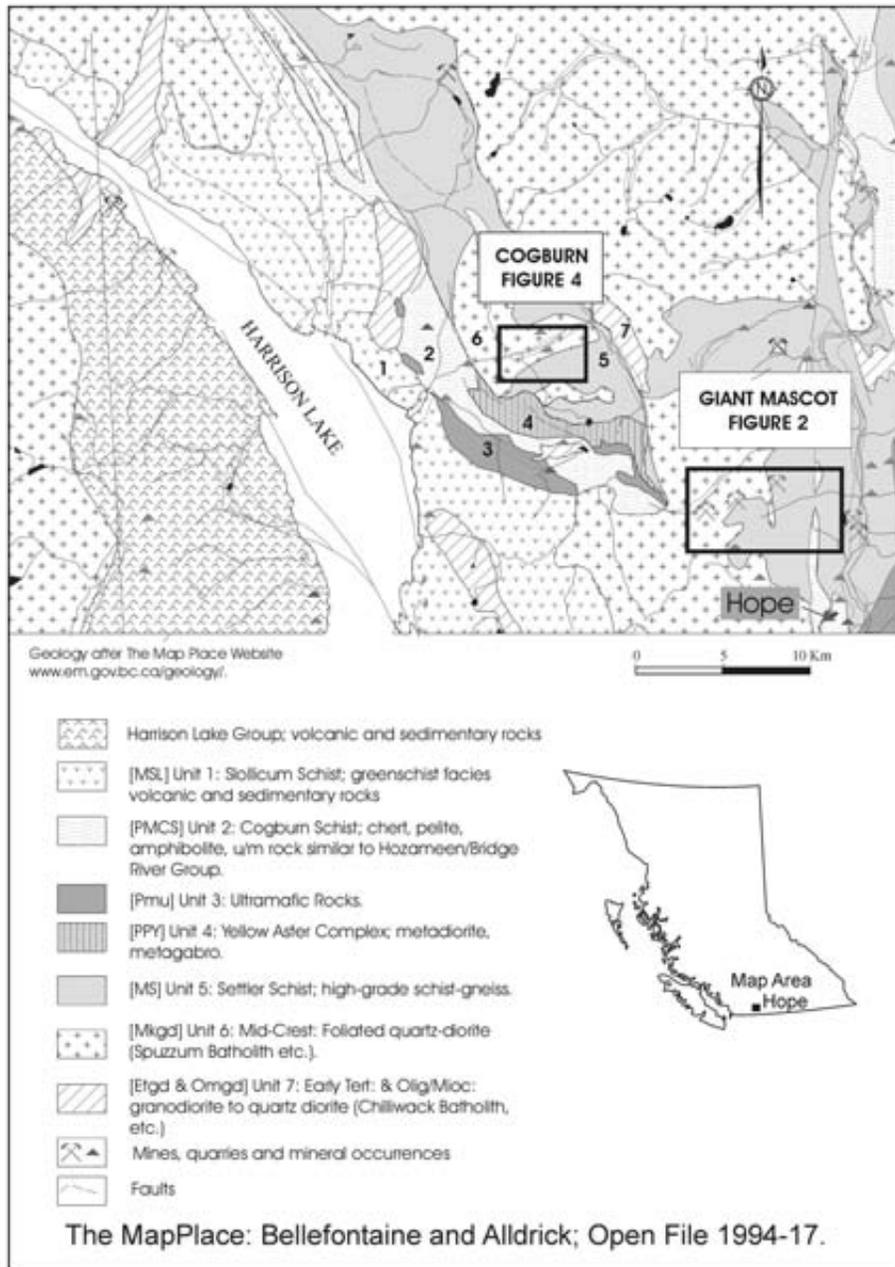


Figure 1. Generalized bedrock geology map of the Harrison - Hope area showing the mineralized areas studied. Data after Bellefontaine and Aldrick (1994), Monger and Journeay (1994), Monger (1970, 1986 and 1989) and "The Map Place" website.

The ultramafic rocks in the area occur in two distinct geological settings. Most occur as large and small, discontinuous lenses in northwesterly-trending belts on either side of the Cogburn Schist and can be seen to the west and east of Talc Creek (Figure 1). The belts can be traced from north of Cogburn Creek, south to Emory Creek, where they appear to be cut-out by the Spuzzum pluton. These lenses show no obvious relationship to the Spuzzum or other, apparently younger, plutons.

By contrast, the remaining ultramafic bodies are intimately associated with rocks of the Spuzzum pluton (Figures 1). They include the Giant Mascot ultramafic body, which hosts the nickel-copper deposit (Figure 2). This is on strike with the northeastern belt of ultramafic lenses discussed above, but is separated from it by several hundred metres of Spuzzum pluton diorite and shows no clear relationship with the Cogburn Schist. There is no indication of a contact between the two, but the ultramafic rocks are partially juxtaposed against high-grade metamorphic rocks of the Settler Schist. The nature of that contact is uncertain, but inclusions of schist are found in the ultramafic body. Further north, the Hut Creek mafic to ultramafic body, which hosts the nickel-copper showings at Cogburn Creek, is similarly enveloped by diorite and separated from the Cogburn Schist unit. It is also in close contact with Settler Schist (Figure 1).

The relationship between the ultramafic rocks found in the two disparate structural settings is uncertain. McLeod (1975) suggests that the Giant Mascot cumulate probably formed through early fractionation of the Spuzzum pluton; however, Ash (2002) suggests that it may be a raft of Unit 3 caught up in the diorite.

GIANT MASCOT MINE AREA (MINFILE 092HSW 004)

INTRODUCTION

The Giant Mascot (Pacific Nickel) deposit is located at the head of Stulkawhits (Texas) Creek, approximately 20 kilometers by road northwest of Hope. It was discovered by a prospector, Carl Zofka, in 1923 and was subject to a considerable amount of surface exploration and underground development prior to the first attempt at production, in 1958. This failed but, with improved metal prices and corporate restructuring, the mine was successfully restarted the following year. Giant Mascot Mines Limited acquired the operation in 1961 and kept it in near-continuous production through to 1974. It was temporarily closed in November 1968, following the collapse of one of the Brunswick stopes, and in August 1970, when the 1270 tonne/day mill burnt down. In the mid-1960s, the mine employed approximately 130 people. The upper part of the Pride of Emory deposit was mined by open pit methods; however, most of the ore was extracted by cut and fill and long-hole mining methods. The mine produced a bulk nickel-copper concentrate, most of which was trucked to Vancouver and shipped to the Sumitomo smelter in Japan (Stephens, 1963). Aho (1954, 1956), Clarke (1969), Christopher (1974) and Christopher and Robinson (1974) discuss the mine's development at dif-

ferent stages in its life. There were no systematic studies of platinum-group element distribution at the mine while it was in production, but there are enough published analyses (Hulbert, 2001) to indicate that platinum and palladium must have been present in the ore.

In 2001, Ministry of Energy and Mines staff revisited the Giant Mascot deposit, examined and sampled the surface rocks and collected a wide range of mineralized samples from the dumps for a study of platinum-group element distribution. Figure 2 is a simplified geology map of the Giant Mascot ultramafic body after Aho (1954). It shows the distribution of the principal ultramafic, mafic and sedimentary rock types and sample locations. The Pride of Emory is the only orebody exposed on surface and access to *in-situ* mineralization was limited. However, the principal lithologies are exposed in zones of near-continuous outcrop along the main road from the mill-site to the 3550 level adit.

HISTORY

The mine consisted of a series of small ore-shoots, most of which were clustered at the west end of a (2.0 km long) ultramafic body that underlies what is now known as Zofka Ridge (Figure 2). The shoots were predominantly northerly plunging "pipe-like" and northerly dipping "tabular" bodies of mineralized peridotite and/or pyroxenite (Figure 3). The mill was developed at the head of Stulkawhits Creek and most of the ore-bodies were developed through an upper portal at the 3550 level, driven through the ridge into the Emory Creek drainage, and a lower, main haulage, portal at the 2600 level. Over the years, the owners undertook a considerable amount of development between these levels, particularly on the 3250 and 2950 sublevels. They also drove a major crosscut on the 3050 level to access two satellite ore-zones north and east of the main development (Figure 3). These deposits were also accessed by means of a portal collared at 3275 feet elevation along the main access road over Zofka Ridge.

The Brunswick and Pride of Emory ore-bodies were the only deposits of any size to crop out at surface (Figure 3). Most of the shoots were located and defined by underground drilling. The company systematically drilled off large sections of the main access levels with 200 ft (61 m) spaced, horizontal drill holes. Production came from numerous ore-zones in several deposit clusters. Table 1, after Christopher and Robinson (1974), summarizes the approximate dimensions, tonnages and nickel-copper grades of 26 ore-zones. Most contained a relatively modest tonnage; however, four (Pride of Emory, Brunswick #2, 4600 and 1500) are reported to have each contained in excess of 500 000 tonnes at mineable grade. The table shows that Ni/Cu ratios of the ore-zones range from 1.78 (4300 zone) to 4.03 (2000 zone) with several clustering around values of 2.3 and 3.0. There is no obvious pattern to their distribution among the ore-shoots and, given the intimate association of both high and low values in the Brunswick area, they probably reflect a single episode of deposit formation, possibly followed by some remobilization of the component metals. As of October 1st, 1973, reserves at the mine were 860 000 tonnes grading 0.75 % Ni and 0.30 % Cu (Tindall, 1987).

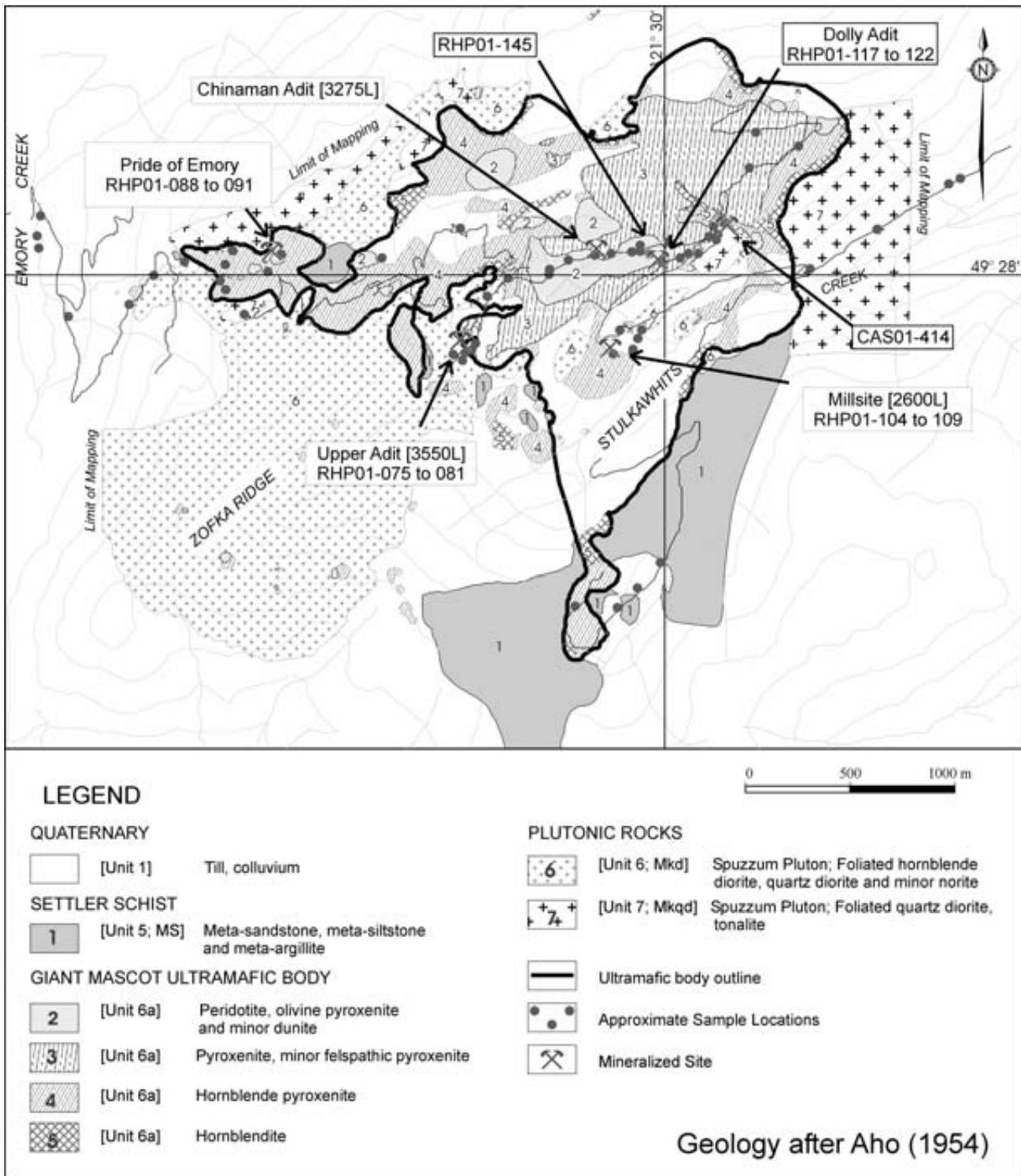


Figure 2. Schematic surface geology map of the Giant Mascot area, after Aho (1954), showing the principal rock units named locations and sample sites.

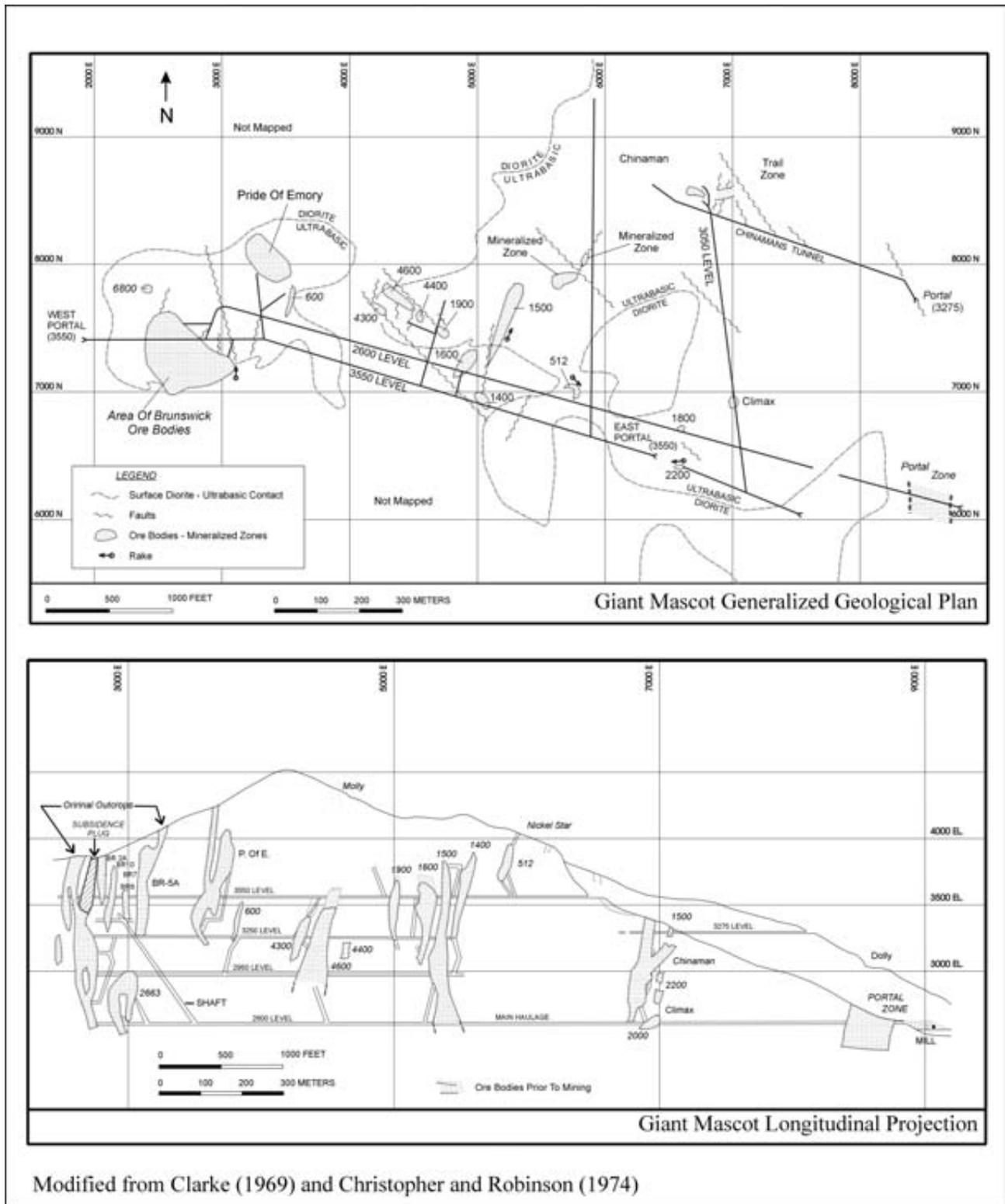


Figure 3. Simplified surface geology map with projections of ore shoots and an, east to west oriented, longitudinal projection of the Giant Mascot mine after Clarke (1996), and Christopher and Robinson (1975). The figures show steeply dipping ore-pipes.

TABLE 1
SUMMARY OF GIANT MASCOT ORE SHOOTS

ID	Dimension Horizontal (m)	Dimension Vertical (m)	Tonnage Tonnes x 1000	Grade Ni %	Grade Cu %	Ratio Ni/Cu	Deposit Type*
Pride of Emory	45.7 x 18.3	266.7	638.6	1.46	0.38	3.84	Unzoned
Brunswick #1	33.5 x 18.3	160.0	111.6	1.1	0.35	3.14	Zoned
Brunswick #2	54.7 x 21.3	251.5	517.0	1.4	0.6	2.33	Unzoned
Brunswick #2A	33.5 x 21.3	106.7	263.0	0.98	0.35	2.8	Unzoned
Brunswick #2G	21.3 x 19.8	91.4	118.8	0.56	0.27	2.07	Unzoned
Brunswick #5	36.6 x 21.3	182.9	371.0	1.49	0.5	2.98	Zoned
Brunswick #7	27.4 x 15.2	61.0	20.9	2.37	0.75	3.16	Zoned
Brunswick #8	6.1 x 15.2	53.3	10.9	1.75	0.61	2.86	Unzoned
Brunswick #10	21.3 x 16.8	61.0	34.5	0.74	0.05	2.11	
2663	15.2 x 18.3	99.1	92.5	0.86	0.32	2.69	Zoned
6800	15.2 x 15.2	91.4	42.6	0.66	0.24	2.75	
600	30.5 x 13.7	91.4	75.3	1.42	0.42	3.04	
Portal		189.0	2154.4	0.25	0.11	2.27	
4600	76.2 x 30.5	196.0	730.2	1.35	0.73	1.8	Zoned
4400	12.2 x 15.2	45.7	24.7	0.51	0.22	2.31	
4300	27.4 x 12.2	68.6	56.2	0.91	0.51	1.78	Zoned
2200	15.2 x 15.2	228.6	122.4	0.68	0.38	1.79	
2000	9.1 x 9.1	15.2	3.1	1.33	0.33	4.03	
1900	15.2 x 24.4	91.4	40.8	0.86	0.45	1.91	Zoned
1800	15.2 x 24.4	45.7	36.3	0.53	0.23	2.3	Zoned
1600	51.8 x 27.4	129.5	195.9	0.97	0.34	2.85	Zoned
1500	61.0 x 21.3	344.4	605.9	1.37	0.45	3.04	Unzoned
1400	15.2 x 18.3	142.6	48.1	0.71	0.32	2.21	
Chinaman	27.4 x 30.5	194.5	341.1	0.73	0.3	2.43	Zoned
Climax	15.2 x 27.4	182.3	191.4	0.78	0.36	2.16	Zoned
512	9.1 x 15.2	68.6	25.4	1.08	0.41	2.63	Zoned
# of deposits			26	26	26	26	
Average			264.33	1.03	0.38	2.59	

After Christopher and Robinson (1974)

* Zoned or Unzoned deposits, where known

In 1980, ownership of the mine was transferred to Mascot Gold Mines Limited, a subsidiary of Giant Mascot Mines Limited. In 1986, after an extended period of inactivity, Mascot Gold Mines Limited resumed exploration. The company was particularly interested in the gold and platinum-group element content and its distribution (Tindall, 1987). International Corona Corporation acquired Mascot Gold Mines Limited as part of its acquisition of the Nickel Plate gold deposit, near Hedley, British Columbia, in 1988. The company continued Mascot Gold's platinum group element study, but did not release the results.

In 1992, Homestake Canada Limited acquired International Corona Corporation and its interests at Giant Mascot as part of its acquisition of the Eskay Creek gold deposit. The company has spent the last few years reclaiming the mine-site. It has now sealed the portals, groomed the dumps and seeded the tailings. In 2001, the company extended an old logging road on the Emory Creek side of Zofka Ridge up to the Pride of Emory and filled a "glory-hole" in the Brunswick area.

PREVIOUS WORK

The geology of the Giant Mascot deposit has been described and discussed by several authors, including Cairnes (1924), Cockfield and Walker (1933) and Horwood (1936, 1937) during its early exploration; Aho (1954, 1956) at the start of production; Clarke (1969) while the mine was in operation and Christopher (1974) at the time of closure. These authors provide similar descriptions of the ultramafic body that hosts the deposit and discussions on the geometry of the ore-zones, and nature of the mineralization; however, they differ slightly in their conclusions as its mode of formation. They also differ in their interpretation of the age of the ultramafic body with respect to the Spuzzum pluton. Cockfield and Walker (1933) and Horwood (1936, 1937) indicate that the diorite intrudes the ultramafic body. However, Cairnes (1924) and Aho (1954, 1956) suggest that the ultramafic body may be younger than the Spuzzum pluton.

There were several detailed studies undertaken shortly before the mine closed. They include petrologic studies of the 4600 zone by Muir (1971) and of the Climax and Chinaman ore-zones by McLeod (1975), and a study of the contact relations around the ultramafic body by Vining

(1977). McLeod (1975) also completed six K/Ar age-date determinations to resolve the relative ages of the igneous rocks. The results suggest that the ultramafic body (119-95 Ma) is older than the Spuzzum pluton (79-89 Ma; McLeod *et al.*, 1976); however thermal resetting of the rocks may have occurred during subsequent metamorphism and the ages may not be absolute.

GEOLOGICAL SETTING

The Giant Mascot ultramafic body has a pronounced northeasterly trend (Figure 2). It is enveloped on three sides by two types of diorite and is juxtaposed against meta-sediment on the fourth. It is irregular in outline, but is approximately 2.0 kilometres long and 1.0 kilometre wide. The ultramafic rock is composed of olivine and orthopyroxene-rich cumulate, with variable but lesser amounts of clinopyroxene, feldspar and hornblende. It ranges in composition from peridotite (harzburgite - lherzolite) through olivine pyroxenite (olivine websterite) to pyroxenite (websterite) and hornblende pyroxenite. The cumulate is typically massive and relatively uniform in composition and texture, at least at outcrop scale. Contacts between individual units are either sharp, or they may be transitional over a few centimeters. Contacts are locally crosscutting and rounded inclusions of one variety of pyroxenite can be seen in another, or in peridotite. There is no obvious penetrative fabric but the rocks are faulted and in some localities the olivine crystals are systematically cross-fractured and serpentinized and the pyroxenes are noticeably deformed. Narrow zones of hornblende are commonly found on the outer contact of the ultramafic body.

ULTRAMAFIC ROCKS

The ultramafic rocks vary considerably in grain-size and bulk composition. The principal rock type is pyroxenite, which is present in several varieties, most of which contain small, scattered, euhedral crystals of olivine (1-2 mm) and spinel (< 1.0 mm). At the eastern end of the ultramafic body the pyroxenite is medium grained (3-6 mm) and porphyritic, with large (10-20 mm), locally poikilitic, phenocrysts of orthopyroxene and small amounts of interstitial feldspar. In the central part, near the 3275 portal, it consists of relatively homogenous, coarse (6-8 mm) and fine-grained (2-4 mm) varieties. Towards the west and locally around the contact, it contains an appreciable amount of hornblende (Figure 2). The hornblende crystals are most commonly poikilitic and large (10-30 cm). Locally, the olivine grain size (3-4 mm) and content increases and the pyroxenite shows rapid transition to olivine pyroxenite and peridotite. The latter forms large, irregular-shaped masses within the pyroxenite in the central part of the body and also occurs in small, mineralized "pipe-like" structures at the west end. Aho (1956) describes several mineralized peridotite pipes in the Brunswick and Pride of Emory area that were developed early in the life of the mine. More recently, Muir (1971) has studied the 4600-zone pipe and McLeod (1975) has examined the Climax and Chinaman deposits on the 3050 level crosscut.

Irrespective of composition, the cumulate displays a consistent paragenetic evolution. Olivines and spinels occur as, euhedral to subhedral, cumulus-textured crystals that are commonly poikilitically-enclosed in larger, euhedral crystals of also cumulus-textured orthopyroxene. Some of the latter contain minute lamellae of clinopyroxene, which also occurs interstitial to, and in an interlocking relationship with, the orthopyroxene. In some samples, large clinopyroxene crystals poikilitically enclose olivine and orthopyroxene. Hornblende is found in pyroxenite near the outer margins of the ultramafic body, where it commonly occurs as large, poikilitic crystals filling inter-cumulus spaces. Alternatively, it occurs as smaller, subhedral crystals. Feldspar is found in small amounts in some of the less olivine-rich pyroxenites, although rarely in those that contain hornblende. It is invariably interstitial to the other minerals.

The cumulate displays modal layering but electron microprobe data, from Muir (1971) and McLeod (1975) show little evidence of appreciable cryptic layering. The silicate minerals are not obviously zoned and their compositions are reasonably consistent from one lithology to another. Muir (1971) analyzed coexisting minerals in samples of olivine pyroxenite and peridotite from the 4600 Zone. He shows that the crystals are unzoned, have a mean forsterite composition of 83.43 +/- 0.27 (mol. %) Fo, and have a mean nickel content of 0.13 % Ni. His work also shows that the mean enstatite content of the orthopyroxene in the peridotite is En 84.3 and that in the olivine pyroxenite is En 81.85. Muir found less enstatite in orthopyroxenes within hornblende-rich cumulates. The mean enstatite content of orthopyroxene in hornblende pyroxenite inside the ore zone was found to be En 80.9, and outside the orebody En 77.0. Muir found that the 4600 Zone orthopyroxenes contain between 1.8 % and 3.6 % Al₂O₃.

McLeod (1975) conducted a similar study of mineral compositions in peridotites and pyroxenites in and around the Climax and Chinaman deposits. He found that olivine crystals range in composition from Fo 80.0 to Fo 86.65, with the higher values in the more olivine-rich rocks. Similarly, he found that orthopyroxene crystals range in composition from En 85.65 to En 75.10 and coexisting clinopyroxenes range from Wo 39.5 to Wo 48.15, En 43.95 to En 52.75 and Fs 5.8 to Fs 10.8.

McLeod *et al.* (1976) show that the crystal compositions are consistent with their formation as cumulate in a magma chamber. They show that distribution coefficients between Ca-rich and Ca-poor pyroxenes (K_D average: 0.729) imply a magmatic origin, and that 15 ortho- and clinopyroxene pairs from the interior of the body (McLeod, 1975) yield an average temperature of 990° +/- 50° C, using the method of Wood and Banno (1973).

The ultramafic rocks are largely unaltered; however, they are weakly to strongly altered in the vicinity of major faults. Deformed and altered rocks commonly take on a crumbly appearance (Christopher and Robinson, 1974) as primary minerals are progressively altered to actinolite, biotite, talc and magnetite. Locally, secondary serpentine veinlets form a network throughout olivine crystals.

HORNBLENDITE

Contact relations between ultramafic rocks and the surrounding rocks commonly show conflicting age relationships because of the development of large amounts of hornblende on, or immediately adjacent to, the contact. Aho (1956), McLeod (1975) and Vining (1977) discuss the problem. Hornblende locally (1) cuts diorite, (2) replaces pyroxenite, (3) replaces diorite and (4) forms a coarse-grained, locally pegmatitic, matrix to hornblende-altered pyroxenite fragments along brecciated contacts. Hornblende is well developed towards the east end of the ultramafic body (Figure 2), where it separates a quartz-rich phase of the diorite from a hornblende-rich phase of the pyroxenite. Sample CAS01-414 is a fine-grained variety of hornblende collected from a particularly well-developed hornblende zone on the main access road. It has been submitted for Ar/Ar age dating. The results are pending and will be reported on separately. Narrow (10-20 mm) tonalite dikes in pyroxenite at the east end of the ultramafic body have well-developed (10-20 mm) amphibole-rich alteration envelopes formed as a result of hydration and metasomatic alteration. The envelopes suggest that the contact hornblende may also have formed as a result of hydration and metasomatism following emplacement of the diorite. Vining (1977) conducted a lithochemical study and established that the hornblende could be formed from pyroxenite or diorite through a moderate amount of chemical transference from either rock type to the other. He concluded that it was formed by metasomatism shortly after emplacement of the Spuzzum diorite.

MAFIC DIKES

The ultramafic cumulate is cut by numerous dikes of fine-grained (1.0 mm) mafic gabbro and/or hornblende. They have sharp contacts and show little alteration of the surrounding rock. The dikes are commonly narrow (0.1-0.2 m) and anastomosing and locally display disturbed contacts indicative of injection of several phases of differing composition. Most are composed of hornblende with a variable amount of feldspar. The dikes are discussed by Aho (1956) and Vining (1977). The latter concluded that some could be genetically related to the marginal amphibolite discussed above. Sample RHP01-145 was collected from a dike cutting the cumulate along the main access road east of the 3275 portal (Figure 2). It is currently being age dated by Ar/Ar methods. The results are pending.

SPUZZUM DIORITE

The southern part of the Spuzzum pluton is described by Richards (1971) and by Richards and McTaggart (1976) who differentiate the body into three outwardly zoned, gradational diorite phases and a distinctive (but probably related), outer tonalite. Their work, south of American Creek, shows that the pluton has two core areas of hypersthene-augite diorite (Type I) surrounded by zones of augite-hypersthene-hornblende diorite (Type II). The latter

is enveloped by biotite-hypersthene-hornblende diorite (Type III) and all of the above are enclosed by biotite-hornblende tonalite. The three phases of diorite vary systematically in modal composition. The quartz (1% - 9%) and hornblende (1% - 20%) contents increase outwards at the expense of hypersthene (13% - 1%). The pyroxenes become progressively altered to amphibole near the outer rim of the diorite complex and feldspar crystals become increasingly zoned from core to margin. The tonalite contains less plagioclase than the diorite, but is appreciably richer in quartz and biotite. The three phases of diorite and the tonalite are strongly foliated. The diorite found at the mine resembles Type III, as defined by Richards (1971).

Aho (1956) and Vining (1977) describe two varieties of foliated diorite in the Giant Mascot mine area (Figure 2). They show that the west side of the ultramafic body is enveloped by "hornblende diorite" and that the east end is in contact with "quartz-diorite". This study shows that most of the diorite to the south and east of the mine is rich in hornblende and relatively quartz poor, although local quartz enrichment occurs adjacent to some of the hornblende zones at or near ultramafic rock contacts. For example, it was found at the eastern contact of the small diorite body exposed below the switchback on the road to the upper portal (Figure 2). The two phases appear to be gradational and can be treated as a single unit. The diorite is commonly medium grained (3-6 mm) and weakly to strongly foliated. It is composed of up to 40% of mafic minerals (ragged orthopyroxene, hornblende and biotite) with the remainder made up of strongly zoned feldspar and minor amounts of quartz.

Although the Giant Mascot cumulates are deformed, the deformational fabric is weak and previous workers focused on the fault, rather than fold, relations at the mine (Aho, 1956; Clarke, 1969; Muir, 1971; McLeod, 1975) as some of them control the distribution of mineralization. However, internal contact relations described in the literature show considerable three-dimensional complexity to the distribution of rock units in the cumulate body that cannot entirely be attributed to faulting. In the past, much of it has been attributed to remobilization and re-injection of cumulate (Muir, 1971; McLeod, 1975); however, Friesen (1967) suggests that early folding may also have played an important part in controlling the distribution of rock-types and locating some of the ore zones.

The cumulate body underwent a second phase of deformation after emplacement of the diorite. The diorite and hornblende at the west end of the ultramafic body (Figure 2) are strongly foliated and they, and the cumulate body, appear to have been folded and faulted about a northeasterly-trending axis. Similarly, contact relations in the vicinity of the small body of diorite exposed below the switchback on the main access road to the upper adit (Figure 2) show that both the ultramafic body and the diorite intrusion must have undergone considerable, if local, deformation about a northwesterly-trending axis. The diorite, adjacent hornblende and the hornblende pyroxenite are all sheared and folded about a shallow, northwesterly-trending, northwesterly-dipping axis. The map pattern displayed by the cumulate body is consistent with two major phases of

post-diorite deformation. Structural relations are complicated by late, post-mineral faults.

MINERAL DEPOSITS

Giant Mascot Mines Limited identified twenty-eight mineral deposits within the ultramafic body and mined twenty-two for a total production of 4 319 976 tonnes containing 26 573 090 kilograms of nickel and 13 212 770 kilograms of copper. The mine also produced 140 700 kilograms of cobalt between 1971 and 1973, and 16 516 grams of silver and 1026 grams of gold in 1958 (MINFILE 092HSW004). Christopher and Robinson (1974) describe the size, shape, geological and structural setting, and tonnage and grade of the twenty-six deposits shown in Figure 3. Some of the data are reproduced in Table 1. They show that most of the deposits are “pipe-like” or “tabular”. They range in horizontal section from approximately 80 m x 40 m to 7 m x 15 m. Most plunge at a moderate to steep (55° to 80°) angle to the northwest; however a few (1600, 600, 512) plunge at a similar angle to the southwest and one, 1800, has an anomalous plunge to the southeast. Continuity down plunge ranges from 15 m to 350 m. In some localities the ore zones grade out into sub-economic mineralization; at others, they terminate on faults. Some of the ore zones appear to be isolated while others, particularly in the Brunswick area (Figure 3), belong to well-defined clusters. Giant Mascot Mines Limited traced most of the zones from their uppermost expression down to the 2600 haulage level. At closure, it concluded that the ore bodies exposed at that elevation were low grade and that they would likely be cut out by diorite at depth.

The company recognized two principal types of deposit at the mine; zoned deposits, largely comprised of disseminated mineralization in one or more rock type (Brunswick #1, #5, #6 and 4600, 1600, 1900 and 512), and unzoned deposits, largely comprised of semi-massive to massive sulphide lenses (Pride of Emory, Brunswick #2, #8 and #9; Table 1). Narrow sulphide veins occur in both types of deposit.

Aho (1956) describes several zoned deposits in the Brunswick area. Typically, they are concentrically zoned. They are composed of interstitial blebs of sulphide disseminated in olivine-rich peridotite and dunite in or near the core of sub circular, “pipe-shaped” bodies that are enveloped by more pyroxene-rich peridotite and pyroxenite. In most of these deposits, the sulphide content increases locally to form segregations and drops-off rapidly outwards, as the orthopyroxene content of the rock increases. The 4600 zone is unusual in that the greatest sulphide concentrations are found in hornblende pyroxenite (Muir, 1971). The Climax and Chinaman deposits are also zoned (McLeod, 1975). Although the sulphide is fairly uniformly distributed in most of the deposits, some, such as the Climax and Chinaman, are reported to have projectable high-grade concentrations along their structural footwall contacts (McLeod, 1975).

Aho (1956) also describes several unzoned deposits, including the Pride of Emory. These are typically irregularly shaped, tabular, and semi-massive to massive sulphide bodies that have sharp, commonly banded, contacts that are lo-

cally controlled by changes in lithology. The ore commonly consists of angular fragments of country-rock peridotite or pyroxenite in a sulphide matrix that contains euhedral to subrounded crystals of olivine and/or pyroxene. The amount of silicate material mixed in the sulphide is variable.

The two ore-types are intimately associated and may be gradational in the Brunswick and Pride of Emory areas. The controls on the distribution of the two types of deposit and their mode of formation are uncertain. However, Clarke (1969) suggests that they may be structurally controlled and related to two principal fault sets. He attributes much of the mineralization in the Brunswick and Pride of Emory area (Figure 3) to northwesterly-trending, northeasterly-dipping structures that appear to dam some of the ore-shoots and to offset others. He attributes the primary control on the orientation of the 600, 1600 and 512 deposits to northeasterly-trending, near-vertical faults. In an in-house proposal for future exploration, Friesen (1967) notes that the ore in the 600 and 1500 ore bodies was far richer at bottom than the top and suggests that these deposits may have been subject to gravity separation after emplacement. Similarly, he describes partial flowing “of sulphide solutions” along a fault plane away from the bottom of the 1500 deposit and suggests that it must have been a pre-ore fault that acted as a dam. In the case of the 2200 orebody, he suggests that its geometry reflects folding.

Table 1 shows that the zoned and unzoned deposits differ considerably in tonnage but are similar in grade. In both cases, the ore is composed of abundant pyrrhotite with lesser amounts of pentlandite, chalcopyrite, magnetite and traces of pyrite. There has been very little work done on the distribution of platinum-group elements in the deposit and there are no public domain references to platinum-group minerals being found. In zoned deposits, the sulphides commonly occur as irregular grains or granular aggregates interstitial to the silicate minerals. The aggregates are composed of large, anhedral grains of pyrrhotite that commonly contain fine-grained pentlandite exsolution lamellae. The pyrrhotite groundmass also contains smaller, more granular crystals of pentlandite. Chalcopyrite crystals are less directly tied to pyrrhotite. They are found either in close proximity, or at some remove, from the pyrrhotite-pentlandite crystal aggregates.

In the more massive ores of the unzoned deposits, there is greater continuity between the pyrrhotite crystals and the rock may become net textured. Where this occurs, large pyrrhotite crystals commonly show a similar texture to poikilitic hornblende found in hornblende pyroxenite. The proportions of sulphides and silicates vary and net-textured ores are gradational into semi-massive ores. Although the latter are not necessarily deformed, some are brecciated and show clear evidence of solid-state deformation of sulphide. In these samples, the sulphide-silicate assemblage becomes grain-size and compositionally banded around country-rock fragments that either contain disseminated mineralization, or are barren. The sulphide appears to enclose and “cement” silicate fragments. In these deformed rocks, there is local evidence of sulphide replacing silicate crystals, particularly along cleavages and fractures. Deformed sulphide aggre-

gates show a similar textural relationship between pyrrhotite and pentlandite to that found in undeformed sulphide aggregates; however, chalcopyrite is less frequently found as isolated grains and more commonly occurs as well-defined, coarse or fine-grained veinlets that cut the sulphide-silicate assemblage (Aho, 1956; Clarke, 1969).

McLeod (1975) studied the distribution of sulphide in the Climax and Chinaman areas of the mine and paid particular attention to the compositions of the sulphides. He notes that the net texture is commonly well developed in the lower-grade portions of the ore shoots. As part of his study, he analyzed coexisting pyrrhotite and pentlandite crystals using an electron microprobe and determined that both display a wide range in composition. He found that their compositions were related both to local differences in bulk sulphide composition and to systematic differences in the silicate composition of the rocks. In general, he found that nickel and iron increase in pentlandite as one approaches the Climax deposits.

THIS STUDY

As part of this study, a total of 22 sulphide-bearing samples were collected from the Giant Mascot nickel-copper deposit. The samples came from the Pride of Emory, 3550 portal dump, 2600 portal dump and the Dolly adit (Figure 2, Table 4). They form a continuum selected to include a range of total sulphide contents and different textures. Some contain small amounts of interstitial sulphide, others contain sufficient sulphide to develop a net texture, and still others are composed of semi-massive and breccia-cement sulphide. Several display elements of more than one textural type.

Samples RHP01-080, -089, -105, -108 and -109 are composed of coarse (5-10 mm) and fine-grained (2-5 mm) peridotite samples that contain small amounts of poikilitic, inter-cumulus hornblende and minor amounts of disseminated sulphide. Sample RHP01-109 is unusual, in that it also contains interstitial plagioclase. In each sample, the sulphide occurs as irregular-shaped, coarse and/or fine-grained blebs in the interstitial spaces between olivine and pyroxene crystals. The sulphide is predominantly pyrrhotite with minor pentlandite and granular crystals of chalcopyrite. The latter are either intimately associated with the other sulphides or are scattered among the silicate crystals at some distance from them. Locally, the pyrrhotite appears to corrode and partially replace pyroxene crystals along fractures. It may have been remobilized.

Samples, RHP01-106, -120 and -121 display sharp, planar contacts between barren and mineralized rock. The interstitial hornblende content drops-off rapidly across the contact and its place is taken up by sulphide. Sample RHP01-120 is brecciated.

Samples RHP01-078, -077, -091, -107, -090, -117, -088, -081, -118 and -075, show a progression from silicate-rich rocks that contain interstitial sulphide to silicate-poor rocks that are net-textured and/or composed of semi-massive sulphide. The transition results from a progressive increase in inter-cumulus sulphide and decrease in

inter-cumulus hornblende. As the sulphide content of the rock increases, the olivine and pyroxene crystals appear to be increasingly disaggregated and in the most sulphide-rich rocks individual silicate grains are completely enveloped by sulphide. Most of these ores are semi-massive and homogeneous; although some, such as RHP01-088, display a weak, imposed, tectonic fabric. The silicate grains are typically euhedral to subrounded and range in size from 1.0 mm to 5.0 mm. Pyrrhotite and pentlandite are evenly distributed throughout the matrix and chalcopyrite commonly occurs as wispy veinlets, and is more dispersed. Sample RHP01-078 is undeformed but particularly rich in chalcopyrite.

At some localities, most notably around the Dolly adit, the host rocks were clearly deformed and brecciated before they were mineralized and angular to subrounded fragments of barren peridotite and pyroxenite are cemented by net-textured to semi-massive sulphide. The rocks have a knobby appearance caused by preferential weathering of the sulphide-rich matrix that surrounds the barren blocks. Locally, narrow bands of net-textured sulphide appear to feather out into barren, massive peridotite or pyroxenite. The matrix cement in samples RHP01-076, -104, -119, -120 and -122 is similar to that described above; however, the rocks commonly have a crushed, protoclastic texture. The silicate component commonly includes angular fragments of country rock, as well as different grain-sizes of olivine and pyroxene. The sulphide breccia cement commonly contains well-developed stringers and veins of chalcopyrite that also wrap around the country rock fragments. A few semi-massive samples, such as RHP01-076 are extremely deformed. In this sample, the sulphide-silicate matrix contains both fragments of country rock silicate and deformed, coarse-grained pyrrhotite crystals. The sample is also strongly veined by chalcopyrite.

COGBURN CREEK AREA

INTRODUCTION AND HISTORY

In the late 1960s, Giant Explorations Limited formed the "Nickel Syndicate" to explore the Cogburn Creek area for nickel-copper mineralization. It staked 242 claims in 1969 and added a further 322 units the following year, establishing a substantial land position. At the same time, it flew an airborne magnetometer survey from the mine north to Cogburn Creek (Crosby, 1970) and conducted detailed stream sediment and contour soil geochemical surveys (Gayfer, 1970a, 1970b). The company established grids on, and mapped and sampled seven areas and diamond drilled three, two along Cogburn Creek and one at Daioff Creek (Berg and Clarke, 1971a, 1971b). At Cogburn Creek, it identified several areas of low-grade nickel-copper mineralization in an ultramafic to mafic cumulate body west and east of Settler Creek.

PREVIOUS WORK

There was little interest in the nickel-copper potential of the Cogburn area from the mid-1970s to the late-1990s, but the ultramafic cumulates attracted the attention of Granite Creation and Stoneworks Limited. The company ex-

tracted a bulk sample of “black granite” from the Raven Quarry (MINFILE 092HNW 078) in 1996 (Sanguinetti, 2000a). Four years later, it drilled 13 diamond drill holes, for a total length of 397 metres, at the quarry site and other localities north of Cogburn Creek (Sanguinetti, 2000b). In 2001, it returned to the Raven Quarry and extracted a larger test sample. Exploration for nickel-copper and platinum group elements resumed in the late 1990s. David Houghton, a prospector working on the Provincial Government’s Prospector Assistance Program was one of the first into the area, staking the Jason Claims west of Settler Creek in 1999. Several junior companies acquired large ground holdings in the area in 2000 and 2001.

GEOLOGICAL SETTING

The plutonic rocks in the Cogburn Creek area were considered by Lowes (1972) to be part of the Spuzzum pluton. This was based on inferred map continuity and observed similarities with foliated quartz diorite in the type area near the Fraser River, described by McTaggart (1970) and Richards and White (1970). More recent mapping has shown that the Hut Creek pluton is a separate entity, albeit with strong similarities to the Spuzzum pluton. The Hut Creek pluton was included by Gabites (1985) in a detailed study of age relations in the Cogburn Creek area. She subdivided it into an inner core of “hornblende-hypersthene gabbro” and an outer, more extensive zone of foliated diorite (Figure 4). The former is a composite body composed of ultramafic to mafic cumulate.

ULTRAMAFIC TO MAFIC ROCKS

North of Cogburn Creek, the ultramafic to mafic cumulate body is approximately 3.5 km wide. It is bounded to east and west, and partially to the south by diorite (Gabites, 1985). The cumulate is best exposed on the north side of Cogburn Creek (Figure 4). It is composed of differing compositions, grain-sizes and textural varieties of pyroxenite, feldspathic pyroxenite and gabbro. Most of it is massive and homogenous; however the feldspathic pyroxenite exposed at the Raven quarry is intermittently rhythmically layered as a result of subtle variations in grain-size. At one locality at this site, the layering is distorted around an inclusion of slightly different (more pyroxene-rich) composition. The layers display a pronounced northwesterly-trend and a moderate southwesterly dip. This type of banding is uncommon; most of the cumulate is massive, with both diffuse and sharp transitions between different varieties.

The cumulate is largely fine-grained (2-4 mm), medium-grained (3-6 mm) and coarse-grained (5-8 mm) feldspathic pyroxenite, or gabbro. The modal composition varies, but the rocks commonly contain subhedral to euhedral crystals of orthopyroxene (25-50%), interstitial plagioclase (25-30%), relatively large anhedral to subhedral crystals of clinopyroxene (20-35%), small inclusions of opaques and, locally (1-10%) secondary biotite. However, in some localities, most notably near the mineralized outcrop north of Cogburn Creek, the feldspathic rocks include layers that are richer in pyroxene and include euhedral olivine crystals.

Granite Creation and Stoneworks Limited drilled several exploratory holes in massive pyroxenite and feldspathic pyroxenite cumulate alongside the road north of Cogburn Creek. Most were collared in medium-grained feldspathic

pyroxenite (“pyroxene gabbro”) and either intersected it throughout, or intersected weakly intercalated layers of fine to coarse-grained, black pyroxene gabbro (Sanguinetti, 2000a).

South of Cogburn Creek, the cumulate has been intruded by diorite and partially disaggregated to form irregularly shaped, northerly-trending bodies. West of Settler Creek, these become fully disaggregated and ultramafic and mafic xenoliths become progressively smaller and less frequent within the main body of diorite (Berg and Clark 1971a; Berg, 1972; Gonzales and Clarke, 1972 and 1973). Although Gonzalez and Clarke (1972, 1973) identified a highly feldspathic, gabbroic phase of the cumulate body south of Cogburn Creek, elsewhere feldspar is less evident and the rocks appear to be more mafic to ultramafic. It is predominantly massive, blackish-brown, medium-to-coarse-grained, orthopyroxene-rich pyroxenite that contains, locally abundant, large crystals of late, interstitial and also secondary amphibole.

HUT CREEK DIORITE

The cumulate is intruded by medium-grained (3-6 mm), weakly to strongly foliated hornblende diorite. The contacts appear to be tectonic and, as at Giant Mascot, they are commonly marked by the development of hornblendite. The plutonic rocks are jointed. The principal joint sets are oriented in a northeasterly direction with a steep northerly dip, and in a northwesterly direction with a moderate northeasterly dip. They are also cut by, northerly-trending, vertical zones of intense shearing. Some of the joints in the cumulate areas contain narrow (centimeter-scale) tonalite and diorite dikelets, clearly indicating that the cumulate was deformed prior to intrusion of the diorite. Some of the steep northeasterly-trending fractures contain aphanitic to fine-grained (1.0 mm) hornblendite dikes with sharp contacts that are similar in texture and composition to those found at Giant Mascot. The Hut Creek pluton is juxtaposed against Settler Schist north and south of Cogburn Creek; however the nature of the contact is uncertain. It may be tectonic.

MINERAL DEPOSITS

SETTLER CREEK: NI: ZONE #4 (MINFILE 092HNW 045)

In 1970, Giant Exploration Limited located mineralized pyroxenite along a logging road that exposed an outcrop of cumulate south of Cogburn Creek (Figure 4). Company staff later mapped the area and conducted soil geochemical and geophysical surveys (Berg and Clarke, 1971a, 1971b). Chip samples assayed 0.4% Ni and 0.2% Cu over an undefined length (Berg and Clarke, 1971a) and three diamond drill holes, with an total length of 500 metres (Eastman, 1971) located a “short interval” grading 0.3% Ni and 0.3% Cu (Berg and Clarke, 1971a). The soil geochemical survey located a strong but relatively restricted, coincident nickel and copper anomaly uphill from the showing (Gonzales and Clarke, 1973).

The Zone #4 showing is underlain by hornblende-rich pyroxenite near a creek controlled by one of the main, northerly-trending faults. At this locality, the mineralized pyroxenite appears to be juxtaposed against coarse-grained,

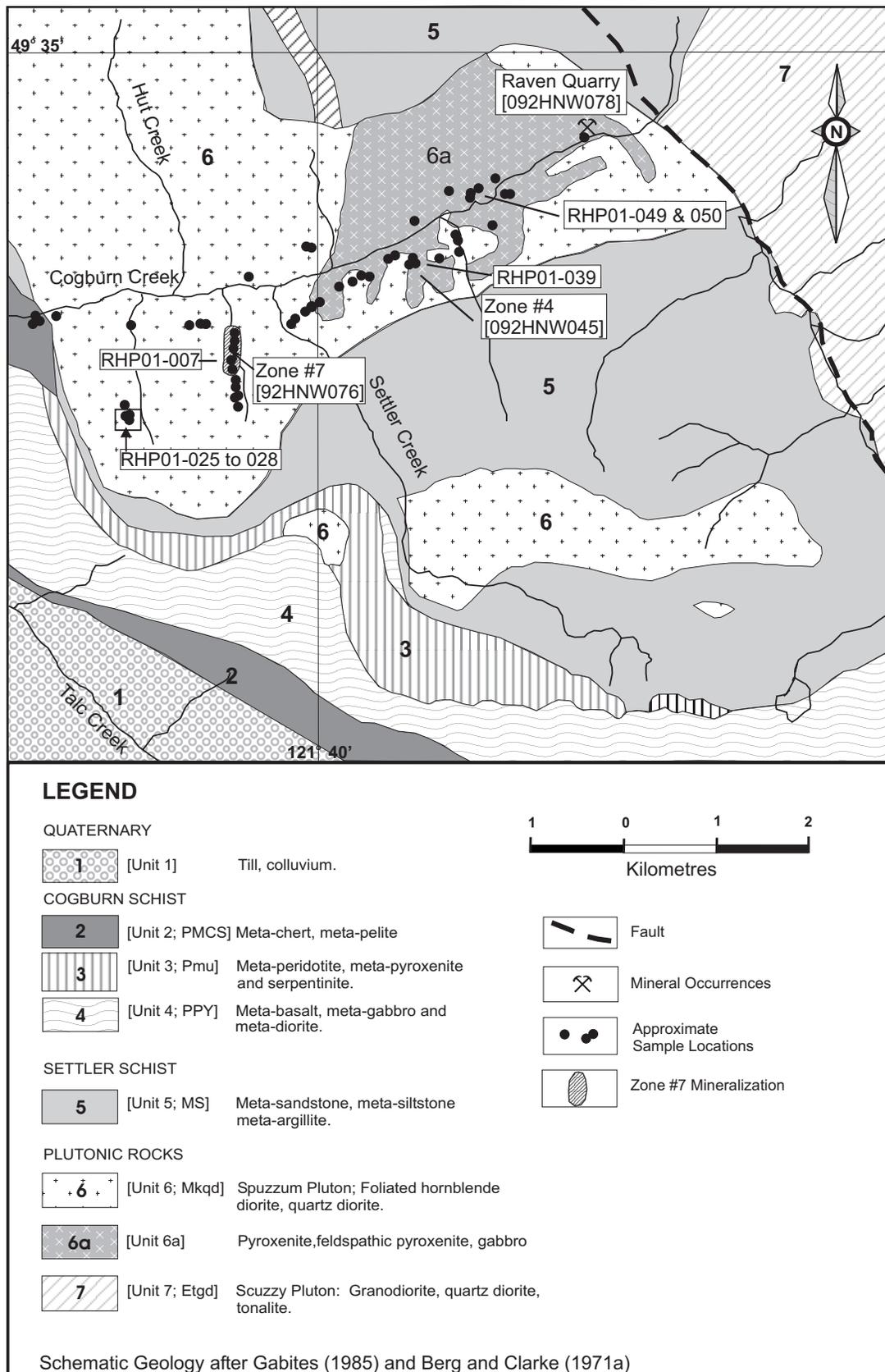


Figure 4. Schematic surface geology map of the Cogburn Creek area, after Gabites, showing the principal rock units, mineral occurrences and sample sites.

pegmatitic hornblendite. The pyroxenite is largely composed of crystals of orthopyroxene (2-3 mm) that are locally poikilitically enclosed in larger (10 mm) hornblendes. In outcrop, the rock contains fine disseminations and rare patches of net-textured sulphide in fresh, undeformed, hornblende-free pyroxenite. Rare float samples show that the net-texture is also to be found in crushed pyroxenite surrounding sub angular to sub rounded fragments of barren hornblende pyroxenite. The silicate minerals in Sample RHP01-039 are crushed and some are partially recrystallized. Small crystals display 120° degree angles and envelope larger crystals. The sulphide occurs as disseminations, net-textured concentrations and wispy veinlets in the silicate matrix and some of the larger sulphide blebs enclose large, isolated crystals of olivine and pyroxene that do not appear to be recrystallized.

Giant Exploration Limited also located trace amounts of sulphide at several localities within a north to northwesterly-trending belt of pyroxene-rich pyroxenite north of Cogburn Creek. The mineralization on this side of the river occurs in three settings, all of which occur in a 200-metre section through the pyroxenite west of the Settler Creek turn-off (Figure 4). It is found as (1) fine, disseminated and lacy, net-textured sulphide, (2) as veins and heavy disseminations in crushed silicate in breccia zones cutting the pyroxenite and (3) as veins and disseminations within inclusions in barren pyroxenite.

Granite Creation and Stoneworks Limited found small amounts of fine, disseminated and net-textured sulphide in one of their diamond drill holes (#5) but report low metal values (Sanguinetti, 2000a). Within a few metres of this drill site, there are several roadside blocks of mineralized pyroxenite float. Sample RHP01-050, from one of them, is similar in appearance and texture to mineralized pyroxenite found south of the river. It is composed of fresh, adcumulate-textured orthopyroxenite that contains a minor amount of interstitial to net-textured sulphide.

Sample RHP01-049 was collected at the same locality. It resembles RHP01-039, which was collected south of the river. It is a foliated, feldspathic pyroxenite, composed of small euhedral orthopyroxene and larger, more ragged, clinopyroxene crystals in a matrix of feldspar. The rock is deformed and cut by a narrow vein (5.0 mm wide) that is partially composed of pyrrhotite. The vein has diffuse outer boundaries and pyrrhotite appears to have permeated outward from the main fracture along micro-fractures and crystal boundaries. Pyrrhotite locally extends several centimeters from the main fracture. The vein also contains chalcopyrite, however it is not found in the surrounding rock.

The third style of mineralization has only been seen at one locality. There are two mineralized pyroxenite inclusions in unmineralized pyroxenite exposed on a glacially polished rock surface by the side of the Cogburn road. The larger of the blocks is irregular in outline and gossanous on surface. It is fractured and appears to be mineralized along the cross-fractures.

JASON: NI: ZONE #7 (MINFILE 092HNW076)

Giant Explorations Limited located small amounts of sulphide in pyroxenite in diorite south of Cogburn Creek and west of Settler Creek (Figure 4) and, in 1972, extended

its exploration into what is now known as the Jason area (Gonzales and Clarke, 1972). The company identified and studied an extensive area of near-continuous outcrop of low-grade mineralized pyroxenite along the bed of a north-flowing tributary of Cogburn Creek. It collected channel samples and estimated a grade of 0.03% Ni and 0.02% Cu over 150 metres. The company drilled two short diamond-drill holes for an aggregate depth of 100 metres. One was collared half way up the creek and the other was sited along the access road, near the foot of the main outcrop section. The results are not available (Berg and Clarke, 1972).

The hornblende diorite west of Settler Creek contains numerous small, isolated and large, elongated bodies of hornblende pyroxenite cumulate that is similar in composition and texture to that found east of the creek. The largest of the known bodies underlies a north-flowing creek and its lateral extent is unknown. At this locality, massive to partially deformed hornblende pyroxenite contains intermittent, spotty, sulphide mineralization over a distance of approximately 250 metres. The sulphide appears to be most abundant in rocks that have knobby appearance, possibly indicating early brecciation and recementation of the cumulate. The sulphide is composed of lacy, interstitial crystals of pyrrhotite with traces of pentlandite and chalcopyrite. Sample RHP01-007 is a coarse-grained hornblende pyroxenite composed of relatively small (2-4 mm) crystals of pyroxene that are locally, poikilitically, enclosed in large (20-30 mm) hornblende crystals. The sulphide occurs as rare, scattered blebs in the matrix surrounding the large hornblende crystals. There is no olivine in the rock, but some of the fresh, barren pyroxenites in the creek bed (RHP01-003) do contain small amounts of early-formed, cumulus olivine. Samples RHP01-025; -026; -027 and -028 are float samples collected approximately 1.0 kilometre to the west of the mineralized creek bed (Figure 4). They are texturally similar, but richer in sulphide. In these samples, the matrix pyroxenes are locally recrystallized. They are more ragged and altered and show partial to near complete replacement by the interstitial hornblende. Sample RHP01-027 is almost completely composed of large (10-20 mm), irregular-shaped, poikilitic hornblende crystals. In this sample, there is very little pyroxene remaining in the matrix.

WHOLE-ROCK GEOCHEMISTRY

A total of 27 rock samples from Giant Mascot and 35 samples from the Cogburn Creek area were selected as being representative of the principal ultramafic and mafic rock types found at the two localities. The samples were crushed in a hardened-steel jaw crusher and reduced to a fine powder in a tungsten carbide swingmill. The samples were analyzed for major and minor elements by X-ray fluorescence at the Cominco Research Laboratory, Vancouver. Accuracy and precision were monitored by international standards included in the run. The analytical results for both areas are listed in Table 2. The samples are grouped by lithology as determined by visual estimate of modal abundance, either in hand specimen or thin section. Thirteen samples (RHP01-007, -025, -026, -027, -028, -049, -050, -080, -088, -089, -105, -109 and -119) contain an appreciable amount of sulphur, and the ferrous iron content of the rock was reduced by the amount calculated to be present in sulphide prior to calculation of CIPW norms.

Table 2 continued

Feldspathic Pyroxenites		Hornblendites		Dikes		Q/C		Easting		Northing		Sr		Y		Zr		Nb			
ID	Sample	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	FeO	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	Ba*	LOI	SUM	Rb	Sr	Y	Zr	Nb	
Method	Lab	XRF1	XRF1	XRF1	XRF1	TIT	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1	XRF1	FUS	CAL	XRF2	XRF2	XRF2	XRF2	XRF2	
% Difference		COM	COM	COM	COM	COM	COM	COM	COM	COM	COM	COM	COM	COM	COM	COM	COM	COM	COM	COM	
RHP 01-003	594987 5489900	43.72	0.43	4.46	2.37	10.69	0.18	28.01	6.13	0.73	0.11	0.02	0.01	1.14	99.19	6	115	10	23	10	
RHP 01-006	595035 5490009	49.27	0.44	6.01	1.94	8.84	0.18	20.37	8.02	0.89	0.15	0.01	0.01	1.79	98.91	5	143	9	27	10	
RHP 01-007	595048 5490069	48.79	0.77	6.96	2.45	8.80	0.18	20.32	7.69	1.09	0.20	0.03	0.01	0.93	99.20	5	162	13	30	9	
RHP 01-025	594129 5489765	47.93	0.62	5.61	3.21	10.21	0.23	22.10	6.38	0.81	0.14	0.03	0.01	0.64	99.06	11	78	13	33	9	
RHP 01-026	594129 5489765	46.56	0.50	5.34	2.62	8.49	0.18	24.36	8.42	0.86	0.31	0.07	0.02	0.57	99.25	10	112	13	48	9	
RHP 01-027	594129 5489765	47.61	0.87	6.86	2.84	8.79	0.18	21.18	8.02	1.04	0.15	0.01	0.01	0.68	99.22	8	115	13	31	9	
RHP 01-028	594129 5489765	48.02	1.03	5.28	3.25	9.72	0.18	21.03	8.42	0.82	0.11	0.02	0.01	0.70	99.68	<3	95	16	32	10	
RHP 01-017	595955 5490114	50.49	0.68	5.73	0.44	12.62	0.20	17.04	7.59	0.88	0.33	0.01	0.01	1.97	99.37	14	65	22	43	8	
RHP 01-021	596040 5490205	48.75	0.43	18.84	0.35	6.11	0.11	8.84	11.30	1.88	0.03	0.01	0.01	1.80	99.45	15	610	11	34	10	
RHP 01-030	596274 5490412	47.74	0.54	18.31	0.11	9.15	0.15	9.53	10.10	1.50	0.09	0.05	0.01	1.14	99.44	4	603	12	22	10	
RHP 01-034	599407 5491923	51.63	0.40	9.51	1.29	9.60	0.20	16.79	8.25	1.11	0.05	0.01	0.01	-0.09	99.83	5	282	13	21	8	
RHP 01-036	597160 5490671	50.04	0.54	4.73	1.15	9.35	0.18	18.39	12.26	0.41	0.02	0.01	0.01	0.92	99.06	12	82	11	23	10	
RHP 01-038	597145 5490665	50.06	0.40	2.49	1.50	13.02	0.23	21.94	7.51	0.18	0.01	0.01	0.01	0.49	99.30	4	12	8	22	10	
RHP 01-039	597143 5490680	45.04	0.56	3.82	1.74	10.13	0.17	27.18	8.18	0.44	0.11	0.03	0.01	0.34	98.88	6	72	10	36	9	
RHP 01-043	597596 5490925	49.43	1.04	17.30	2.62	6.30	0.15	7.61	10.22	2.75	0.07	0.20	0.01	0.82	99.23	<3	716	13	14	9	
RHP 01-044	597583 5490900	50.43	1.08	17.34	0.29	9.66	0.15	8.30	8.13	2.67	0.07	0.12	0.01	0.31	99.64	4	572	12	29	10	
RHP 01-045	597600 5490873	47.04	1.12	13.15	1.16	9.47	0.17	13.02	9.90	1.49	0.15	0.02	0.01	1.69	99.45	6	350	21	23	10	
RHP 01-049*	597481 5491349	47.15	0.33	2.32	2.60	17.40	0.23	20.90	4.73	0.12	0.01	0.01	0.01	1.40	99.15	<3	10	<3	16	7	
RHP 01-050*	597481 5491349	48.54	0.28	2.27	3.38	16.08	0.25	22.88	2.74	0.05	0.01	0.01	0.01	1.51	99.80	3	4	<3	16	8	
RHP 01-056	597399 5491372	48.41	1.59	19.48	3.07	6.40	0.10	5.69	10.44	2.85	0.15	0.01	0.01	0.70	99.62	9	864	8	16	9	
RHP 01-058	597484 5491357	50.72	0.99	16.35	1.28	7.39	0.14	9.39	9.57	2.42	0.05	0.01	0.01	0.37	99.52	<3	621	6	21	9	
RHP01-030nep		47.93	0.54	18.46	0.17	9.04	0.15	9.46	10.22	1.49	0.09	0.05	0.01	1.19	98.91	<3	592	11	20	9	
RHP 01-015	594210 5490150	48.06	0.91	19.76	2.26	5.19	0.10	6.89	11.23	3.22	0.20	0.09	0.01	1.19	99.49	9	715	15	41	9	
RHP 01-018	595955 5490114	49.43	0.87	11.14	0.83	9.23	0.15	12.84	5.63	1.83	0.57	0.14	0.02	1.32	98.95	15	243	19	50	10	
RHP 01-037	597113 5490663	47.81	1.49	10.52	1.20	8.29	0.12	14.17	11.61	1.47	0.28	0.01	0.01	1.46	99.37	7	189	21	36	10	
RHP 01-052	593995 5490477	47.65	1.05	8.36	2.93	8.61	0.20	14.76	11.42	1.30	0.18	0.07	0.01	1.73	99.23	3	116	19	33	17	
RHP 01-009	595043 5490089	52.06	0.93	19.63	1.43	5.42	0.10	4.63	8.52	4.71	0.25	0.18	0.02	0.77	99.26	8	727	20	82	10	
RHP 01-010	595045 5490122	57.88	0.81	16.53	1.91	3.66	0.09	2.73	5.53	4.11	1.91	0.18	0.08	3.16	98.99	41	491	27	156	14	
RHP 01-023	596200 5490359	54.06	0.81	14.10	0.84	6.56	0.12	8.75	8.42	3.07	0.33	0.11	0.02	1.38	99.31	13	450	17	66	14	
Elements																					
Units																					
Method																					
Lab																					
ID	Sample	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	FeO	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	Ba*	LOI	SUM	Rb	Sr	Y	Zr	Nb	
RHP 01-033	596889 5490724	57.06	1.13	16.37	1.47	5.99	0.14	2.29	3.34	4.92	1.61	0.31	0.07	4.23	99.60	35	399	25	141	13	
RHP 01-049*		Total FeO: Value used for CIPW-Norms reduced by % taken up by sulphide.																			
56054 RHP01-101		52.84	0.23	3.04	2.31	6.85	0.15	24.4	4.42	0.33	0.02	0.01	0.01	3.61	98.99	3	39	8	18	9	
56060 RHP01-101rep		52.97	0.25	3.14	2.3	6.82	0.15	24.32	4.53	0.38	0.03	0.01	0.01	3.52	99.19	4	39	5	19	11	
% Difference		0.2	8.3	3.2	0.4	0.4	0.0	0.3	2.5	14.1	40.0	0.0	0.0	2.5	0.2	28.6	0.0	46.2	5.4	20.0	
56090 RHP01-030		47.74	0.54	18.31	0.11	9.15	0.15	9.53	10.1	1.5	0.09	0.05	0.01	1.14	99.44	4	603	12	22	10	
56099 RHP01-030nep		47.93	0.54	18.46	0.17	9.04	0.15	9.46	10.22	1.49	0.09	0.05	0.01	1.19	99.81	-3	592	11	20	9	
% Difference		0.4	0.0	0.8	42.9	1.2	0.0	0.7	1.2	0.7	0.0	0.0	0.0	4.3	0.4	1400.0	1.8	8.7	9.5	10.5	
56080 Stg. MRG1		38.97	3.75	8.39	8.09	8.96	0.15	13.42	14.72	0.74	0.15	0.05	0.01	1.3	99.7	9	242	11	96	17	
CANNMET MRG-1		39.32	3.69	8.5	8.63	8.26	0.17	13.49	14.77	0.71	0.18	0.06	0.01	0.98	100.1	8.0	260.0	16.0	105.0	20.0	
% Difference		0.9	1.6	1.3	6.5	8.1	12.5	0.5	0.3	4.1	18.2	18.2	0.0	28.1	11.8	7.2	37.0	9.0	16.2	14	
56052 Stg. SY4		49.84	0.28	20.54	3.11	2.75	0.1	0.55	7.98	7.11	1.63	0.11	0.03	4.86	99.2	51	1194	116	513	14	
CANNMET Stg SY 4		49.9	0.287	20.69	2.86	3.45	0.108	0.54	8.05	7.1	1.66	0.131	0.034	4.56	1191.0	55.0	1191.0	119.0	517.0	13.0	
% Difference		0.1	2.5	0.7	8.4	22.6	7.7	1.8	0.9	0.1	1.8	17.4	12.5	6.4	7.5	0.3	2.6	0.8	7.4	7.4	

NOTES:
 W-C mill grinding @ GSB
 XRF 1 = Fused Disc - X-ray fluorescence
 Ba* = Fused disc analysis for XRF calibration. Values should be used with CAUTION.
 COM = Cominco Research Labs
 FUS = Loss on ignition @ 1100°C
 SUM = Sum of oxides
 CAL = Calculated sum
 % Difference = ABS (x1-x2)/(x1+x2)/2x100
 XRF2 = Pressed pellet - X-ray fluorescence

Figures 5a and b show the distinctive chemical and mineralogical trends shown by the two cumulate bodies. The Giant Mascot cumulate contains relatively constant feldspar content and shows significant enrichment towards clinopyroxene. The Cogburn cumulate shows weaker enrichment in clinopyroxene and a strong trend towards feldspar enrichment.

The Giant Mascot cumulates have their compositions controlled by the modal proportions of the principal cumulus phases (olivine, orthopyroxene and clinopyroxene) and the amount of inter-cumulus feldspar and/or hornblende in the rock. Figures 5a and b show that the pyroxenites contain between 7% and 20% normative feldspar; however their modal contents appear to be appreciably lower. Inter-cumulus feldspar is found in the fresh pyroxenites at the east end of the ultramafic body (Figure 2) but it is noticeably absent from the hornblende-rich pyroxenites found further west and round the margin of the body. Its position as a late phase in the rock appears to be taken up by hornblende.

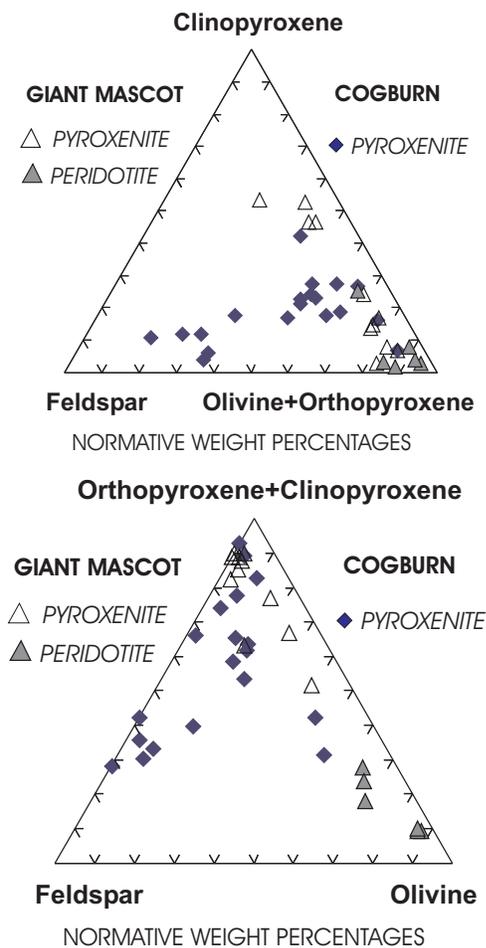


Figure 5. CIPW-normative compositions (wt.%) of peridotite and pyroxenite from the Giant Mascot (closed and open circles) and Cogburn area (diamond) ultramafic to mafic bodies. Figure 5a shows the relationship between feldspar, clinopyroxene and olivine plus orthopyroxene. Figure 5b shows the relationship between feldspar, orthopyroxene plus clinopyroxene and olivine.

The Cogburn cumulate compositions are similarly related to the modal proportions of the principal cumulate and inter-cumulus phases. However, at this locality, the rocks appear to be relatively deficient in modal olivine and enriched in pyroxene, feldspar and inter-cumulus and secondary amphibole. Hornblende is present in large amounts near diorite contacts but is relatively uncommon in the core of the body, north of Cogburn Creek. Figures 5a and b show that most of the Cogburn cumulate contains small amounts of normative olivine; however several samples from the mineralized areas south of the creek contain up to 57% of olivine in their norm. Sample RHP01-003, which contains 50% normative olivine is, as noted above, a fresh unaltered pyroxenite, however the others, including RHP01-026 (57%), RHP01-027 (20%) and RHP01-007 (15%) are hornblende pyroxenites with little or no olivine remaining. The Cogburn cumulates contain between 7% and 66% normative feldspar, however up to 25% may be taken up as hornblende. Most of the “feldspathic pyroxenites” can be classified as olivine gabbro or gabbro.

The plutonic rocks that envelope the Giant Mascot and Cogburn Creek cumulate bodies are mapped as belonging to two separate phases of the Spuzzum pluton. Giant Mascot is on the east contact of the main pluton and Cogburn Creek is on the south side of the Hut Creek pluton (Figure 1). In both instances, the plutonic rock is foliated, hornblende-rich diorite. Analytical data, in Table 2 show that there is broad similarity in composition between the diorites found in each locality. The principal difference appears to be a slight increase in titanium content in the Cogburn area.

Richards (1971) analyzed representative samples of the three types of diorite and the tonalite found in the Spuzzum pluton south of Giant Mascot and, despite differences in modal composition, established that the three types of diorite were chemically similar. Figures 6 to 8 show broad chemical similarity between the diorites found at Giant Mascot, Cogburn Creek and those described by Richards (1971). All three sample populations are sub alkaline (Figure 6) and plot as calc-alkaline on a standard AFM diagram (Figure 7). They also have similar alumina contents (Figure 8). The data support previous contentions that the ultramafic to mafic cumulate bodies are enveloped in calc-alkaline, Spuzzum-type diorite (Aho, 1956; McLeod, 1975; Vining, 1977).

LITHOGEOCHEMICAL ASSAYS

A total of 22 mineralized samples from Giant Mascot, and 8 from the Cogburn Creek area were sent to Acme Analytical Laboratories Limited in Vancouver and analyzed for a selection of major and minor elements including sulphur, base and precious metals and platinum and palladium. The rock powders were digested using four acids (HF-HClO₄-HNO₃-HCl) to release near-total amounts of most base, precious element and platinum group elements. However, the digestion only produces partial results for chromium and other rock-forming (lithophile) elements. The solutions were analyzed by inductively coupled plasma mass spectrometry (ICP-MS) and emission spectroscopy.

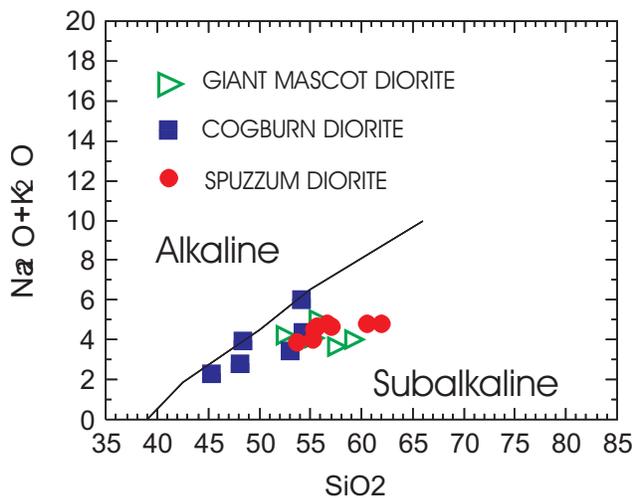


Figure 6. Alkalis versus silica plot (wt.%) of diorite samples from Giant Mascot (triangles); Cogburn (squares), this study and the Spuzzum pluton (circles), (Richards, 1971). The alkaline-subalkaline discrimination line is from Irvine and Baragar, 1971.

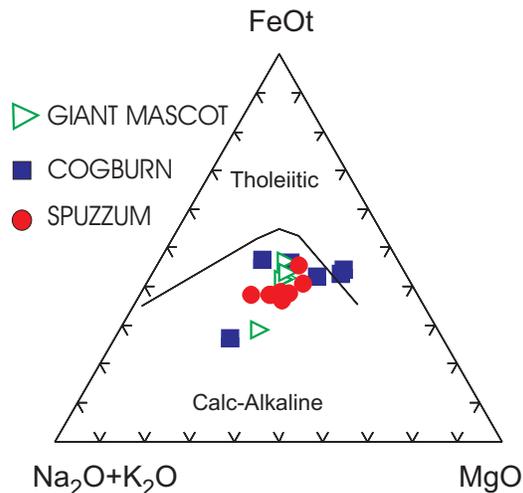


Figure 7. Alkalis-total iron-magnesia plot (wt.%) of diorite samples from Giant Mascot (triangles), Cogburn (squares), this study and the Spuzzum pluton (circles), (Richards, 1971). The calc-alkaline-tholeiitic discrimination line is from Irvine and Baragar (1971).

Gold, platinum and palladium determinations were done by fire-assay with an ICP finish. The results are given in Table 3.

The Giant Mascot samples contain between 1.54% sulphur and 22.65% sulphur (average 8.31% sulphur), depending on the proportions of sulphide and silicate in the rock. Rocks with interstitial sulphide invariably contain less sulphur than those with net-textured or semi-massive sulphide. Although the metal content of the samples might be expected to increase with increase in sulphur content, the results show that this is not always the case. There is a general increase in nickel and copper with increase in sulphur; however, the relationship is far from systematic and there is considerable inter-element variability. This is illustrated in Ta-

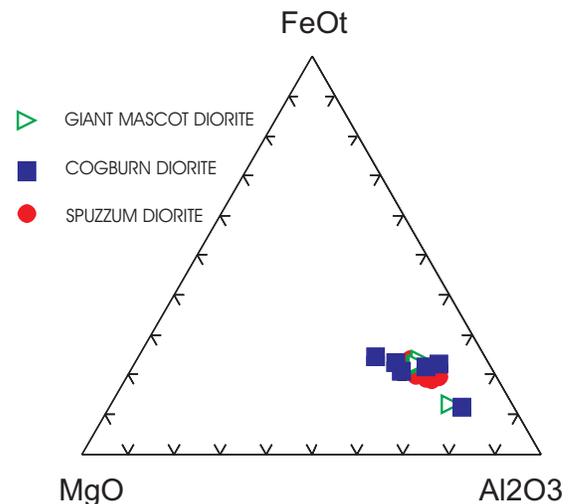


Figure 8. Magnesia-total-iron-alumina plot (wt.%) of diorite samples from Giant Mascot (triangles), Cogburn (squares), this study and the Spuzzum pluton (circles), (Richards, 1971).

ble 4, which lists the samples according to sulphur content. The table shows that the Giant Mascot samples contain between 0.19% and 2.57% nickel (average 1.16 % Ni) and from 0.12% to 4.01% copper (average 0.98 % Cu). The suite includes a few samples that appear to be particularly enriched in one or other element (Sample RHP01-107 is rich in nickel and Sample RHP01-122 is enriched in copper) and it has clearly been affected by remobilization of chalcopyrite. The results are consistent with rock textures that show that chalcopyrite has been mobile and is commonly found in wispy veinlets and larger veins that cause relative enrichment, or depletion, at the scale sampled.

Figure 9 illustrates the distribution of nickel and copper with respect to sulphur. It shows a poorly defined cluster of samples with a Ni/Cu ratio close to that of the global average of the mine (2.6), as determined from an average of the ore-shoots, and a pronounced trend toward copper enrichment. The samples are numbered to allow for correlation with platinum group element data in Tables 4 and 5.

Tables 3 and 4 also show that the samples contain from 3 ppb to 332 ppb gold (average 49.2 ppb Au), from 1.3 ppb to 1142 ppb platinum (average 107.9 ppb Pt) and from 9.6 ppb to 465.9 ppb palladium (average 173 ppb Pd), again with poor correlation between precious metal content and the amount of sulphur or base metal present. There are significant traces of platinum group elements in both sulphide-rich (RHP01-078, 287 ppb Au, 1142.2 ppb Pt, 889 ppb Pd) and sulphide-poor (RHP01-109, 332 ppb Au, 359.1 ppb Pt, 139.8 ppb Pd) rocks. No platinum-group minerals have been reported from the mine and, in common with other deposits, the platinum group elements are probably present either as minor phases, or in solid solution within the sulphide assemblage.

A subset of 14 samples were sent to Activation Laboratories Limited, Ancaster, Ontario, for neutron activation analysis of the platinum group elements (Os, Ir, Ru, Rh, Pt, Pd), gold (Au) and rhenium (Re) using nickel sulphide pre-concentration. The data are presented in Tables 3 and 5.

**TABLE 3
LITHOGEOCHEMICAL ANALYSIS OF THE COGBURN CREEK AND GIANT MASCOT AREAS**

Sample	Easting	Northing	wt% (ACME Analytical Labs)										ppm (ACME Analytical Labs)									
			Mg	Ti	Al	Na	K	Fe	Ca	P	S*	Mo	Cu	Pb	Zn	Ag	Ni	Co	Mn	As	U	Au
Giant Mascot																						
RHP01-075	607721	5480101	6.43	0.18	1.18	0.14	0.01	26.89	0.94	< 0.02	16.92	< 2	9000	< 5	74	1.3	14838	883	678	< 5	< 10	< 4
RHP01-076	607721	5480101	4.07	0.06	0.64	0.08	< 0.1	30.41	2.63	< 0.02	22.65	< 2	37786	< 5	117	12.1	25523	1076	568	< 5	< 10	< 4
RHP01-077	607721	5480101	16.41	0.13	1.2	0.19	0.02	18.47	1.1	0.002	7.44	< 2	2426	< 5	80	1	13069	527	1238	< 5	< 10	< 4
RHP01-078	607721	5480101	11.94	0.14	2.09	0.4	0.05	17.81	1.77	< 0.02	10.72	< 2	36019	< 5	135	13.1	18308	419	950	< 5	< 10	< 4
RHP01-080	607785	5480176	20.84	0.15	1.92	0.39	0.09	13	1.53	0.011	2.4	< 2	2448	< 5	84	1	5944	253	1277	< 5	< 10	< 4
RHP01-081	607761	5480141	14.79	0.09	1.15	0.11	0.02	16.7	0.99	< 0.02	6.63	< 2	1852	< 5	75	< 5	6761	509	1252	< 5	< 10	< 4
RHP01-088	606600	5480600	11.01	0.09	1.05	0.12	0.02	20.05	1.84	< 0.02	11.84	< 2	6729	< 5	106	1.5	14733	729	1477	< 5	< 10	< 4
RHP01-089	606600	5480600	18.22	0.11	1.5	0.23	0.04	12.43	2.16	0.003	2.25	< 2	2412	< 5	99	< 5	2429	159	1411	< 5	< 10	< 4
RHP01-090	606600	5480600	7.93	0.11	1.04	0.13	0.01	21.55	4.7	< 0.02	14.38	< 2	8547	< 5	78	1.9	21986	918	937	7	< 10	< 4
RHP01-091	606600	5480600	16.08	0.09	1.29	0.25	0.05	17.37	1.99	0.006	6.98	< 2	9469	< 5	99	1.4	8261	412	1316	< 5	< 10	< 4
RHP01-104	608550	5480160	11.28	0.17	1.17	0.11	0.01	18.15	3.55	< 0.02	8.19	13	3210	< 5	91	0.5	10835	489	1352	< 5	< 10	< 4
RHP01-105	608550	5480160	19.45	0.15	1.45	0.24	0.05	12.74	1.15	0.005	1.54	< 2	1339	< 5	96	< 5	1905	186	1249	< 5	< 10	< 4
RHP01-106	608550	5480160	19.98	0.07	1.12	0.25	0.04	14.11	2.14	0.011	3.12	< 2	1172	< 5	54	< 5	3809	338	1217	< 5	< 10	< 4
RHP01-107	608550	5480160	15.7	0.02	0.21	0.03	0.01	23.54	0.21	< 0.02	13.44	< 2	3789	< 5	73	1.2	22488	1006	1060	14	< 10	< 4
RHP01-108	608550	5480160	12.24	0.18	1.31	0.2	0.03	13.93	3.38	< 0.02	5.61	< 2	16872	< 5	107	3.7	8470	300	1160	< 5	< 10	< 4
RHP01-109	608550	5480160	14.71	0.21	2.2	0.37	0.15	12.31	1.75	0.005	2.52	< 2	5501	12	100	6	3850	181	1396	< 5	< 10	< 4
RHP01-117	608632	5480624	10.41	0.05	0.5	0.06	< 0.1	23.58	2.06	< 0.02	15.51	< 2	7233	< 5	70	1.6	25705	1099	822	7	< 10	< 4
RHP01-118	608632	5480624	10.73	0.09	0.87	0.11	< 0.1	19.14	3.53	< 0.02	12.41	< 2	7332	< 5	66	1.9	16933	804	840	< 5	< 10	< 4
RHP01-119	608632	5480624	17.23	0.1	1.13	0.08	< 0.1	12.19	2.42	< 0.02	2.68	< 2	1990	< 5	85	< 5	5832	256	1456	< 5	< 10	< 4
RHP01-120	608632	5480624	16.69	0.08	0.93	0.09	0.01	15.6	1.47	< 0.02	5.55	< 2	7690	< 5	90	1.6	9901	412	1272	< 5	< 10	< 4
RHP01-121	608632	5480624	14.21	0.16	1.51	0.2	0.01	11.37	7.02	< 0.02	3.09	< 2	3676	< 5	62	0.7	6398	276	1209	< 5	< 10	< 4
RHP01-122	608632	5480624	18.67	0.03	0.34	0.04	< 0.1	18.42	0.77	< 0.02	8.21	< 2	40106	< 5	163	7.8	7945	374	1085	< 5	< 10	< 4
Cogburn Creek																						
RHP01-007	595048	5490069	12.44	0.48	4.06	0.87	0.2	8.96	5.61	0.015	0.4	< 2	175	< 5	83	< 5	270	64	1450	< 5	< 10	< 4
RHP01-025	594129	5489765	14.07	0.38	3.26	0.64	0.15	11.08	4.47	0.014	0.25	< 2	77	< 5	136	< 5	396	74	2030	< 5	< 10	< 4
RHP01-026	594129	5489765	14.99	0.29	2.96	0.66	0.31	8.98	5.71	0.039	0.09	< 2	56	< 5	77	< 5	382	75	1489	< 5	< 10	< 4
RHP01-027	594129	5489765	12.71	0.51	3.92	0.81	0.16	9.12	5.61	0.008	0.29	< 2	164	< 5	91	< 5	397	73	1476	< 5	< 10	< 4
RHP01-028	594129	5489765	12.69	0.58	2.92	0.61	0.12	9.86	5.7	0.01	0.13	< 2	60	11	139	< 5	235	73	1465	< 5	< 10	< 4
RHP01-039	597143	5490680	16.58	0.28	1.73	0.18	0.07	12.21	3.24	0.01	1.89	< 2	2325	< 5	101	0.6	2159	166	1437	< 5	< 10	< 4
RHP01-049	597481	5491349	12.84	0.2	1.33	0.1	0.01	15.17	3.5	< 0.02	3.06	< 2	1465	< 5	127	< 5	1731	199	2001	< 5	< 10	< 4
RHP01-050	597481	5491349	14.13	0.18	1.31	0.06	< 0.1	14.35	2.13	< 0.02	2.11	< 2	1545	< 5	142	< 5	1184	157	2175	< 5	< 10	< 4
RHP01-050REP	597481	5491349	13.75	0.18	1.28	0.06	0.01	14.29	2.15	< 0.02	2.41	< 2	1408	< 5	143	< 5	1332	175	2086	< 5	< 10	< 4
Q/C																						
		Std. W/MGI	6.97	0.38	4.83	0.12	0.08	12.98	10.16	0.048	3.39	2	4942	8	100	3.1	2302	166	1209	5	-10	-4
		CANMET Value	7.15	0.41	4.4	0.13	0.08	11.89	10.7	0.048	3.7	1.4	5900	15	110	2.7	2700	200	1170	7	0.65	0.1
		RHP01-050	14.13	0.18	1.31	0.06	-0.01	14.35	2.13	-0.002	2.11	-2	1545	-5	142	-0.5	1184	157	2175	5	-10	-4
		RHP01-050REP	13.75	0.18	1.28	0.06	0.01	14.29	2.15	-0.002	2.41	-2	1408	-5	143	-0.5	1332	175	2086	5	-10	-4

Table 3 continued

Sample	ppm (ACME Analytical Labs)														ppb **[ACME]							ppb ***[Activation Labs]							
	Th	Sr	Cd	Sb	Bi	V	La	Cr	Ba	W	Zr	Sn	Y	Nb	Be	Sc	Au	Pt	Pd	Os	Ir	Ru	Rh	Pr***	Pd	Au	Re		
<i>Giant Mascot</i>																													
RHP01-075	2	25	<4	<5	<5	114	<2	3342	11	<4	<2	3	<2	3	<1	8	3	8.2	31.2	8	11	10	14.7	66	166	11	130		
RHP01-076	2	15	<4	<5	<5	127	<2	543	4	<4	<2	4	2	3	<1	20	4	5.7	141.6	5	5.1	11	7.4	-5	98	6.3	23		
RHP01-077	<2	30	1.1	<5	<5	91	<2	1116	12	<4	3	<2	2	<2	<1	12	4	4.8	88.8	137	120	180	100	1140	894	280	34		
RHP01-078	2	61	1.3	<5	<5	63	<2	921	16	<4	6	2	3	<2	<1	8	287	1142.2	889	3	4.2	-5	52	156	182	46	9		
RHP01-080	<2	96	<4	<5	<5	63	<2	1841	44	<4	7	<2	3	<2	<1	8	42	92.9	161.4	3	4.2	-5	1.2	-5	26	12	24		
RHP01-081	<2	20	0.7	<5	<5	85	<2	2723	7	<4	<2	<2	<2	<2	<1	14	5	2	19.4	-2	0.5	-5	1.2	-5	26	12	24		
RHP01-088	<2	22	0.8	<5	<5	122	<2	910	15	<4	<2	4	<2	<2	<1	21	35	126.3	186.4	5	8.4	10	39.4	110	189	38	21		
RHP01-089	<2	53	<4	<5	<5	163	<2	879	27	<4	6	2	2	<2	<1	15	8	24.6	34	5	8.4	10	39.4	110	189	38	21		
RHP01-090	<2	23	<4	<5	<5	162	<2	812	7	<4	<2	4	2	3	<1	30	74	1.3	237.1	10	9	11	9.7	42	413	47	65		
RHP01-091	<2	64	0.9	<5	<5	89	<2	1322	41	<4	6	4	2	<2	<1	13	45	15	44.4	-2	0.3	-5	0.4	8	9	3.6	-5		
RHP01-104	<2	16	1.1	<5	<5	434	<2	2123	5	<4	4	4	6	2	<1	31	20	35.6	465.9	10	9	11	9.7	42	413	47	65		
RHP01-105	<2	52	<4	<5	<5	93	<2	1438	24	<4	4	<2	2	<2	<1	8	3	9.6	9.6	-2	0.3	-5	0.4	8	9	3.6	-5		
RHP01-106	<2	58	0.5	<5	<5	51	<2	1386	23	<4	5	3	2	2	<1	10	5	15.8	27	3	0.3	-5	0.4	8	9	3.6	-5		
RHP01-107	<2	9	1.3	<5	<5	22	<2	737	5	<4	<2	<2	<2	<2	<1	3	3	110.4	244.2	8	12	11	12.7	88	150	24	7		
RHP01-108	<2	82	1.1	<5	<5	114	<2	1233	16	<4	7	2	4	<2	<1	20	24	196.4	149.8	3	0.3	-5	0.4	213	141	300	-5		
RHP01-109	<2	61	2.8	<5	<5	407	<2	1442	107	<4	7	2	4	<2	<1	19	332	359.1	139.8	18	25	40	31.9	100	285	13	48		
RHP01-117	<2	15	<4	<5	<5	58	<2	835	5	<4	<2	4	<2	3	<1	13	4	10.1	255.1	-2	0.8	-5	2.6	38	81	7.1	7		
RHP01-118	<2	20	1.8	<5	<5	103	<2	1140	4	<4	<2	4	2	<2	<1	24	11	89.2	316.8	3	0.3	-5	0.4	213	141	300	-5		
RHP01-119	<2	15	0.5	<5	<5	107	<2	1631	5	<4	<2	2	<2	2	<1	21	7	34.9	73.8	18	25	40	31.9	100	285	13	48		
RHP01-120	<2	19	1.4	<5	<5	74	<2	1741	8	<4	<2	2	<2	<2	<1	14	3	5	116.4	-2	0.8	-5	2.6	38	81	7.1	7		
RHP01-121	<2	39	0.6	<5	<5	205	<2	2012	6	<4	4	<2	4	3	<1	37	9	79.4	49.9	2	3.3	-5	4.5	82	60	11	15		
RHP01-122	<2	10	1.8	<5	<5	21	<2	874	4	<4	<2	<2	<2	<2	<1	6	154	5.5	130.8	6	9.1	5	11.7	37	135	44	19		
<i>Cogburn Creek</i>																													
RHP01-007	<2	180	<4	<5	<5	264	<2	890	80	<4	13	3	7	<2	<1	42	<1	1.1	1	2	0.8	-5	0.8	49	31	15	5		
RHP01-025	<2	91	<4	<5	<5	193	<2	1147	76	<4	21	2	10	2	<1	31	<1	1.4	1.6	-2	0.3	-5	0.3	23	11	24	11		
RHP01-026	<2	123	<4	<5	<5	152	2	1102	164	<4	32	2	7	2	<1	35	1	2.6	0.7	2	0.3	-5	0.3	23	11	24	11		
RHP01-027	2	129	<4	<5	<5	233	<2	952	61	<4	20	<2	11	3	<1	37	<1	2.7	2	2	0.3	-5	0.3	23	11	24	11		
RHP01-028	2	110	<4	<5	<5	280	<2	772	97	<4	16	3	11	2	<1	38	<1	1	<.5	40.7	28.1	2	0.8	-5	0.8	49	31	15	5
RHP01-039	<2	53	<4	<5	<5	139	<2	1943	53	<4	14	5	6	<2	<1	23	12	40.7	28.1	-2	0.3	-5	0.3	23	11	24	11		
RHP01-049	<2	14	<4	<5	<5	223	<2	941	5	<4	5	4	5	<2	<1	38	26	8.5	8	2	0.3	-5	0.3	23	11	24	11		
RHP01-050	<2	9	<4	<5	<5	209	<2	923	4	<4	3	4	3	<2	<1	33	41	4.2	6	6	9.1	5	11.7	37	135	44	19		
RHP01-050REP	<2	9	0.4	<5	<5	204	<2	1014	4	<4	3	5	3	<2	<1	32	21	4.2	6.1	763.5	367.5	731	382	4.2	6.1	4.2	6.1		
QC																													
	2	38	1.2	6	-5	160	4	582	106	-4	31	4	12	5	-1	25	91	763.5	367.5	731	382	4.2	6.1	4.2	6.1	4.2	6.1		
	1.1	41	1.1	1.8	149	770	114	1.3	43	2.2	12	6	0.6	26	110	731	382	4.2	6.1	763.5	367.5	731	382	4.2	6.1	4.2	6.1		
	-2	9	-0.4	-5	-5	209	-2	923	4	-4	3	4	3	-2	-1	33	41	4.2	6	763.5	367.5	731	382	4.2	6.1	4.2	6.1		
	-2	9	0.4	-5	-5	204	-2	1014	4	-4	3	5	3	-2	-1	32	21	4.2	6.1	763.5	367.5	731	382	4.2	6.1	4.2	6.1		

Notes:

Prep. Sample jaw crushed & steel milled @ GSB. Quartz wash between each sample milled.

Major (%) and Minor (ppm) elements by %; TICP, HF-HCL04-HN03-HCL digestion - ICPEs

ACME = ACME Analytical, Vancouver

* Sulphur % by Leco Combustion

**FAIC = Fire assay-ICP finish (15 g sample)

*** Platinum Group Elements by Instrumental Neutron Activation Analysis

TABLE 4
GIANT MASCOT AND COGBURN AREA ROCK AND SULPHIDE DATA

#		Rock*	Sulphide**	Rock	Sulphide	Rock	Sulphide	Rock	Sulphide	Rock	Sulphide	Rock	Sulphide	Sulphide		
		Cu ppm	Cu%	Ni ppm	Ni%	Au ppb	Au ppb	Pt ppb	Pt ppb	Pd ppb	Pd ppb	S %	S%	Fe%		
GIANT MASCOT																
RHP01-076	BX-SM	1	UA	37786	6.32	25523	4.27	4	6.7	5.7	9.5	141.6	236	22.65	37.87	51.55
RHP01-075	NET	2	UA	9000	2.06	14838	3.39	3	7	8.2	19	31.2	71	16.92	38.95	55.87
RHP01-117	NET	3	DA	7233	1.78	25705	6.33	4	10	10.1	24.8	255.1	628	15.51	38.17	53.72
RHP01-090	SM	4	PE	8547	2.27	21966	5.84	74	197	1.3	3.5	237.1	631	14.38	38.19	53.7
RHP01-107	NET	5	MS	3789	1.08	22488	6.4	3	8.5	110.4	313	244.2	694	13.44	38.26	54.26
RHP01-118	NET	6	DA	7332	2.26	16983	5.24	11	34	89.2	275	316.8	976	12.41	38.3	54.2
RHP01-088	BX-SM	7	PE	6729	2.18	14733	4.75	35	113	126.3	409	186.4	604	11.84	38.4	54.64
RHP01-078	NET	8	UA	36019	12.3	18308	6.25	287	979	1142.2	3895	889	3031	10.72	36.59	44.86
RHP01-122	BX-NET	9	DA	40106	17.73	7945	3.51	154	681	5.5	24	130.8	578	8.21	36.29	42.47
RHP01-077	NET	10	UA	2426	1.25	13069	6.71	4	21	4.8	24.4	88.8	456	7.44	38.17	53.87
RHP01-091	NET	11	PE	9469	5.15	8261	4.5	45	24.5	15	82	44.4	242	6.98	37.99	52.36
RHP01-104	BX-NET	12	MS	3210	1.51	10835	5.09	20	94	35.6	167	465.9	2190	6.98	38.44	54.96
RHP01-081	NET	13	UA	1852	1.08	6761	3.95	5	29	2	12	19.4	113	6.63	38.72	56.25
RHP01-108	INT	14	MS	16872	11.1	8470	5.57	24	158	196.4	1292	149.8	986	5.61	36.9	46.43
RHP01-120	BX-NET	15	DA	7690	5.21	9901	6.7	3	20	5	34	116.4	788	5.55	37.58	50.51
RHP01-106	INT	16	MS	1172	1.45	3809	4.7	5	62	15.8	195	27	333	3.12	38.53	55.32
RHP01-121	INT	17	DA	3676	4.46	6398	7.77	9	109	79.4	964	49.9	606	3.09	37.51	50.26
RHP01-119	BX-INT	18	DA	1990	2.8	5832	8.2	7	98	34.9	491	73.8	1038	2.66	37.68	51.32
RHP01-109	INT	19	MS	5501	8.14	3859	5.71	332	4913	359.1	5315	139.8	2069	2.52	37.3	48.85
RHP01-080	INT	20	UA	2448	3.81	5944	9.24	42	653	92.9	1445	161.4	2510	2.4	37.32	49.63
RHP01-089	INT	21	PE	2412	4.09	2429	4.13	8	25	24.6	418	34	578	2.25	38.24	53.54
RHP01-105	INT	22	MS	1339	3.33	1905	4.73	3	89	9.6	283	9.6	283	1.54	38.27	53.67
COGBURN																
RHP01-049	BX-NET	A	#4	1465	1.86	1731	2.2	26	331	8.5	108	8	102	3.06	38.94	57
RHP01-050	BX-NET	B	#4	1545	2.83	1184	2.17	41	754	4.2	77	6	110	2.11	38.77	45.12
RHP01-039	BX-NET	C	#4	2325	4.5	2159	4.35	12	242	40.4	820	28.1	566	1.89	38.1	52.85
RHP01-025***	INT	D	#7	77		396		<1		1.4		1.6		0.4		
RHP01-027***	INT	E	#7	164		397		<1		2.7		2		0.29		
RHP01-028***	INT	F	#7	60		235		<1		1		<0.5		0.13		
RHP01-007***	INT	G	#7	175		270		<1		1.1		1		0.1		
RHP01-026***	INT	H	#7	56		382		1		2.6		0.7		0.09		

*Lithochemical analyses, ACME Analytical Laboratories, Vancouver [see Table 3].

**Sulphide analyses by calculation as discussed in text.

***Sulphur and metal values judged to be too low to obtain a meaningful sulphide determination.

INT = Interstitial; NET = Net-textured; SM = Semi-Massive; BX = Breccia Cement

MS = Millsite; PE = Pride of Emery; UA = Upper Adit; DA = Dolly Adit

#4 = Cogburn Area #4; #7 = Cogburn Area #7

The results for the two analytical procedures (FAIC and INAA) produced similar results for palladium and gold and broadly similar results for platinum. However, the platinum values show greater variability and there are small differences in a few samples. Sample RHP01-076, -080 and -122 contain more platinum as determined by INAA than by FAIC and RHP01-109 contains less (Table 5).

The INAA data (Table 5) show that most of the Giant Mascot samples contain low but detectable (ppb level) amounts of most of the platinum group elements. Samples RHP01-078 (a sample with copper-rich interstitial sulphide) and RHP01-118 (mesh-textured sulphide veined by chalcopyrite) are particularly enriched in each of the elements. The minor platinum group metals appear to be strongly correlated; when one is enriched they all are. The table lists the samples in order of decreasing sulphur content, and the data show a general decrease in platinum-group-element content with decrease in sulphur. However, the correlation is only strongly evident in rhenium.

These results can be compared with those of Hulbert (2001), who analyzed 8 samples collected from the mine and 8 from McLeod's thesis collection. The former include a spectrum of sample textures, similar to those analyzed in this study. The latter include a more limited range of interstitial sulphide-bearing samples. Average metal contents are listed in Table 5. Hulbert's samples are similar in nickel and copper content to those analyzed in the present study; however, they appear to be slightly richer in most platinum-group elements. McLeod's samples are, with one exception, less well mineralized than those analyzed in this study and, even including the "higher-grade" sample (46A-1), their average platinum palladium and gold values (Table 5) are lower. There are too many "below-detection" determinations to make a meaningful average determination of the lesser abundant platinum group elements, but McLeod's "higher-grade" sample contains significant amounts of each. The rock contains 1.4% Ni, 1.1% Cu, 240

TABLE 5
PLATINUM GROUP ELEMENTS

ID	Os ppb	Ir ppb	Ru ppb	Rh ppb	Pt ppb	Pt* ppb	Pd ppb	Pd* ppb	Au ppb	Au* ppb	Re ppb
GIANT MASCOT											
RHP01-076	8	11	10	14.7	66	5.7	166	141.6	11	4	130
RHP01-118	18	25	40	31.9	100	89.2	285	316.8	13	11	48
RHP01-088	5	8.4	10	39.4	110	126.3	189	186.4	38	35	21
RHP01-078	137	120	180	100	1140	1142.2	894	889	280	287	34
RHP01-122	6	9.1	5	11.7	37	5.5	135	130.8	44	154	19
RHP01-077	5	5.1	11	7.4	-5	4.8	98	88.8	6.3	4	23
RHP01-104	10	9	11	9.7	42	35.6	413	465.9	47	20	65
RHP01-081	-2	0.5	-5	1.2	-5	2	26	19.4	12	5	24
RHP01-108	8	12	11	12.7	88	196.4	150	149.8	24	24	7
RHP01-120	2	3.3	-5	4.5	82	79.4	60	49.9	11	9	15
RHP01-119	-2	0.8	-5	2.6	38	34.9	81	73.8	7.1	7	7
RHP01-109	3	0.3	-5	0.4	213	359.1	141	139.8	300	332	-5
RHP01-080	3	4.2	-5	5.2	156	92.9	182	161.4	46	42	9
RHP01-105	-2	0.3	-5	0.4	8	9.6	9	9.6	3.6	3	-5
Average	14.2	14.9	17.7	17.3	148	156	202	201.6	60.2	66.9	28
(1.07% Ni, 1.22% Cu)											
Hulbert (2001)	21	22	39	41	193		382		38		44
(1.99% Ni, 0.65% Cu)											
McLeod**					57		140		35		
(0.27% Ni, 0.19% Cu)											
COGBURN											
RHP01-049	-2	0.3	-5	0.3	23	8.5	11	8	24	26	11
RHP01-039	2	0.8	-5	0.8	49	40.7	31	28.1	15	12	5

PGE Analyses from Activation Laboratories (see Table 3)

Pt*, Pd* and Au* data from Acme Analytical Laboratories (see Table 3)

**McLeod *in* Hulbert (2001)

ppb Pt, 940 ppb Pd, 220 ppb Au, 46 ppb Rh, 40 ppb Ru, 24 ppb Os, 29 ppb Ir and 13 ppb Re.

Table 6 shows the extent of the correlation between the various elements (excluding iron) found in the sulphides at Giant Mascot. Correlation coefficients for the rocks analyzed in this study show that there is a strong positive correlation between nickel and sulphur (0.94), a moderate correlation between copper and sulphur (0.50) and a weak correlation between most of the platinum group elements (except rhenium (0.87)) and sulphur (0.10 - 0.39). The platinum group elements (excluding rhenium) are very strongly inter-related (>0.85) and, geochemically, appear to have behaved in a similar manner. Nickel and copper are moderately related (0.36), as might be expected from the observed degree of copper remobilization.

In magmatic rocks, where the sulphides have formed from droplets and the mineralogy is limited to a relatively simple sulphide assemblage, it is possible to reduce the affect of silicate dilution by calculating the "normative" content of the sulphide minerals and recasting the data as if the rock was composed entirely of sulphide. This reduces the differential caused by comparing values from sulphide-rich and sulphide-poor samples. It is done in three steps. Sufficient Fe and S are assigned to the available Cu content to form the mineral chalcopyrite (CuFeS₂). Sufficient Fe and S are then allotted to the available Ni content to form the mineral Pentlandite (Fe_{4.5}Ni_{4.5}S₈). Lastly, sufficient Fe is allo-

cated to the remaining S to form the mineral pyrrhotite (Fe₇S₈). For a magmatic sulphide assemblage, the total Fe content of the sulphide is taken to be the sum of that required for the chalcopyrite, pentlandite and pyrrhotite. This figure can be used to estimate the percentage of the rock composed of sulphide and this, in turn is used to estimate the composition of the bulk sulphide without its silicate gangue.

Table 4 compares the original metal and sulphide values with calculated, silicate-free, figures using data from Table 3. The data provides a useful approach for comparing samples, but the calculated values should be considered with some caution, as the calculation is predicated on having accurate base, precious metal and sulphur determination and sulphides with "ideal" structural formulae. The nickel content of the rock may be slightly elevated if the silicate gangue contained nickel-rich olivine and it contributed to the total. However, given the small amount of nickel Muir (1971) found in olivine (0.13% Ni), it is not likely to be a significant problem and the pentlandite content should not be significantly overestimated. The samples are estimated to contain between 1.08% Cu and 17.73% Cu (average 4.61% Cu); between 3.39% Ni and 9.24% Ni (average 5.59% Ni); between 6.7 ppb Au and 4913 ppb Au (average 379 ppb Au); between 3.5 ppb Pt and 5315 ppb Pt (average 713 ppb Pt) and between 71 ppb Pd and 3031 ppb Pd (average 893 ppb Pd) when considered in bulk-sulphide form (Table 4). The samples are biased towards high-grade and

TABLE 6
GIANT MASCOT CORRELATION COEFFICIENTS

	Os	S	Ir	Cu	Ru	Rh	Pt	Pd	Ni	Au
Re	0.09	0.87	0.13	0.46	0.1	0.15	0	0.23	0.82	-0.16
Au	0.62	-0.11	0.58	0.25	0.6	0.5	0.74	0.6	-0.01	
Ni	0.41	0.94	0.46	0.36	0.43	0.56	0.19	0.48		
Pd	0.92	0.35	0.93	0.45	0.92	0.89	0.86			
Pt	0.97	0.1	0.96	0.47	0.96	0.9				
Rh	0.93	0.39	0.95	0.49	0.94					
Ru	0.99	0.24	1	0.46						
Cu	0.49	0.5	0.52							
Ir	1	0.27								
S	0.22									

do not constitute a statistically meaningful population; however, they suggest that the concentrate produced at the Giant Mascot mine must have contained several tens of parts per billion of gold and a few hundreds of parts per billion of platinum and palladium. It may also have contained a few tens of parts per billion of the other platinum group elements.

Figure 9, relates the amount of platinum group elements and gold to the sulphur content of the rock and the Ni/Cu ratio. There are no clear correlations; however, there is a suggestion that precious metals may be slightly higher in samples that contain large amounts of nickel and copper relative to the amount of sulphur present. This should be the case if platinum group elements favour pentlandite and chalcopyrite over pyrrhotite.

The mineralized samples from Cogburn Creek generally contain far less sulphide and have lower metal contents (Table 3 and 4). They contain between 0.09% sulphur and 2.11% sulphur (average 1.03% S). The low values are partially a function of the style of mineralization. The disseminated to blebby, sulphide in hornblende pyroxenite south of Cogburn Creek (RHP01-007, -025, -026, -027 and -028) is scattered throughout a large volume of rock and produces a noticeable nugget effect. The analytical results for these samples show low sulphur contents (0.09 - 0.29% S) and only trace amounts of nickel (235 - 397 ppm Ni), copper (56 - 175 ppm Cu), platinum (1.0 - 2.7 ppb Pt) and palladium (0.5 - 2.0 ppb Pd). These are background levels that suggest little metal enrichment.

Samples of fracture-controlled mineralization (RHP01-039, -049, -050), found north and south of Cogburn Creek, are richer in sulphur (1.89 - 3.06% S) and base and precious metals. However, none of the analyzed samples included an appreciable amount of chalcopyrite vein material and the analytical data (Table 3 and 4) show the more disseminated and net-textured sulphides contain only relatively minor amounts of nickel (1184 - 2159 ppm Ni) and copper (1465 - 2325 ppm Cu). However, they also contain a significant trace of gold (12 - 41 ppb Au), platinum (4.2 - 40.7 ppb Pt) and palladium (6 - 28.1 ppb Pd). The rocks appear to be more pyrrhotite-rich, for the amount of nickel and copper present, than those at Giant Mascot.

Two samples, RHP01-039 and RHP01-049 were sent to Activation Laboratories with the samples from Giant Mascot. The samples were analyzed for the same suite of elements and the results are shown in Tables 3 and 5. The platinum, palladium and gold values obtained by instrumental neutron activation analysis are similar to those obtained by conventional fire-assay with ICP finish. The Os, Ir and Ru values, obtained by neutron activation analysis are either below, or barely above, detection (Table 5).

DISCUSSION

Regional mapping by Lowes (1972), Monger (1986, 1989) and Ash (2002) show that the ultramafic bodies east of Harrison Lake are found in two distinct geological settings. Most are clearly deformed and metamorphosed slivers or lenses in Cogburn Schist (Lowes, 1972; Troost, 1999; Ash, 2002); however, some, including those at Giant Mascot and Cogburn Creek are less obviously deformed and metamorphosed. They are irregular-shaped, bodies intimately associated with the Spuzzum and Hut Creek diorite plutons and they are in contact with Settler, rather than Cogburn Schist (Gabites, 1985; McLeod, 1985). The principal areas of nickel-copper mineralization are found in the latter.

The present study shows numerous points of similarity between the mineralized bodies at Giant Mascot and Cogburn Creek and one major point of difference. The cumulate at Giant Mascot is far richer in olivine and contains

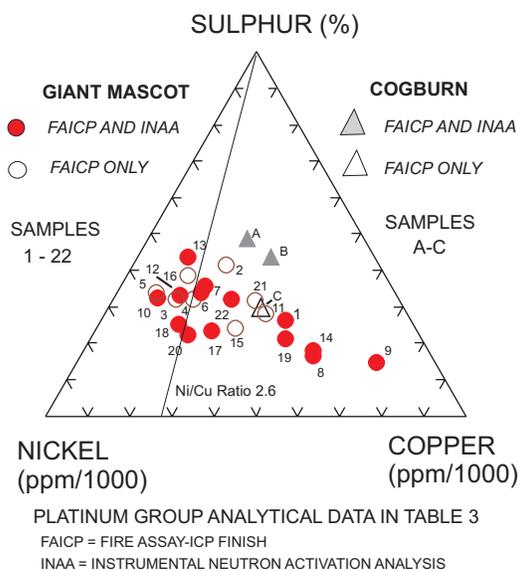


Figure 9. Nickel-sulphur-copper plot (wt.%) of mineralized samples from the Giant Mascot (circles) and Cogburn (triangles) areas. The plot shows the spread of data about the "global" Ni/Cu average of 2.6. Giant Mascot samples are numbered and the Cogburn samples are lettered for reference to Tables 4 and 5. Open samples have been analyzed for platinum-group elements by Fire-assay with ICP finish. Closed samples have been analyzed for platinum group elements by Fire-assay with ICP finish and instrumental neutron activation analysis.

far less feldspar than is found at Cogburn Creek. However, both bodies are composed of thick units of massive, relatively homogenous cumulate of differing compositions that are inter-layered with each other and locally crosscut each other, suggesting that they may have been deformed prior to, and after, final consolidation. In some localities, at Giant Mascot, mineralized cumulate surrounds blocks of barren cumulate; elsewhere, at Cogburn Creek, mineralized inclusions are found in barren cumulate. Delicate layering is uncommon, it has only been observed at one locality along Cogburn Creek.

The sulphides at both localities are found in relatively unaltered rock. They fall within a continuum from rare, scattered interstitial blebs through net-textured, inter-cumulus sulphide to semi-massive sulphide. The latter includes mineralization found in both deformed and undeformed cumulate. At some localities, the sulphide is enriched along well-defined deformation zones cutting fresh rock. In both areas (Giant Mascot and Cogburn Creek), the sulphide is commonly spatially associated with rocks that show late development of inter-cumulus and/or replacement hornblende. However, the relationship may be coincidental as there is very little hornblende with the mineralized rocks north of Cogburn Creek. Net-textured ores at Giant Mascot commonly also contain very little hornblende, however this may be because sulphide displaced silicate magma as the principal inter-cumulus material.

The two cumulate bodies may have been folded but there is little evidence that they were metamorphosed prior to intrusion of the diorite. They were, however, faulted, as diorite and tonalite dikes occur along well-defined fractures at both localities, and contacts between the cumulate body and diorite are commonly brecciated. The contact is commonly defined by hornblendite, which forms in zones several metres in width. In many localities, altered pyroxenite and diorite fragments are cemented by a coarse hornblende-feldspar pegmatite. In both areas, the interstitial, inter-cumulus phase in proximity to the contact is hornblende while feldspar is more abundant at some distance from the diorite. Rock textures suggest that the hornblende is high-temperature and magmatic, formed from hydrated residual magma during the final phase of consolidation, possibly as the diorite was being intruded. Alternatively, it may be porphyroblastic. Secondary amphibole formation continued on cooling, particularly south of Cogburn Creek. The two cumulate bodies were deformed with the Spuzzum and Hut Creek diorite during the mid-Cretaceous, however they behaved in a more competent manner than the diorite and they show little sign of foliation. They have, however, been faulted.

Although Aho (1956) considered the possibility of a hydrothermal origin for the zoned ore shoots at Giant Mascot, more recent workers suggest that the deposit formed as a result of segregation of sulphide droplets from a mafic magma, accumulation of the droplets through gravity settling, and subsequent remobilization and emplacement of a mineralized crystal mush into barren cumulate (Muir, 1971 and McLeod, 1975). They base their conclusion on the inter-cumulus nature of much of the sulphide and on the

compositions of coexisting silicates. These indicate high temperatures of formation and a magmatic origin for the pyroxenes (McLeod *et al.*, 1976).

Clarke (1969) studied the geometry of the ore-shoots and concluded that they were controlled by three principal fault sets, although the nature of the control was uncertain. Given the complexity of the distribution of cumulate lithologies in the mineralized areas described by Aho (1956), Muir (1971) and McLeod (1975), it is possible the current distribution of ore-shoots at Giant Mascot is a function of primary sulphide accumulation by gravity followed by folding and faulting, and migration of sulphide-rich material to low-pressure zones prior to intrusion of the diorite. In some localities, there is textural evidence to show that at least some of the sulphide has been remobilized into deformation zones. Current geometric relations will have been complicated by deformation, both folding and faulting, since the emplacement of the diorite.

Magmatic sulphide deposits are formed through accumulation of immiscible sulphide droplets, derived from sulphur-saturated mafic magmas, into ore-grade concentrations. Theoretically, droplets formed during a single sulphur saturation event should be similar in composition and should settle to form deposits with predictable metal ratios. The metal content of a sulphide droplet will be controlled by the composition of the silicate magma; the relative volumes of the sulphide and silicate melt and partition coefficients. Deposits formed from magmas of similar composition commonly display broadly similar metal ratios (Naldrett, 1981; Barnes, 1990; Naldrett and Ebel, 1997). The tenors of the metals will, however, be variable.

Deposits formed from sequential, or non-equilibrium segregation of sulphide will be less consistent in composition, as will those that have undergone substantial remobilization. The timing of introduction of sulphur into a magma chamber is important, as early-formed droplets will preferentially scavenge platinum group metals leaving the silicate magma depleted during subsequent sulphur saturation events. If a significant amount of olivine and trace sulphide has already been deposited as cumulate before the main introduction of sulphur, there will likely be less metal to extract (Naldrett, 1981; Barnes, 1990). Platinum group elements have much higher partition coefficients into sulphide than do nickel and copper, and they can readily be removed from the melt and dispersed in cumulate in small amounts of disseminated, interstitial sulphide.

Hulbert (2001) assigns Giant Mascot to a "Tholeiitic Mafic to Ultramafic" class of deposit, although he acknowledges that limited data suggests some association with the Spuzzum pluton, which is calc-alkaline in character. The average Ni/Cu ratio for the ore-shoots at Giant Mascot is 2.6, which is similar to other nickel-copper deposits formed in other tholeiitic gabbroic intrusions discussed in the literature. The geology at Giant Mascot is very similar to that at the Farley mine, at Lynn Lake in Manitoba (Pinsent, 1980). The "A" plug at Lynn Lake contained 15 ore-shoots with an aggregate 25 771 228 tonnes grading 0.91% Ni and 0.49% Cu (Ni/Cu ratio 1.86). The smaller, "El" plug contained two ore-shoots with a total of 1 732 264 tonnes grading 2.07% Ni

and 0.76% Cu (Ni/Cu ratio 2.72). There has been very little systematic work done on its platinum group element distribution.

Naldrett (1981) describes several other “gabbro-related” deposits including the Pechenga deposit on the Kola Peninsula, in Russia, and the Montcalm deposit, in Ontario. For each of these, and others, he has calculated the average metal content of a “100% sulphide” using the same calculation applied here, allowing for direct comparison.

The Pechenga deposit comprises 20 ore-shoots and prospects in a series of ultramafic to mafic cumulate bodies “intruded” into metasedimentary rock interbedded with thick sequences of submarine basalt. The ore-types include (1) disseminated peridotite-hosted ores, (2) breccia ores in tectonic zones and (3) veinlets in country rocks. The Cu/(Cu+Ni) ratio of the first two ore types is reported to be 0.28 and of the third, 0.51. Based on 13 samples, (Naldrett, 1981) estimated that the sulphide concentrate would contain approximately 600 ppb Pt, 500 ppb Pd and 200 ppb Au. These values are similar to the average values obtained for Giant Mascot (713 ppb Pt, 893 ppb Pd and 379 ppb Au).

The Montcalm deposit (3.56 million tonnes grading 1.44% Ni, 0.68% Cu and 50 ppb total PGE) is similar, but notably depleted in platinum group elements (Barrie *et al.*, 1990). It has a global Ni/Cu ratio of 2.1, but has a very low platinum group element tenor. Naldrett (1981, Table 2) suggests that the “concentrate” from this deposit would likely contain approximately 58 ppb Pt, 17 ppb Pd, 2.4 ppb Rh, 3.7 ppb Ru, 0.7 ppb Ir, <1.5 ppb Os and 82 ppb Au. The data are consistent with sulphide segregation from a primitive magma that has already fractionated much of its olivine, clinopyroxene and chromite, along with trace amounts of sulphide. The deposit formed after the bulk of the platinum group elements had been removed from the magma (Barrie *et al.*, 1990).

Similarly, Paktunc (1989) reports finding low platinum group element tenors in sulphides in the St. Stephen “tholeiitic mafic-ultramafic intrusion”, that straddles the border between New Brunswick and Maine. The intrusion hosts several deposits, of which the three largest contain 907 000 tonnes grading 1.03% Ni and 0.47% Cu (Ni/Cu ratio 2.19). Paktunc analyzed 19 sulphide-bearing samples by neutron activation analysis and determined concentrations of <5 to 289 ppb Pt, <2 to 150 ppb Pd, <1 to 68 ppb Au, 1 to 5 ppb Rh, <5 to 100 ppb Ru, 0.1 to 1.9 ppb Ir, <3 to 5 ppb Os and <5 to 37 ppb Re. Based on the nickel content of olivines, he concluded that sulphur saturation must have occurred following formation of the main peridotite mass and that early sulphides had already depleted the magma of its platinum-group elements.

The sulphide at Giant Mascot deposit is relatively homogenous at the deposit scale but metal distribution is highly variable on the local, hand-specimen scale. Correlation coefficients suggest that the platinum-group elements and gold are only moderately allied to nickel and copper distribution, which has clearly been, at least in part, affected by remobilization of chalcopyrite into veins and veinlets. The latter may account for the variation in Ni/Cu ratio. The variability in platinum-group element content may be a function

of sampling, or it may reflect local remobilization, or sulphide fractionation (Naldrett, 1981; Naldrett and Ebel, 1997). Some of the massive sulphide samples from Giant Mascot contain two generations of pyrrhotite: large, early-formed, and later, finer-grained crystals.

Barnes, *et al.* (1993), discuss the distribution of platinum-group elements in several nickel-copper deposits found in possibly mantle-plume related “synvolcanic gabbros” within the Belleterre-Angliers greenstone belt of the Pontiac sub province, in Quebec. They compare the tenors of metals found in 8 of these deposits and prospects and, by recalculating the values to 100% sulphide established benchmark estimates for platinum-group element contents of “undepleted” and “depleted” deposits. They also examined the possibility of using the Cu/Pd ratios as a tool for exploration. They show that the Cu/Pd ratio for mantle rocks will be in the range 10^3 to 10^4 and that the ratios for palladium depleted and enriched mantle-derived magmas will be somewhat greater, and somewhat lower, respectively (Barnes, *et al.*, 1993; Figure 12). If the palladium content of the Giant Mascot deposit is around 100 - 200 ppb, the Cu/Pd ratio for the deposit will be approximately 10^4 . The sulphide ratio plots close to the transition point between mantle-derived and depleted rocks (Barnes, *et al.*, 1993), suggesting that the source magmas had not been previously depleted in platinum-group metals.

The analytical results for Giant Mascot indicate that the deposit is “gabbro-related”, as defined by Naldrett (1981) and that the host magma became sulphur saturated while olivine was crystallizing and was being fractionated. Sulphur was introduced early enough to scavenge a significant, but trace amount of platinum, palladium, gold and detectable amounts of the other platinum group elements as well as copper and nickel. Although there are insufficient data to evaluate the distribution of platinum group elements at Cogburn Creek fully, the abundance of feldspathic cumulate and relative enrichment in pyrrhotite, as opposed to pentlandite and chalcopyrite, and the relatively low platinum and palladium values obtained, suggests that there is greater likelihood of prior platinum group element depletion in this area. This is consistent with the observed presence of mineralized pyroxenite inclusions in feldspathic pyroxenite north of Cogburn Creek. The inclusions indicate an earlier mineralizing event.

CONCLUSION

The study shows that the two principal areas of nickel-copper mineralization east of Harrison Lake (at the Giant Mascot mine and at Cogburn Creek) are similar in their geological setting and style of mineralization. The sulphides are magmatic in origin and the deposits occur in bodies of ultramafic to mafic cumulate that are intimately related to Settler Schist and Spuzzum-type diorite. The principal difference between the two areas appears to be the relative abundance of ultramafic cumulate at Giant Mascot and of mafic cumulate in the Cogburn area.

The age and origin of the cumulate remains in question. Contact relations suggest that the cumulate bodies predate

intrusion of the Spuzzum diorite; however, rock textures appear to show inter-cumulus hornblende developed as a late magmatic phase in pyroxenite around the margins of the cumulate bodies. This suggests that the cumulate may have contained a small amount of residual (interstitial) magma that was weakly hydrated when the body was intruded by diorite. The Giant Mascot cumulate body was deformed prior to and after intrusion of Spuzzum diorite and the current configuration of the ore-shoots is probably a result of both primary and secondary influences. The role, if any, of the Spuzzum pluton in the formation of deposit is uncertain.

The Giant Mascot ore-shoots contain nickel, copper, gold and platinum group element concentrations that are similar to other “gabbro-related” deposits that have not suffered appreciable depletion of platinum group elements. The platinum-group elements appear to be present as trace amounts (several 100s of ppb Pt and Pd in “100% sulphide”) that would be unlikely to be economic to mine on their own. They would; however, add considerably to the value of a nickel-copper deposit. The ore-shoots are most commonly associated with olivine-rich cumulates, consistent with their early formation in a magma chamber. The Cogburn sulphides are similar, but appear to contain less nickel, copper and platinum-group elements relative to the amount of pyrrhotite present. They are in more feldspathic cumulates and may have formed later than those at Giant Mascot, after the main stage of olivine crystallization and fractionation.

Platinum-group elements are found in magmatic sulphides at both localities and the study suggests that future exploration for these elements should focus on similar, sulphur-saturated, cumulate bodies associated with Settler Schist and Spuzzum-type diorite. The ultramafic lenses found in Cogburn Schist have, to date, proved to be largely sulphide-free and are, consequently considered a less attractive target.

ACKNOWLEDGMENTS

The author wishes to thank Gene Gulajek of Homestake Canada Limited, for permission to review company data and to sample the Giant Mascot mine. He also wishes to thank David Haughton and Mike Sanguinetti for their help in obtaining data and for their comments in the field. The author would like to extend his appreciation to several members of the Ministry of Energy and Mines, including Graham Nixon, Chris Ash, Ray Lett, Nick Massey, Dave Lefebure and Jacques Houle who have each contributed significantly to the project. In particular, the author would like to thank Mary Dubravcic for her help in the field, Maggie Dittrick and Christy Cattermole in the Ministry’s Mineral Development Office, and Dave Lefebure and Chris Ash for valuable editorial comments.

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