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Ministry of Energy, Mines and
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ULTRAMAFIC ASSOCIATED CHROMITE AND NICKEL OCCURRENCES IN BRITISH COLUMBIA

By Kirk D. Hancock

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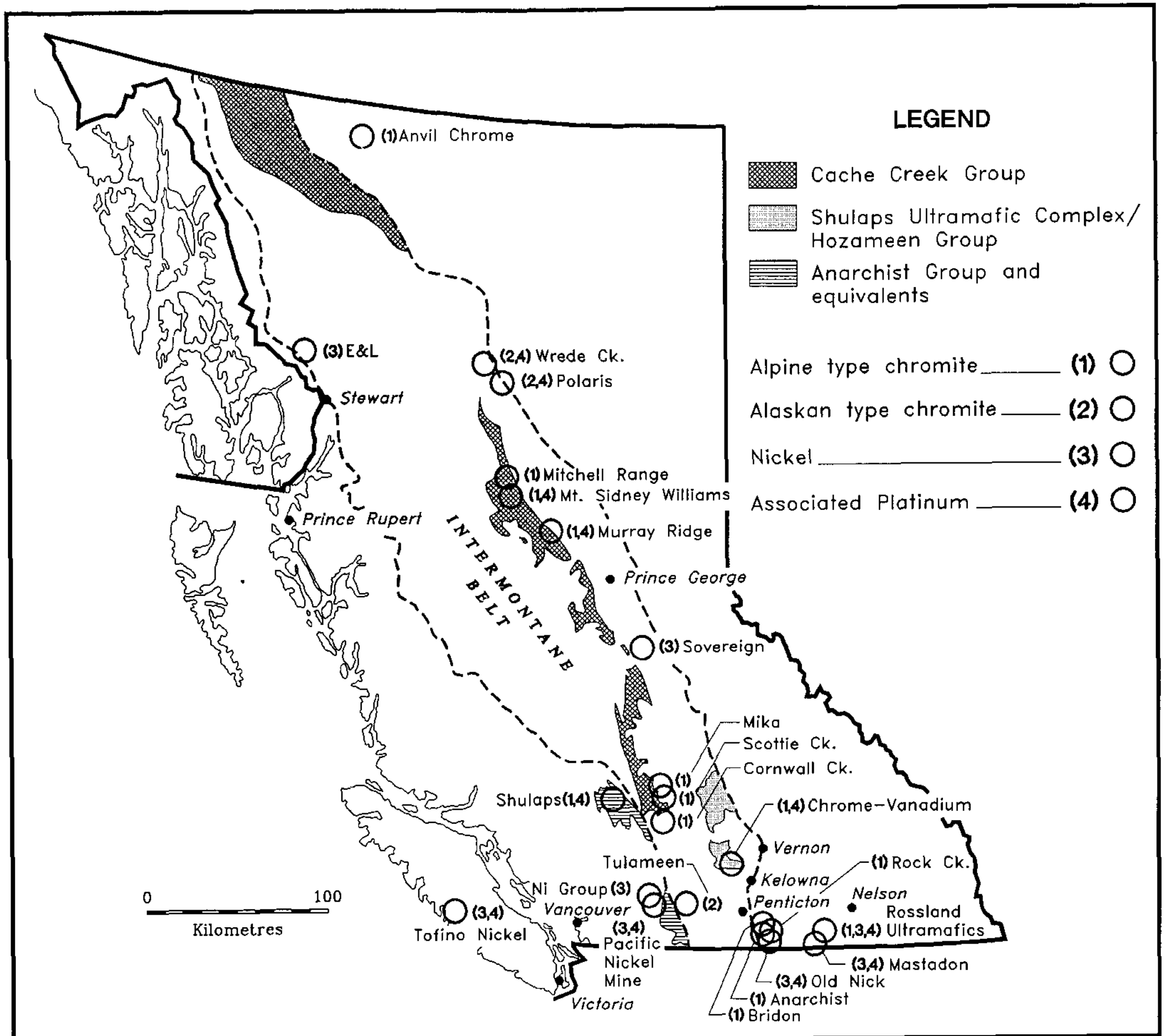

Frontispiece. Ultramafic associated chromite and nickel in British Columbia.

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PURPOSE AND SCOPE OF REPORT

This Open File report records the most significant mafic-ultramafic-associated chromite and nickel occurrences in British Columbia. Its primary focus is the chromite occurrences in the province, however, due to the mineralogical association of platinum group metals and nickel with ultramafic rocks, they are also included where appropriate.

All known chromite and nickel occurrences are compiled, using the MINFILE database as the initial data set. Geological information available to the Geological Survey Branch was evaluated for reported occurrences and they were then divided into two groups. The first group includes all deposits where sufficient data are available for concise descriptions including location, geology, mineralization, history and current claims, if any. These occurrences are grouped by genetic classification and geographic location. The second group is listed by MINFILE number and geographical coordinates in an appendix, as sufficient geological information is not available or the occurrence is not appropriate for inclusion in the body of this report.

SOURCES OF INFORMATION

This report is based on research of as much information as time permitted; no field examinations of the mineral occurrences were made. When possible, public and private-sector geologists were consulted with respect to specific occurrences or regional geology. Printed material researched included British Columbia Ministry of Energy, Mines and Petroleum Resources publications and assessment reports; Geological Survey of Canada Memoirs, Papers, Bulletins, Open Files and Maps; unpublished M.Sc and Ph.D theses; mining company reports and information releases; mining industry publications and newspapers; and, professional and academic journals. All information sources are included in the reference list at the end of the report.

EXPLORATION FOR ULTRAMAFIC-ASSOCIATED CHROMITE, NICKEL AND PLATINUM GROUP METALS IN BRITISH COLUMBIA

Exploration for chromite in British Columbia has not been extensive. It was primarily done in the early 1930s through to the late 1940s when the Second World War and associated events increased the price of chromite which led to the evaluation of domestic resources. Since that time, an excellent regional geological database for ultramafic rocks in the province has been available as a result of the work of both the Geological Survey of Canada and the British Columbia Geological Survey Branch. The primary targets in exploration for chromite mineralization are the mantle portions of ophiolite bodies and ultramafic intrusions. Regionally, the most significant settings for ultramafic rocks are the Cache Creek terrane, the Anarchist Group rocks and their equivalents, the Shulaps ultramafic complex and the Hozameen Group as well as the Alaskan-type mafic-ultramafic intrusions (*see* frontispiece).

In specific locations, ground and airborne magnetic, VLF/EM and gravity surveys have been used successfully to outline the ultramafic bodies. Prospecting and geological mapping of the ultramafites may then be effective in locating dunite and chromite mineralization. Judging by most published reports, soil and silt geochemistry for chromium, nickel, and platinum group elements has to date proven to be of limited use. This may be due to insufficient sample density the low chemical mobility of chromium as chromite is chemically very stable, or lack of mineralization in the areas surveyed. Lithogeochemical sampling, however, is very effective in evaluating specific targets. Nickel mineralization most commonly occurs in sulphide form in mafic-ultramafic rocks but in the ultramafic complexes of British Columbia, sulphide mineralization is commonly absent or very rare. Nickel is found with sulphides in mafic bodies, usually gabbroic rocks, at a few locations in the province.

ACKNOWLEDGMENTS

I wish to thank the following individuals for providing geological information about specific chromite or nickel occurrences as well as background material: G.T. Nixon, C. Ash, J.L. Nelson, J.T. Fyles, R. Gaba, P. Wilton and D. Hora. Also, the late John L. Stevenson, whom I have quoted extensively, provided an excellent unpublished manuscript of the major chromite occurrences in the province. I also thank the mineral exploration companies which provided information about their chromite or nickel properties.

CHROMITE - BACKGROUND INFORMATION

CHROMITE - THE MINERAL

Chromite is a member of the spinel group $R^{2+}O$-$R^{3+}{}_2O_3$. It has a theoretical composition of FeO-Cr_2O_3 with a maximum of 68 per cent Cr_2O_3 and 32 per cent FeO by weight. However, it commonly contains other elements with Mg, Zn and Ni substituting in the R^{2+} site and Fe, Al and Ti substituting in the R^{3+} site. Chromite is commonly dark brown, with black and red varieties and has a Moh's hardness of 5.5. It has no cleavage, octahedral (1 1 1) parting is rare and it is commonly twinned according to the spinel law, (1 1 1). The mineral is commonly found as disseminated grains 0.5 to 4 millimetres in diameter but also occurs as massive pods, lenses, or layers. It occurs in dunitic ultramafic rocks and their altered equivalents. These include dunite, peridotite, harzburgite, lherzolites, serpentinites, talc and brucite-bearing rocks as well as tropical laterites and some alluvial deposits.

MINERAL ECONOMICS

USES AND DEMAND

Chromite is used in a multitude of applications, both in the ferrous and nonferrous metals industries as well as the industrial minerals sector. Its major application is in the manufacture of specialty metals, including stainless steel, chrome-moly steel and nichel-chrome. It is used as an alloy to provide increased hardness, wearability and resistance to chemical attack. It is also used for hard-facing metals and to provide a fine, smooth finish to precision parts such as hydraulic piston rods and automotive engine valves.

Chromite is used extensively as a refractory material. It is used in the manufacture of refractory brick, basic brick, foundry 'sand', castables, mortar, and ramming and gunning compounds. Chromite has a high melting temperature range of 1545° to 1730°C, depending on its composition, making it a desirable component in refractory brick in ferrous and nonferrous furnaces. Chromite does not react in high-temperature basic environments where silicates would. Thus chromite and chromite-compound brick and tile are used in ferrous industry furnaces, glass furnaces and as a lining in high pH, hot spent-liquor tanks in the pulp and paper industry.

Chromite is also used widely in the chemical industry. Most commonly it is processed into sodium dichromate which is then used to produce other chromium compounds used as antifouling agents, pigments, mordants and dyes, and as a leather tanning agent. Chrome compounds are also used for chrome electroplating, etching and anodizing, and in oxidants and catalysts.

Economic forecasts predict a small but steady increase in the demand for chromite and ferrochrome. Industrialized countries have a steady demand for both products but, in most cases, little increase or even a decline in consumption is projected. However, developing countries that are beginning to industrialize are potential new markets for chromite and ferrochrome. Examples include China and India. With regard to increased demand for chromite ore, countries where electric power is cheap may be future producers of ferrochrome; examples are Brazil, Canada and India.

GRADES

The wide variety of uses for chromite creates markets for three commercial grades with varying amounts of substituting elements: metallurgical, refractory and chemical (Table 1). These were established earlier in this century, and relate to the level of technology of the metals industry at that time. Basic open-hearth furnaces (BOF) set the standard and since then, developments up to the argon-oxygen decarburizaton (AOD) furnace have allowed chemical grade chromite ore to be used in the metals industry. The grades quoted here are only a guide as purchasers of chromite ore also have stringent specifications for other impurities such as sulphur, phosphate and silica.

TABLE 1
CHROMITE GRADES

	Cr_2O_3	Cr_2O_3 + Al_2O_3	Al_2O_3	Cr/Fe	FeO
Metallurgical	45-60%	–	–	2.8-4.3	–
Refractory	–	>60%	>25%	>2	<15%
Chemical	<44%	–	–	1.5	–

PRICES

Major chromite production in the western world is limited to a few major countries, South Africa, Zimbabwe, Turkey and the Philippines. Production of chrome ore in the Soviet block is consumed internally and generally does not affect the western market. South

Africa presently accounts for approximately 55 per cent of the free world output. As a result, it greatly influences prices of chrome ore and ferrochrome. Specifically, there is a wide range of chrome ore producer prices depending on grade. Chemical grade ore has the lowest price and refractory grade the highest. Recent quoted figures shown chemical grade at $US 70 to 75 per tonne (FOB mine, South Africa) and refactory grades from $US 85 per tonne (FOB mine Philippines). Because of the limited number of producers world wide there is no free market. Prices are fixed by contract directly between producers and consumers. The prices of chromite ore have remained effectively constant, with small increases over the last 10 years. This trend is expected to continue barring any major destablizing events.

TABLE 2
WORLD CHROMITE RESERVES AND RESERVE BASE; 1983[1]

(Million Tonnes Shipping Ore[2], Gross Weight)

Location	Reserves	Reserve Base[3]
North America:		
Canada		3.6
Greenland	<0.5	
United States	<0.5	
Total[4]		3.6
South America:		
Brazil	8.2	9.1
Cuba	2.7	2.7
Total[4]	12	11.8
Europe:		
Albania	6.4	20
Finland	17	29
Greece	0.9	0.9
U.S.S.R.	129	129
Total[4]	152	181
Africa:		
Madagascar	7.3	7.3
Republic of South Africa	828	5 715
Sudan	1.8	1.8
Zimbabwe	17	753
Total[4]	854	6 441
Asia:		
Cyprus	0.9	0.9
India	14	60
Iran	1.8	1.8
Pakistan	0.9	0.9
Papua New Guinea	0.9	0.9
Philippines	14	29
Turkey	4.5	73
Vietnam	0.9	0.9
Other	<0.5	0.9
Total[4]	40	180
Oceania:		
Australia		1.8
New Caledonia	1.8	1.8
Total	1.8	1.8
WORLD TOTAL[4]	1 056	6 804

1 World resources derived in consultation with the U.S. Geological Survey.
2 Shipping ore is deposit quantity normalized to 45 per cent Cr_2O_3 for high-chromium and high-iron chromite and 35 per cent Cr_2O_3 for high-alumina chromite. Original values converted to tonnes at 0.9072 tonne = 1 ton.
3 The reserve base includes demonstrated reserves that are currently economic (reserves), Marginally economic (marginal reserves) and some of those that are subeconomic (subeconomic resources).
4 Data presented in this table may not add to totals due to independant rounding and other factors.

Note: Table modified from Papp (1985).

Worldwide Distribution of Chromite Deposits

Chromite is classed as a strategic mineral. It is essential to many sectors of the defense and manufacturing industries. For military purposes chrome is used primarily in alloys associated with ordinance, missiles, armour plate and motor components. In industry it is used in superalloys, commonly light weight and heat resistant, such as jet turbine components, as well as in the making of stainless

TABLE 3
CHEMICAL ANALYSES OF CHROMITE ORES AND CONCENTRATES (MASS %)

Country	Type	Cr_2O_3	FeO_T	Al_2O_3	MgO	SiO_2	Cr/Fe
Brazil	M	40.3	14.23	13.37	16.13	10.03	2.4
Canada	M	40.3	13.40	15.7	18.3	7.7	2.7
	C	46.86	20.52	10.47	14.75	3.83	2.0
	O	48.00	17.40	7.27	17.57	6.27	2.4
	C	49.37	23.63	13.67	11.93	1.40	1.8
Cuba	R	36.43	14.16	26.46	18.56	3.40	2.3
	R	30.55	13.24	29.51	18.77	4.97	2.0
	R	30.5	14.2	27.5	18.3	6.1	1.9
Cyprus	M	46.07	14.60	11.00	17.53	6.60	2.8
New Caledonia	M	58.28	15.10	11.17	12.58	0.81	3.4
	M	55.4	15.76	13.2	11.9	0.3	3.1
Philippines	R	33.60	12.60	33.30	14.30	6.50	2.3
	R	32.09	13.00	27.61	18.18	5.31	2.5
	R	37.18	12.65	21.92	17.97	5.62	2.6
	O	26.2	12.8	4.5	22.8	18.5	1.8
	O	38.8	17.2	10.9	16.4	10.5	2.0
South Africa, Republic of	O	44.0	23.6	13.8	8.3	6.2	1.6
	M	50.7	21.0	11.9	12.8	1.6	2.1
	C	49.2	22.6	13.9	11.7	1.9	1.9
	C	45.2	26.6	15.4	9.6	2.1	1.5
	M	49.7	20.9	12.0	13.0	2.5	2.1
United States of America	O	24.9	23.8	15.3	25.0	7.1	0.9
	C	43.4	20.9	17.0	14.5	3.1	1.8
	R	46.1	24.1	23.8	5.4	1.02	1.7
	C	41.40	20.50	18.20	12.50	4.25	1.8
	O	40.92	13.89	11.00	21.00	10.00	2.6
Zimbabwe	M	49.05	12.25	13.92	14.10	5.25	3.5
	R	42.60	15.70	13.80	15.80	8.60	2.4
	M	48.50	18.27	11.50	13.40	5.60	2.3
	R	50.70	16.40	13.00	13.20	4.30	2.7

M = metallurgical, R = refractory, C = chemical, O = raw ore

Note: This table is an abridged version from: Anhaeuser and Maske (1986): Mineral Deposits of Southern Africa; Volume II, page 1163, Table VI.

steel. Because of its importance, many countries stockpile chromite ore and ferrochrome as a strategic reserve in the event of supply disruption due to political disturbance or military intervention. Domestic supplies in Canada and the United States are uneconomic at present world prices but deposits such as the Stillwater Complex in Montana, have been mined during wartime or other periods of political tension to augment reduced foreign supply.

Economic and subeconomic deposits of chromite are known throughout the world (Table 2, Table 3). Unfortunately, information about chromite resources in the Soviet bloc countries is fragmentary. The Soviet bloc is self reliant and occasionally sells both chromite ore and ferrochrome to the western market economies. Most references to world reserves, production and markets do not include the eastern bloc countries but production was estimated in 1982 at 3.3 million tonnes, about 40 per cent of total world production, and reserves at 21 million tonnes (Hargreaves and Fromsom, 1984).

Chromite deposits are restricted to the ultramafic portions of ophiolite complexes (alpine-type) or layered basic intrusions (stratiform-type). The deposits associated with ophiolite complexes are the 'podiform' type. Producing mines are in the Philippines, New Caledonia and Turkey. These mines commonly exploit a series of closely spaced, high-grade pods of modest tonnage. Deposits associated with stratiform complexes are laterally extensive and contain huge amounts of low-grade chromite. Producing mines are in Zimbabwe and the Republic of South Africa.

At present podiform chromite deposits contain 10 per cent of the world chromite reserves but produce 90 per cent of the metallurgical and refractory grade chromite. Stratiform deposits contain 90 per cent of the world total of chromite reserves and produce effectively 100 per cent of the chemical grade ore. At present the South African producers strongly influence the world supply of chromite ore and to a lesser degree ferrochrome, due to the low ore-refining capacity in other countries. Improvements in ore processing and metals extraction have enabled some chemical grade ores to be used for metals production. This has had a significant impact on the ferrochrome industry as the Republic of South Africa now has an even stronger influence on international markets.

There are several known chromite deposits in North America but most are of subeconomic grade. More important deposits include the Stillwater complex in Montana (limited production); the Muskox intrusion in the Northwest Territories; the Bird River sill in Manitoba and several small deposits in the Eastern Townships of Quebec and in Labrador (limited production). Due to the strategic importance of chromium, evaluation of these deposits is ongoing.

GENESIS OF CHROMITE BODIES

Chromite in economic concentrations confined to ultramafic rocks, however, it is concentrated only in dunite layers within layered basic intrusions and dunitic chromite pods within the mantle section of ophiolite bodies. Otherwise chromite occurs as disseminate grains in concentrations up to about 1 per cent. It is commonly concentrated as crystal aggregates in stringers and lenses or in massive pods.

The major deposits are of two types: alpine-type (or the basal portion of ophiolite complexes) and stratiform-types (layered basic intrusions). Examples of these include the Tiébaghi ultramafic massif in the New Caledonia ophiolite complex and the Merensky Reef and Steelpoort seam in the Bushveld Complex of South Africa respectively. Typical Alpine-type, podiform deposits consist of massive pods or lenses containing several thousand tonnes of chromite; stratiform complexes may contain cumulate strata of several million tonnes. In alpine-type complexes, economic deposits usually consist of a cluster of chromitite pods in which individual pods vary in size from a few tonnes to several million tonnes although pods over one million tonnes are rare. For example, in the Acoje district of the Philippines, there are 15 pods that contained an aggregate total of 1.7 million tonnes (1978 reserves) of chromite. The main orebody in the Coto district measured 550 by 290 by 55 metres and contained 6.3 million tonnes of chromite (Leblanc and Violette, 1983). Chromite also occurs in the dunitic parts of Alaskan type mafic-ultramafic intrusions. However, significant concentrations of chromite in these intrusions are rare.

The actual process of concentration of chromite in podiform bodies is not clearly understood. However, a variety of processes, generally involving crystal fractionation, crystal accumulation in magma chambers or conduits in residual mantle harzburgite tectonite, have been proposed. In the case of stratiform bodies, crystal fractionation and settling in a basaltic melt account for observed features such as graded layers, load casts, and slumping (Cameron, 1963, 1980). These features are more prevalent in the relatively undisturbed stratiform bodies than the altered and tectonically deformed alpine-type complexes. In relation to the number of ultramafic complexes known worldwide, there are few economic chromite deposits. It should be noted that metallurgical grade chromite is restricted to podiform chromite occurrences and that podiform occurrences may have variable grades.

LAYERED BASIC INTRUSIONS

Stratiform ultramafic complexes host the largest reserves of chromite and platinum group metals in the world. The best known is the Bushveld Complex in South Africa. However, other stratiform bodies include the Great Dyke in Zimbabwe, which is producing chromite and platinum group metals, the Muskox layered complex in the Northwest Territories, the Bird River Sill in southern Manitoba and the Stillwater Complex in Montana. There are no layered basic intrusions containing stratiform-type occurrences in British Columbia.

The common features of stratiform bodies are that they are located within stable cratonic blocks and are usually intrusions of Proterozoic age. Morphologically, they fit into two groups, sills (Stillwater, Bird River) and funnel-shaped bodies (Bushveld, Great Dyke, Muskox), both having igneous stratigraphy. The sills generally represent a single intrusive event with one stratigraphic cycle. This usually progresses from a basal dunitic layer through orthopyroxenitic and clinopyroxenitic units to upper gabbroic phases. The funnel-shaped bodies are generally larger. In most cases they are composites of several overlapping and crosscutting intrusions (Great Dyke, Bushveld Complex). However, for each intrusive phase there is a discrete stratigraphy that is generally traceable across each part of the complex. Commonly the layers parallel the floor of the complex and so have conical or inward-dipping morphologies. The stratigraphy in funnel-shaped intrusions is similar to that of the sills but there are cumulate layer variations and repetitions due to the generally larger size of the magma chamber and repetive magmatic history.

Chromitite horizons are locallized in dunite and can be either individual layers or a series of thin layers within a well-developed zone. The chromitite layers consist of massive crystal aggregates or seams of disseminated chromite. Where crystal settling and sedimentation have occurred, classic features such as graded layers, load casts of denser chromite on olivine, and slumping are present. In most economic deposits any given chromitite horizon although comparatively thin, a few metres at best, is laterally continuous for many kilometres. It is for this reason that the Bushveld Complex is so significant; it hosts approximately 75 per cent of the world reverves of chemical and refractory grade chromite (Anhaeusser and Maske, 1986).

OPHIOLITE ULTRAMAFIC COMPLEXES (ALPINE-TYPE)

Ophiolite complexes comprise a sequence of metamorphic to plutonic through hypabyssal volcanic and extrusive to sedimentary rocks. Examples are the Troodos Massif in Cyprus, the Sumail Ophiolite complex in Oman and the Zambales massif in the Philippines. All of these occurrences have mines that produced or are producing chromite and allied metals. In British Columbia there are several ultramafic complexes which are the ultramafic, plutonic or upper mantle sections of a typical ophiolite sequence. These include the Shulaps ultramafic complex, ultramafic sections of the eastern facies in the Cache Creek terrane, and the Blue River ultramafite. Many of these bodies host minor chromite mineralization.

Rarely is the whole ophiolite section preserved on land. However, the classic sequence may be divided into two major segments (*see* Figure 1). First is a crustal sequence, from top to bottom, of pelagic sediments, pillowed basalts, sheeted dikes of gabbro and basalt, mafic cumulates of trondhjemites, diorite and gabbro and ultramafic cumulates of pyroxenite, wherlite with subordinate lherzolite and dunite. The seismic Moho is the boundary between the mafic and ultramafic cumulates of the plutonic crust. The crustal section is underlain by the mantle sequence, down from the top, of residual mantle harzburgite tectonite representing residual mantle after partial melting and magma genesis and lherzolite of the upper mantle (Duke, 1988). The boundary between the crust and mantle is the petrologic Moho. Figure 1 is a schematic summary of an ideal ophiolite sequence.

The petrologic Moho is the critical boundary to the formation of significant chromite bodies. Most chromitites occur within 1 kilometre below the petrologic Moho, commonly less than 0.5 kilometre. Some chromitites do occur in the lowermost ultramafic cumulates of the crustal section above the petrologic Moho. These are much smaller volume than those below the Moho.

The mechanism of primary emplacement of chromite bodies in the mantle sequence has long been a problem for researchers. Several models have been proposed which take into account various petrological and structural constraints. The main features which these

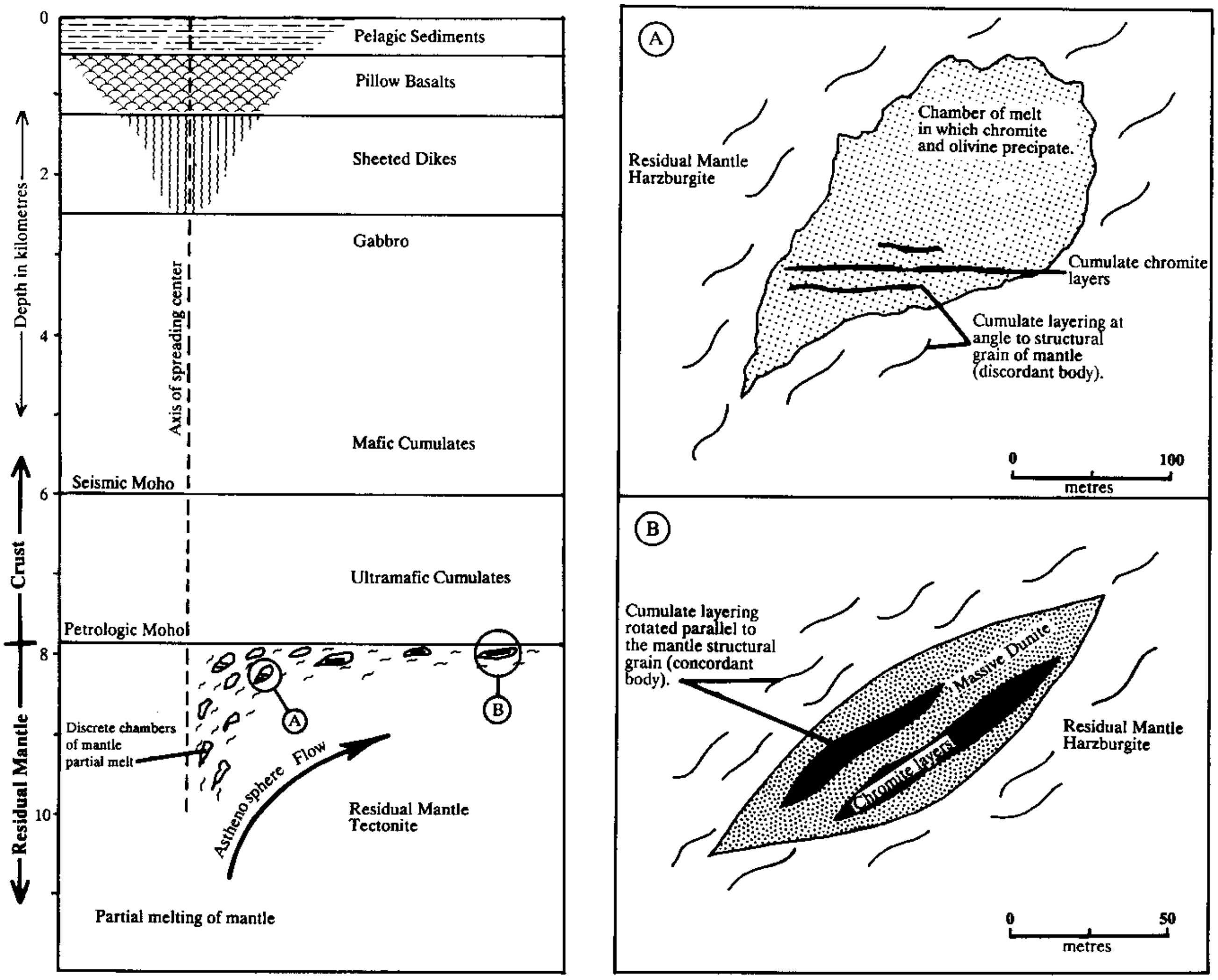


Figure 1. Simplified schematic section of an ideal ophiolite section with details of (A) chamber of melt and (B) podiform Alpine-type chromite body (modified from Christiansen, 1985a, b and Gass, 1979).

models must explain are the relationship of pod orientation with respect to mantle-tectonic fabrics, variable chemistry among chromite pods and the sequence of crystal fractionation from partial melting of mantle materials.

An early model, prior to the development of modern plate tectonic theory, proposed that discrete chromite cumulate pods were entrained in a stiff crystal mush of a rising magma chamber that underwent later deformation followed by dismemberment during orogenesis (Thayer, 1964). Since the development of plate tectonic theory and extensive mapping in ophiolite belts around the world, several important new points emerged. Podiform chromite occurrences are always associated with oceanic ultramafic rocks. Chromite is commonly hosted in dunite pods within residual mantle harzburgite. Also, the alpine-type chromite occurrences are within young, Late Paleozoic to Tertiary orogenic belts such as the Cordillera of North America or the southwest Pacific island arcs. These and other associations have led to the conclusion that the alpine podiform chromitites are generated at depth in oceanic spreading centres. Lago *et al.* (1982) proposed a dynamic model for chromite pod genesis. It envisions an elongate vertical chamber through which the partial melt passes. The melt circulates in the chamber and a combination of pressure drop, heat flow out of the chamber and crystal settling allows the formation of a chromite pod with a dunite shell. A more general model envisages a magma chamber which is undergoing fractional crystallization (Malpas, 1978). A variety of mechanisms involving changes in pressure, temperature and oxygen fugacity have been invoked for chromite precipitation. Either deformation of the magma chamber or soft sediment slumping is believed to create podiform bodies of chromite (Leblanc and Violette, 1983; Moutte, 1982). Christiansen (1985a, b) and Malpas (1978) described chromite pods formed as cumulates in individual magma 'mini-chambers' or dikes rising through the mantle peridotite which are subsequently deformed by mantle tectonism and further deformed during later emplacement and orogenesis.

Formation of podiform chromite bodies within the residual mantle harzburgite tectonite, or mantle tectonite, is a complex process. Partial melting of the primitive mantle (lherzolite) produces a basaltic liquid and residual harzburgite within spreading centres. The resulting melts rise into and through the mantle tectonite. Fractional crystallization, in either conduits (Lago *et al.*, 1982) or chambers (Christiansen, 1985a, b; Malpas 1978) generates dunite-chromite pods. These are typically composed of a thin, up to several tens of centimetres wide, dunite shell around a mass of harzburgite and chromite. The harzburgite is generally composed of 70 to 85 per cent olivine and 15 to 30 per cent orthopyroxene. Chromite content of the pod as a whole can vary from a few per cent to over 90 per cent but generally, chromite content is less than 50 per cent. As mentioned previously the podiform chromites are formed typically within one kilometre below the crust-mantle transition. In the field it is therefore essential to know where one is with relation to the Petrologic Moho to determine which areas are more likely to contain chromitite mineralization.

During or after their formation, the podiform bodies move from near the spreading centre axis by asthenospheric flow of the upper mantle and undergo extensive high temperature hypersolidus to subsolidus ductile deformation. This movement is believed to account for the early phases of deformation observed in obducted ophiolitic rocks. Cassard *et al.* (1981) have recognized three groups of podiform chromite bodies as defined by the relative deformation between the pods and surrounding mantle tectonite. These groups are discordant, subconcordant and concordant. As the pods are moved laterally, internal cumulate layering is initially at high angles to or discordant to the mantle tectonic fabric. With progressive movement the pods are rotated so that the cumulate layering becomes parallel, sub-concordant to concordant with the mantle tectonic fabric (*see* Figure 1). This coincides with a loss of primary magmatic features with increasing transport from the spreading centre. These features have been identified in podiform chromite bodies in the Sumail ophiolite, Oman, by Ceuleneer and Nicolas (1985).

ALASKAN-TYPE ULTRAMAFIC-MAFIC COMPLEXES

Alaskan-type ultramafic-mafic complexes occur in orogenic belts and are believed to have formed in subvolcanic magma chambers in volcanic arcs over subduction zones (Murray, 1972; Irvine, 1974a). The best known complexes have been described in the Alaskan panhandle, British Columbia and the Ural Mountains, U.S.S.R. Figure 2 shows the locations of these complexes in British Columbia and Alaska. These complexes are intrusive and may be crudely zoned from ultramafic lithologies in the 'core' to gabbroic rocks near their margin. The classic locality of Duke Island in southeastern Alaska, described by Irvine (1963, 1967a, 1974a) includes a typical rock suite of dunite, olivine clinopyroxenite and clinopyroxenite, hornblende clinopyroxenite, hornblendite, gabbro and felsic to mafic pegmatites. These ultramafic rocks typically lack orthopyroxene which suggests an alkalic affinity for the parental magmas (Irvine 1974a; Findlay 1969). In some cases, the gabbroic phases are not late stage differentiates but discrete earlier intrusions such as at Duke Island (Irvine, 1967a). Cumulate textures are common. Locally cumulate layering in dunite and olivine-clinopyroxenite is defined by gradation of grain size and alternating layers of olivine and clinopyroxene (*e.g.* Duke Island). In some

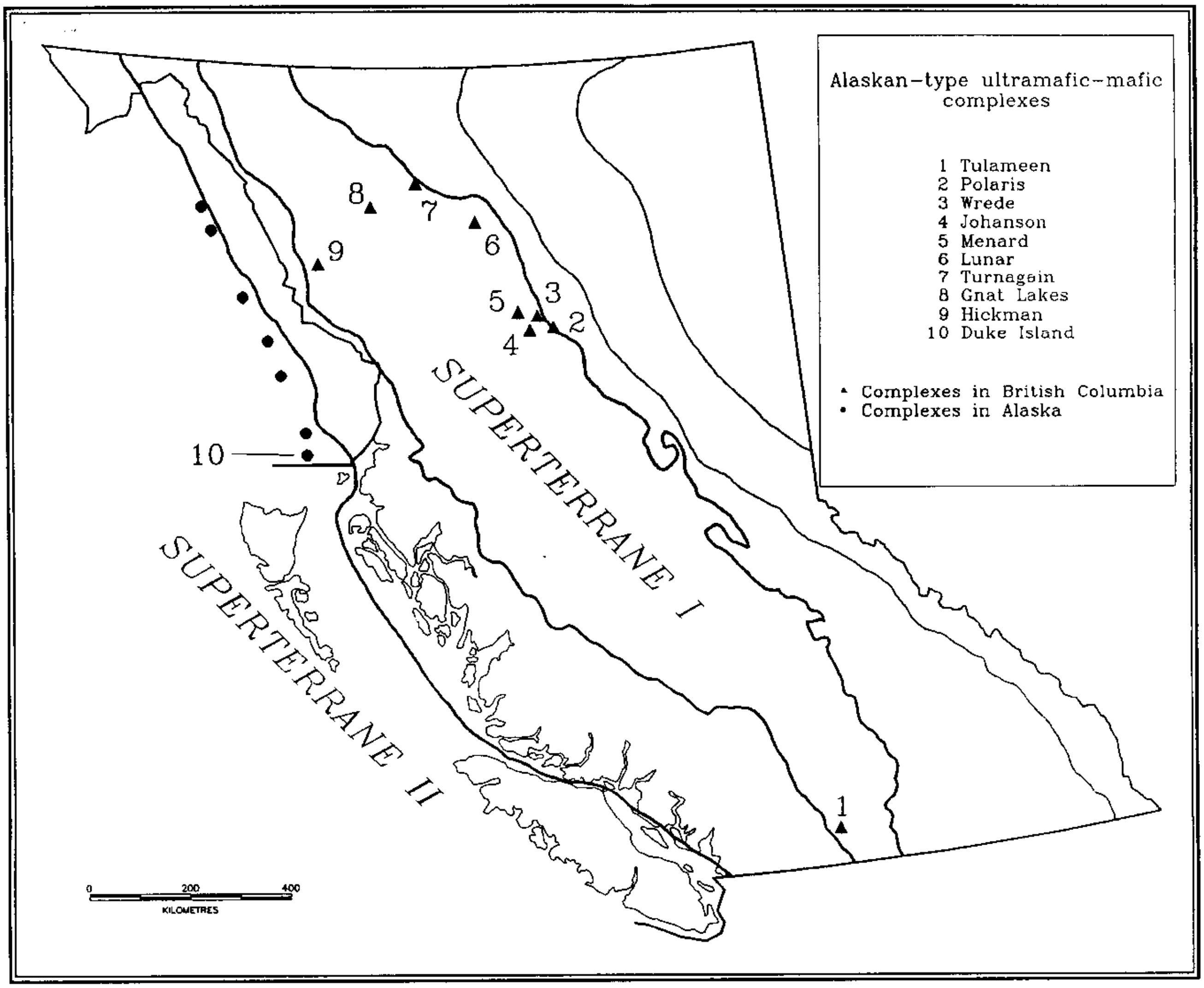


Figure 2. Location of Alaskan-type ultramafic-mafic complexes in British Columbia and Alaska with respect to tectonic setting (modified from Nixon, 1990).

places, mechanical deformation, slumping or currents in the magma chamber disrupt the cumulate features. This results in slump blocks, layers or zones of fragments of one unit within another (*i.e.* olivine-clinopyroxenite in dunite) or folding. Although contacts between units are commonly gradational magmatic-ductile or late brittle deformation may obscure contact relationships. Each complex may not contain a full suite of rock types which may make recognition of an Alaskan-type body difficult. In B.C. the Polaris and Tulameen complexes contain all of the typical rock types but others, such as the intrusions at Johanson lake and Menard Creek, only have some of the characteristic lithologies.

Alaskan-type complexes in British Columbia and Alaska fall into two discrete groups based on age and tectonic setting. Several complexes in Alaska have been dated at 100 Ma by potassium-argon methods (Lamphere and Eberlein, 1966). Several complexes in British Columbia have been dated between 175 Ma and 156 Ma by potassium-argon methods (Roddick and Farrar, 1971, 1972; Wanless *et al.*, 1968; Wong *et al.*, 1985). However, these dates for the B.C. intrusions are considered too young, probably due to loss of radiogenic argon (Roderick and Farrar 1971, 1972), and are generally considered to be Late Triassic to Early Jurassic in age based on geological relationships. Tectonically, the Alaskan bodies are located in Superterrane II, specifically the Alexander terrane (Monger *et al.*, 1982) and the British Columbian bodies are emplaced in Superterrane I, specifically the Stikine and Quesnel terranes (*see* Figure 2).

Alaskan-type complexes may show prominent contact aureoles, usually of amphibolite grade, but they are commonly fault-bounded. The intrusions are usually small in size, a few kilometres across but may reach 20 kilometres in length (*e.g.* Tulameen). Faulting of the complexes can significantly distort their original shape and orientation.

Chromite mineralization in Alaskan-type complexes is restricted to dunite. Chromite occurs as disseminated grains, stringers and small, massive pods and blebs. These are usually dispersed thoroughout the dunite and represent at most one or two per cent of the total rock mass. Results of exploration and mapping of these bodies to date have demonstrated only a sporadic enrichment of PGE and limited chromite potential.

Cr, Al, Fe AND Ti ENRICHMENT IN CHROMITE

Several significant elemental variations have been noted during analyses of chromite. These are described as follows.

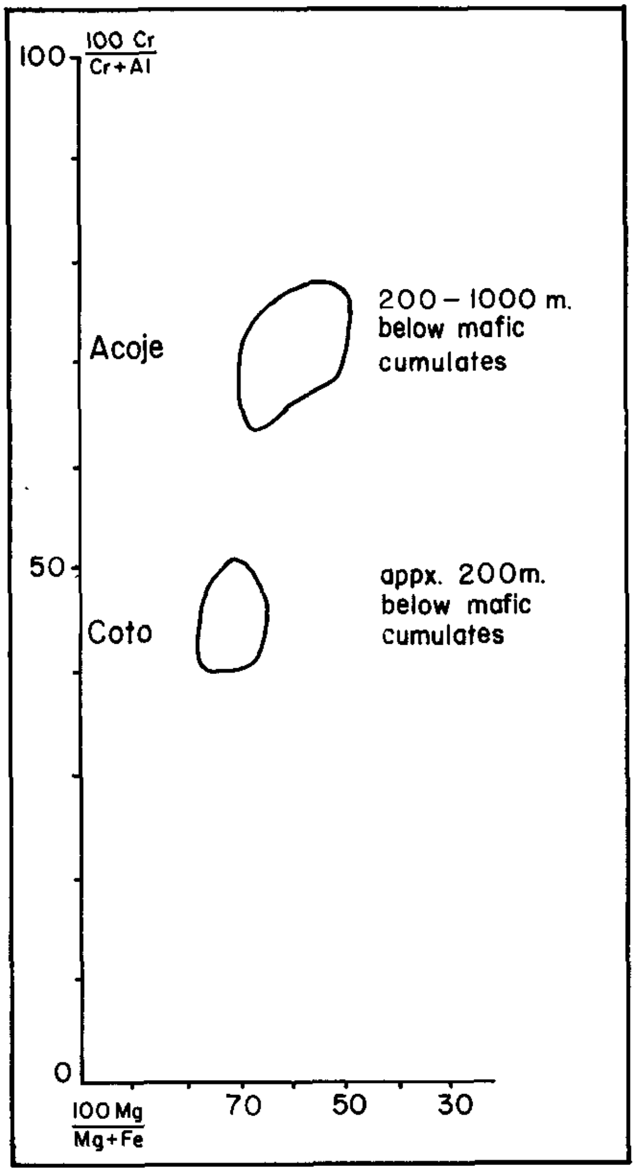


Figure 3. Chromite composition fields (shaded areas) for the Acoje and Coto districts, Zambales Ultramafic Complex, Phillipines, to show relative enrichment of alumina in chromite with respect to depth from the petrologic Moho (modified from Leblanc and Violette, 1983).

CHROMIUM VERSUS ALUMINUM ENRICHMENT

In podiform bodies there is a significant variation in the Cr:Al ratio of the chromite. Chromium is relatively enriched in ultramafic bodies formed at greater depths in the mantle tectonites. Aluminum is enriched in ultramafic cumulate bodies formed near the crust-mantle transition zone. It appears that the feldspathic cumulates, specifically plagioclase, have a significant influence on aluminum partitioning in melts. This has economic significance with respect to high-alumina chromite as it is the ore for refractory grade chrome. Figure 3 illustrates the composition of chromites in the Zambales ophiolite in the Philippines. It shows the Coto district chromite deposits, formed at higher levels, are richer in alumina than the Acoje district deposits, formed at deeper levels. The highest alumina contents of chromite known are in troctolites (gabbro) in Cuba, although those deposits are unusual (Dickey, 1975; Leblanc and Violette, 1983).

TITANIUM VARIATIONS

A significant marker oxide that is used to distinguish between podiform and stratiform-source chromite is TiO_2. Worldwide, podiform chromite bodies tend to have TiO_2 concentrations below 0.3 per cent; stratiform bodies have TiO_2 contents usually greater than 0.3 per cent as illustrated by Figure 4.

IRON ENRICHMENT

There is a notable variation in iron concentrations in chromite from podiform and stratiform chromite. Podiform bodies have relatively low and constant Mg:Fe ratios but there is a large variation in the ratio in chromite from stratiform bodies and it may be substantially enriched in iron as illustrated by Figure 5.

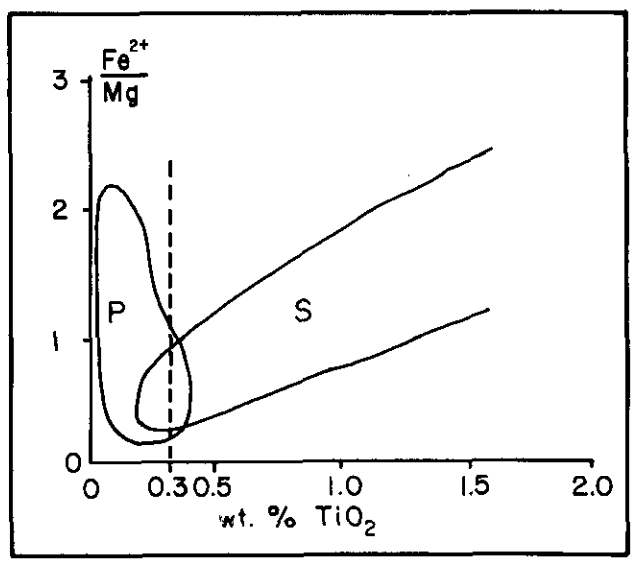


Figure 4. Weight per cent Fe^{2+}/Mg versus TiO_2 to show enrichment of titanium in chromite in stratiform bodies with respect to podiform bodies. S: stratiform deposits, P: podiform deposits (after Dickey, 1975).

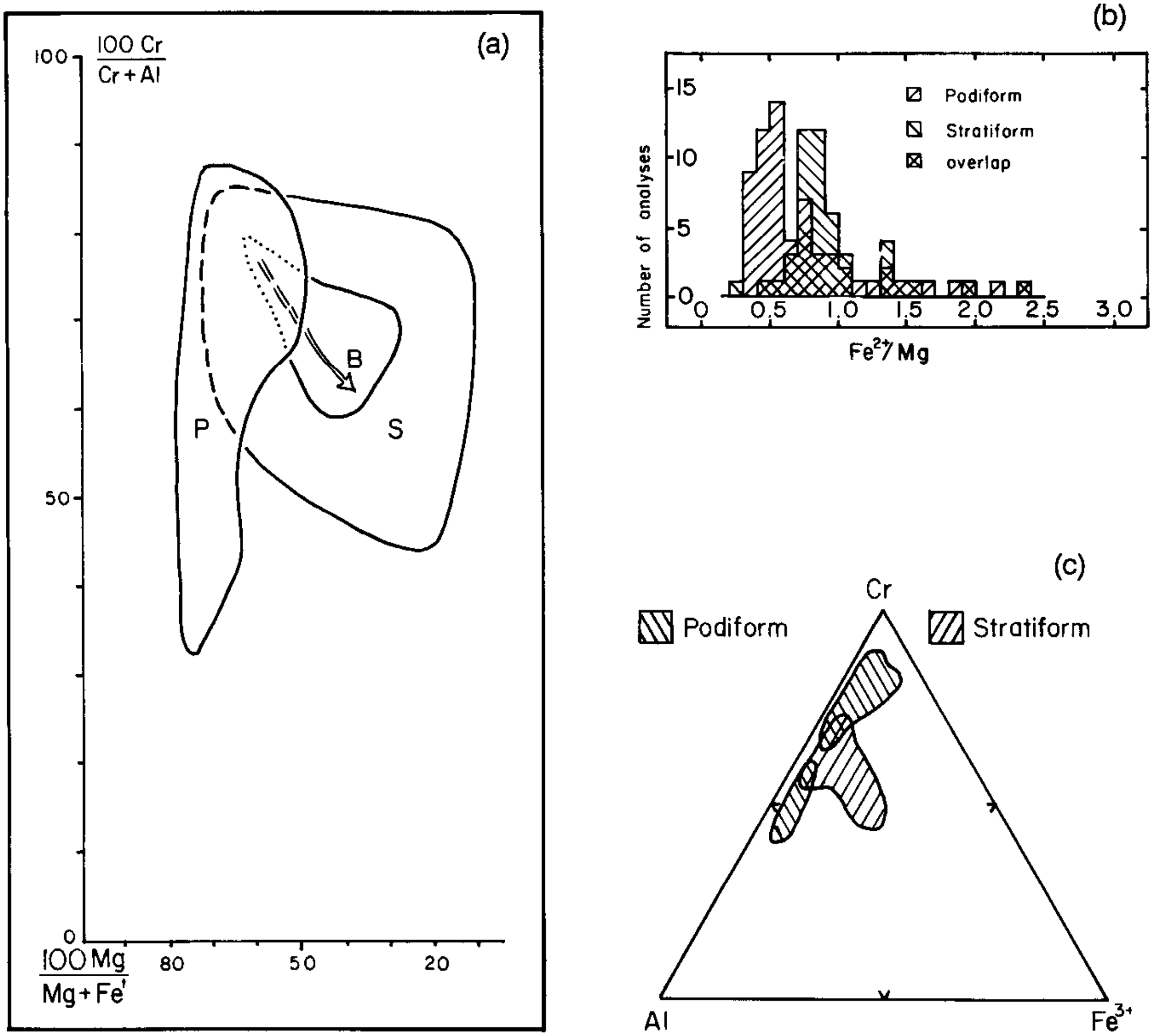


Figure 5. (a) Chromite composition fields to show relative iron enrichment in stratiform versus podiform chromitites. S: stratiform chromitites, P: podiform chromitites, B: Bushveld trend; (b) Atomic ratio of Fe^{2+} versus Mg for chromite from podiform and stratiform bodies to show relative enrichment of iron in the latter (from Dickey, 1975); (c) Ternary diagram to show variations in Cr, Fe and Al enrichment in chromite between podiform and stratiform chromitites (after Dickey, 1975).

OPHIOLITE-RELATED CHROMITE DEPOSITS

SOUTHERN BRITISH COLUMBIA

ANARCHIST CHROME

TU 1 and TU 2 claims
MINFILE: 082ESW024 NMI: 82E 03 Crl
LAT: 49°01'20" LONG: 119°11'5"

The Anarchist Chrome chromite prospect is located 3.6 kilometres southwest of Bridesville and 600 metres north of Highway 3 at Anarchist Summit. A minor road leads from the highway to the workings.

Hostrocks to the deposit are amphibolites, schists, cherts and metavolcanic rocks of the Permo-Carboniferous Anarchist Group (Tempelman-Kluit, 1989). These rocks are intensely folded with vertical to west-verging axial planes. The general trend of the fold axes and layering is 350°. Chevron folding has been identified in greenstones north of the chromitite showings (Sutherland Brown, 1957; Whittaker, 1983).

The showings (Figure 6) are atypical of most chromite deposits. Massive chromite is entirely surrounded by fine-grained, grey carbonate material. The chromite is massive and coarsely crystalline. Microscopically, the chromite grains are fractured and shattered but not sheared. Small calcite-filled fractures crosscut the massive chromitite. Antigorite forms up to 35 per cent of the chromitite, but is only inside the masses and only chromite is in contact with the grey carbonate. This material was previously mapped as a 'chromite dike in limestone' (Sutherland Brown, 1957; Whittaker, 1983). However, this is inconsistant with current models for chromite genesis. Complete alteration of the surrounding ultramafic rock to listwanite has been proven by chemical analysis by Chris Ash of the B.C. Geological Survey Branch. Chromite, once formed, is very stable and could form a casing around contained dunite(?) impenetrable to hydrothermal fluids, allowing antigorite to be formed inside the massive chromite (C. Ash, personal communication, 1990).

Sampling of the massive chromitite has yielded an average grade of 26.7 per cent Cr_2O_3 with a Cr:Fe ratio of 3.15 (Sutherland Brown, 1957). Geochemical sampling in the area of the old workings failed to outline any significant anomalies of gold, silver or platinum (Jones, 1988).

The chromite showings were originally staked in 1956 by the Anarchist Chrome Company Ltd. Initial work, between 1956 and 1958, consisted of some stripping, ground magnetometer surveying and diamond drilling but the results were not published. The claims were allowed to lapse and the ground was restaked by Pacific Chrome Alloys Ltd. in 1961, at which time more magnetometer surveys and diamond drilling were done. Again the claims were allowed to lapse. Later the area was covered by claims staked in association with exploration of the Old Nick nickel prospect, but no work was done on the chromite showings. More recently, Tu Tahl Petro Inc. optioned the TU 1 and TU 2 claims in 1987 and did a ground magnetometer survey across the showings. No further work has been recorded.

BRIDON

RAY 1-4 claims
DON claims
Jolly/Rock Creek
MINFILE: 082ESW025
LAT: 49°11'00" LONG: 119°13'00"

The Bridon chromite showings are located on a ridge crest at the head of Rock Creek, about 17.5 kilometres north of Bridesville. The showings and trenches follow a northwest-trending ridge at elevations between 1890 and 1980 metres. This ground is presently staked as the RAY 1-4 claims.

The chromite is hosted within a long, thin serpentinite body emplaced in metasediments of the Permo-Carboniferous Anarchist Group and is near granodiorites of the Juro-Cretaceous Okanagan batholith (Tempelman-Kluit, 1989). Locally the Anarchist rocks consist of hornblende schists, metaquartzites and limestones with zones of marble. Well developed, penetrative vertical foliation trends northwest in the metasediments and parallels the shearing and sharp boundaries of the serpentinite (Peto, 1987; Whittaker, 1983). Other similar serpentinite bodies have been mapped in the Greenwood area. These are described as thrust slices of oceanic crust associated with the Cache Creek terrane (J.T. Fyles, personal communication, 1989). Plagioclase porphyritic granodiorite of the Okanagan batholith truncates the metasediments of the Anarchist Group along the northern property boundary.

The serpentinite is a narrow body about 1000 metres long and 75 to 100 metres wide at surface. The protolith is dunite, not completely serpentinized, with only rare grains of olivine preserved. The serpentinite is sheared

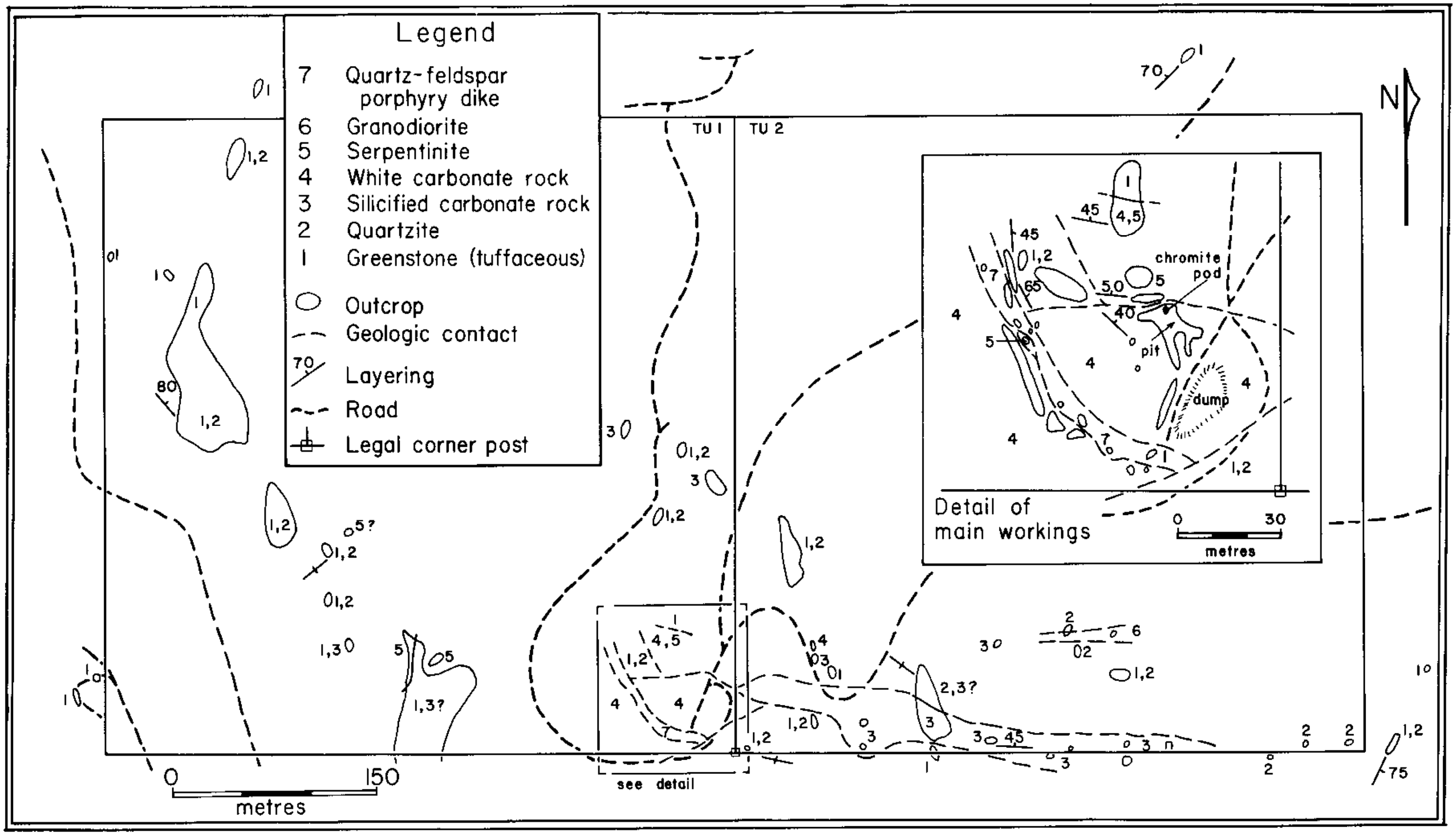


Figure 6. Geology of the Anarchist Chrome showings (modified from Jones, 1989).

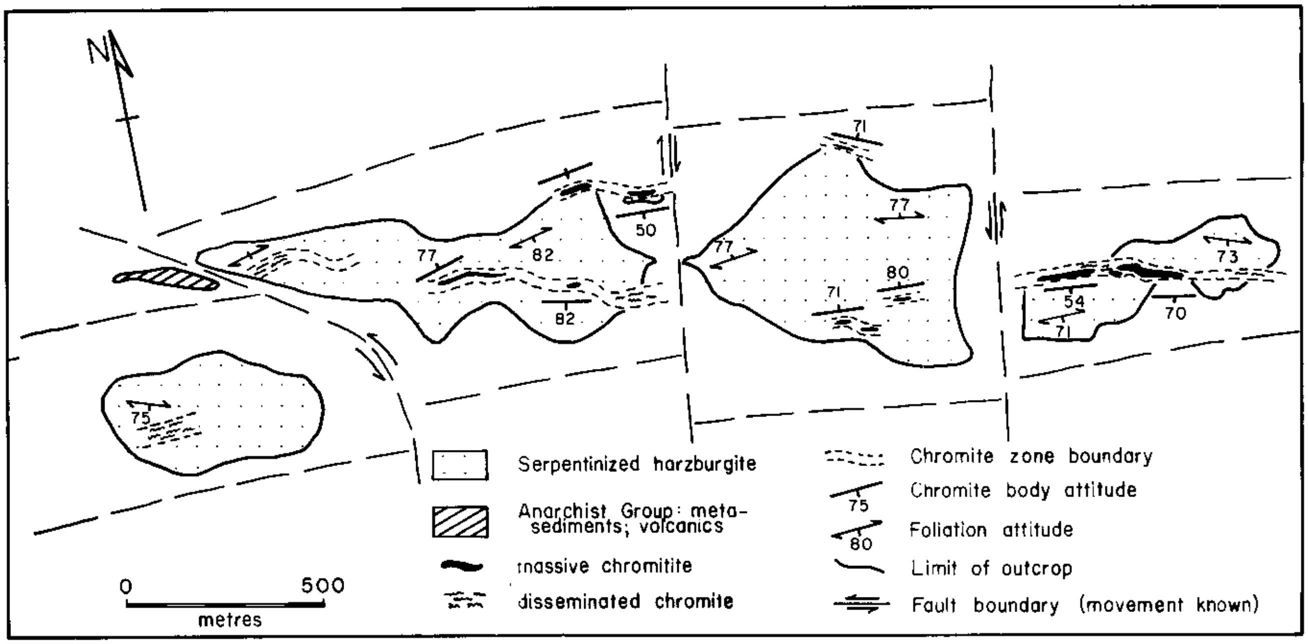


Figure 7. Geology of the Bridon chromite showings (after Whittaker, 1983).

parallel to the regional northwest subvertical foliation. Chromite mineralization is restricted to the serpentinite and is found as short, disseminated stringers and long, narrow aggregates of crystals. The chromite is fine to medium grained and the lenses pinch and swell along their length. Extensive trenching by Belair Mining Corporation Ltd. in 1957 exposed seven large lenses of chromite about 1 metre wide and ranging from 8 to 30 metres long (Figure 7). Some of the lenses have been openly folded leading to a structural thickening of chromite in the fold noses and thinning on the limbs. An average grade across one lens is 20 per cent Cr_2O_3 (Stevenson, 1941) and grades of up to 29 per cent Cr_2O_3, with Cr:Fe ratios of 1.84 have been reported (James, 1957). A sample of cleaned, high-grade chromite yielded the following assay:

	per cent
Cr_2O_3	48.9
Al_2O_3	10.3
CaO	0.40
MgO	11.9
MnO	0.34
TiO_2	1.36
SiO_2	1.38
NiO	—
FeO	22.0

(Stevenson, 1941)

Sampling for platinum and palladium has yielded results of 3 to 100 ppb with platinum values generally of a few tens of ppb and palladium values consistantly lower (Peto, 1987).

The showings were first staked in 1939 as the DON 1 to 8 claims and a small amount of hand trenching was done at that time. The property was further examined by Stevenson (1941) and the claims were apparently allowed to lapse. In 1957 the Belair Mining Corporation Ltd. restaked the ground as the Bridon group. The company did extensive trenching, stripping, mapping, geophysical surveys and diamond drilled several holes totalling 487 metres (Peto, 1987; Zbitnoff, 1988). Seven large chromitite lenses were discovered but the claims were allowed to lapse. In 1986, Granges Exploration Ltd. optioned the RAY 1-4 claims which presently cover the showings. Again extensive geophysical surveys, geological mapping, sampling and 741 metres of diamond drilling in 16 holes were done. This work increased the number of known chromitite lenses and also tested for platinum, gold and palladium mineralization. Specific results have not been made public but the chromite values were considered good and the precious metals values were not encouraging (Peto, 1987; Zbitnoff, 1988). At the time of writing the claims were in good standing and owned by Mr. A. Dupras and others. No further work has been recorded since 1987.

ROCK CREEK

D.W.S. 1-6 claims
Sammy
Tobruch
MINFILE: 082ESW149 NMI: 83E 03 Cr2
LAT: 49°04′58″ LONG: 119°00′32″

The Rock Creek chromite showings are 4.3 kilometres north of the village of Rock Creek and 150 metres west of Highway 33. The showings are on the lower slopes of a small hill.

The chromite is hosted by serpentinite bounded by metavolcanic rocks of the Permo-Carboniferous Anarchist Group. The serpentinite is massive and fractured with talc coating the fracture surfaces. Chromite occurs as stringers of disseminated grains and some nodules up to 20 centimetres in diameter. Trenching and diamond drilling indicate a broad zone of intermittant low-grade mineralization 10 metres wide, with a higher grade stringer 2.25 metres across. The strike length has not been defined. A 3-metre chip sample across a stringer zone assayed 8.87 per cent Cr_2O_3 and a sample of a nodule graded 27.8 per cent Cr_2O_3 (James, 1958). Sampling of old dump material by Stevenson (1941) yielded best assays of 41.6 per cent and 46.6 per cent Cr_2O_3. Rock and soil sampling between 1980 and 1987 (Davies, 1980, 1981, 1983, 1985, 1986, 1987) yielded the results which are detailed in Table 4.

The Rock Creek showings were originally staked in 1937 as the Yellow Ocher, Red Ocher and Green Ocher claims. Later, around 1942, the showings were on ground staked as the Tobruch claim. During that early period, several hand trenches, pits and a short adit were developed on the showings. In 1958, the Belair Mining Corporation Ltd. staked the Belchrome 1-8 claims, not to be confused with the Belchrome property to the west, which were also referred to as the Sammy prospect. At that time 279 square metres of stripping, 45 metres of trenching, and 210 metres of X-ray drilling in 4 holes were done (James, 1958). These claims were later allowed to lapse and in 1980, D.W.S. Davies staked the D.W.S. claims. From 1980 to 1987 the property has been extensively prospected for chromite, nickel and precious metals with marginal results (*see* Table 4). No work has been recorded since 1987 and the claims lapsed in December, 1989.

MASTADON

Castle Mountain Nickel
MINFILE: 082ESE091 NMI: 82E 01 Ni1
LAT: 49°00'33" LONG: 118°10'25"

The Castle Mountain nickel and chromite occurrences are situated on the southwest slopes of Castle Mountain 22.4 kilometres east of Grand Forks. Many old logging roads cover the area and major power and natural gas lines cross the ground. Two sets of claims cover the area of mineralization. The first are Crown grants, Mammoth, Mastadon, Mastadon Fraction, Canyon, Pan and Dominion, owned by Chromex Nickel Mines Ltd. The second set is the Castle group, owned by Nitro Resources Inc. (December, 1989) and surround the Crown grants.

The hostrock to mineralization is a large block of massive serpentinized dunite of the Permo-Carboniferous Anarchist Group. The body extends approximately 2440 metres north from the international boundary and has a maximum width of 1220 metres. The rock is largely serpentinite but locally, unaltered dunite is present. Underground diamond drilling suggests that the body is interleaved with gabbro. Mesh textures in serpentine are absent as are bastites and there are no relict orthopyroxene grains. This suggests the protolith was massive dunite. Shearing and fracturing are pervasive throughout the body with the fractured zones commonly altered to quartz, talc and carbonate. The whole serpentinite block is bounded by faults and has been mapped as

TABLE 4
ROCK CREEK ANALYTICAL RESULTS

Rock Report Year	No. of Samples	Cr	Ni	Ag	Pt
			(Range or Average Value)		
1981	3	-	0.20%	1.37 g/t	-
1983	12	710 to 715 ppm	-	-	-
1985	7	<30 ppm	<50 ppm	-	-
1986	14	110 ppm	-	-	<35 ppb
1987	16	2 to 293 ppm	-	-	dl

Soil Report Year	No. of Samples	Cr	Ni	Ag	Pt
			(Range or Average Value)		
1981	4	-	-	<10 ppb	-
1983	210	<50 ppm	<25 ppm	-	-
1985	21	40 to 974 ppm	-	-	-
1986	21	-	-	dl	-
1987	5	8 to 184 ppm	-	-	-

dl - detection limit or below
- - not analysed.

an upthrust section of an ophiolite (J.T. Fyles, personal communication, 1989).

Crosscutting the serpentinite are dikes described as quartz feldspar porphyry, quartz porphyry, diorite and lamprophyre (Steiner, 1972). The serpentinite block is bounded by greenstones, andesites, volcanic breccias and minor amounts of sediments of the Late Triassic to Early Jurassic Rossland Group. To the east and southeast of the property are small intrusions of monzonite of the Middle Jurassic Nelson plutonic suite (Templeman-Kluit, 1989).

Mineralization in the serpentinite consists of two types, chromite and nickel sulphides. Chromite occurs as disseminated grains, stringers and massive lenses. Disseminated chromite is ubiquitous throughout the body and has a general concentration of 0.5 to 1 per cent. Stringers of chromite consist of elongate trains of coarse crystals, giving the rock a 'pebbly' texture with chromite forming 15 to 40 per cent of the rock. Pods of massive chromitite are exposed in scattered workings across the serpentinite. The pods vary in size from 3 to 7 metres in length and 2 to 3 metres in width (Stevenson, 1941; Freeland, 1918). Assays of cleaned chromite have yielded the following results:

	per cent
Cr_2O_3	49.8
Al_2O_3	8.1
CaO	0.45
MgO	14.2
MnO	0.44
TiO_2	1.44
SiO_2	5.96
NiO	0.10
FeO	17.7

(Stevenson, 1941)

Several grab samples from different mineralized locations were assayed with the following results:

Mineralization Type	per cent Cr_2O_3
Massive	42.8
Pebble	20.5
Massive	39.5
Massive	40.6
Disseminated	14.6
Pebble Massive	23.7
Pebble	24.8
Disseminated	4.6
Pebble	27.9
Disseminated	0.5

(Stevenson, 1941)

Surface and underground development have shown that the chromite mineralization is structurally disrupted by a multitude of fractures and shears. Individual shears vary from 1 to 15 centimetres in width and can be grouped into zones up to 30 metres wide. Occasionally chromite is found concentrated along some of the shear planes. There is no specific orientation to the chromite mineralization but there has been some suggestion that it trends roughly northwest and dips subvertically. Also, the massive pods of chromitite are randomly located. In the past this irregular and unpredictable concentration of mineralization has deterred exploration and development.

The significant exploration for chromite was done in 1917 and 1918. An adit, an inclined shaft and several open cuts and trenches were made to expose and explore the showings. Two short raises were driven from the adit to test the vertical exent of mineralization. In 1918 a shipment of 607 tonnes of picked ore, grading 38.5 per cent Cr_2O_3, was shipped to an unknown location (Freeland, 1918). From 1918 to 1966 no work was done on the claims. In 1966, the claims were aquired by Chromex Nickel Mines Ltd. which has since concentrated its efforts on the nickel potential of the area.

The nickel potential of the serpentinite was recognized well after the exploration for chromite. Nickel minerals present are pentlandite, millerite, heazelwoodite and nickeliferous magnetite. Heazelwoodite is the most common sulphide and occurs as fine disseminations throughout the serpentinite. General sulphide content of the serpentinite has not been described and there appear to be no concentrated zones of sulphides. Work by Hunter Point Explorations Ltd. has indicated that 42 per cent of the total nickel content is held in solid solution and magnetite and sulphides account for the balance (Steiner, 1972). The quoted average nickel content of the rock of 0.24 per cent has not been defined as either total contained nickel or the nickel recoverable from sulphides.

Diamond drilling totalling 6096 metres in 57 holes was done by Hunter Point Explorations Ltd. and Chromex Nickel Mines Ltd. between 1966 and 1977, the majority of it on the Mastadon Crown grant. A total nickel resource of 370 million tonnes has been estimated by the companies (Steiner, 1977). However, serious concerns about the validity of the nickel resource potential have been raised by others and further work and testing has been recommended (Grove and Johnson, 1975). The drilling has shown that nickel mineralization is uniform to depth and the chromite mineralization is erratic.

Platinum is said to occur with chromite in the serpentinite but the only record is the Munition Resources Commission report (Thomlinson, 1920). The assays of eight rock samples were: 0.51 and 0.68 grams per tonne platinum, four samples with trace amounts and two with no platinum. There appear to have been no other examinations for platinum group elements.

Since the nickel evaluation work that ended in 1977 there has been no significant exploration on the Crown grants. They remain in good standing and are owned by Chromex Nickel Mines Ltd. In 1986, Nitro Resources Ltd. had an airborne VLF/EM survey flown over the Castle claims that were staked around the old Crown

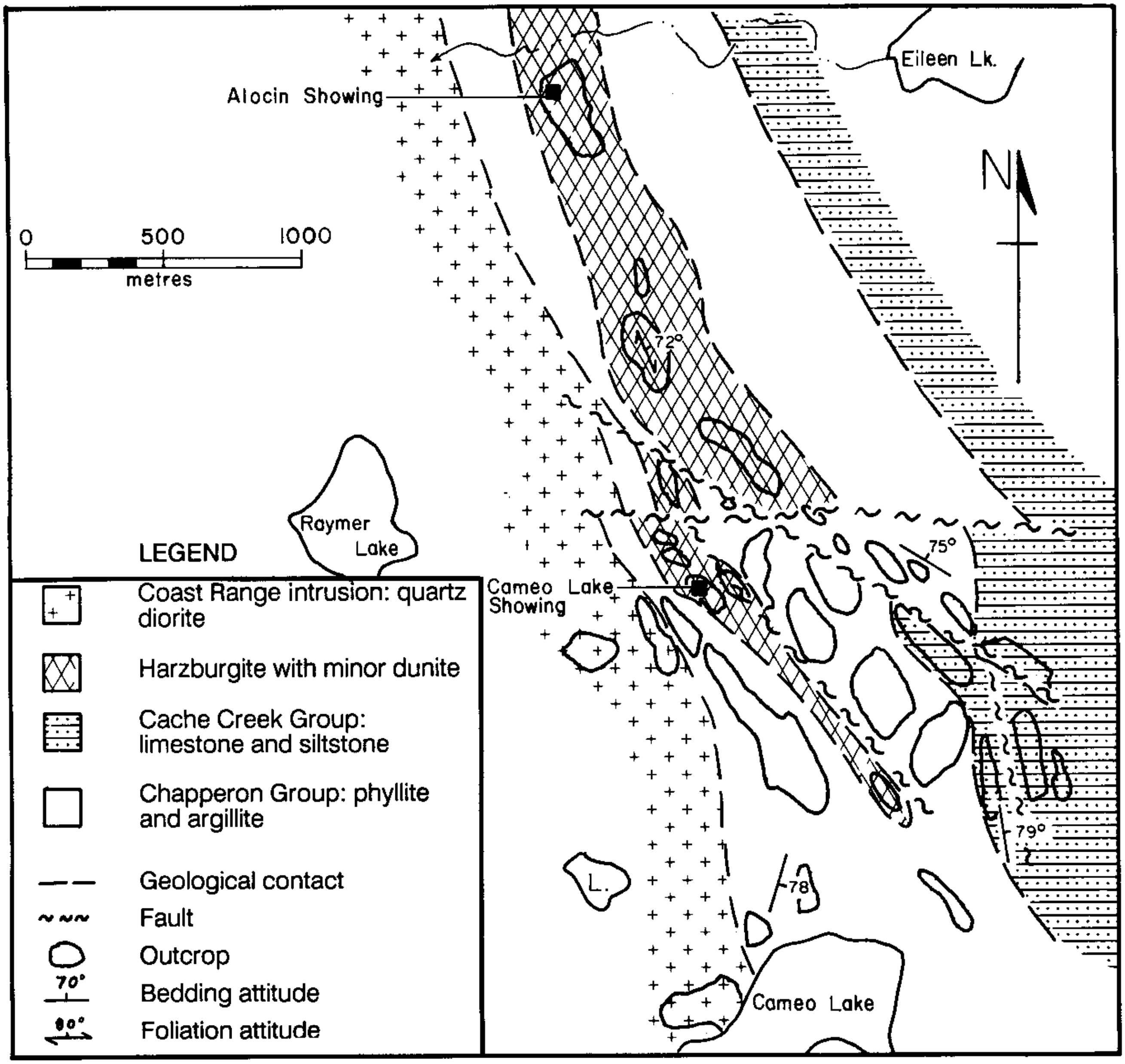


Figure 8. Local geology of the Chrome Ridge area and the Alocin and Cameo Lake (Chrome Vanadium) chromite showings (after Whittaker, 1983).

Grants. No follow-up work has been recorded and the Castle claims have since lapsed.

CHROME RIDGE

Chrome-Vanadium
Nicola
Alocin
Cameo Lake
Jack 5
MINFILE: 082LSW056
LAT: 50°00′00″ LONG: 119°52′15″

The Chrome Ridge showings are located at the head waters of the Nicola River between Eileen Lake, Raymer Lake and Cameo Lake, 35 kilometres west-northwest of Kelowna. Access is by logging roads from the north side of the Alocin Creek bridge. The showings are on top of a prominent northwest-trending ridge.

The hostrock to the chromite is serpentinite, bounded by pelitic rocks of the Late Paleozoic Chapperon Group. These are quartz-mica schists, gneiss and amphibolite. To the east, limestones, silty limestones and calcaerous siltstones of the Upper Paleozoic Cache Creek Group structurally overly the Chapperon Group. (Figure 8). All three units are fault bounded and trend roughly northwest. A well-developed layer-parallel fabric trending 144° with steep easterly dips penetrates all units. This is best developed at the contact of the pelites and serpentinite where it is strongly sheared with interleaved blocks of serpentinite and pelite up to 5 by 10 metres wide (von Rosen, 1977).

The altered ultramafite is massive serpentinite with some talc, chlorite, chrysotile, magnetite with relict orthopyroxene and olivine, indicating the protolith was harzburgite. The serpentinite is a thrust slice, not an intrusion into the pelites as thought by earlier workers. Previously the unit was referred to as the 'Old Dave Intrusions'. The serpentinite has been mapped 8 kilometres along strike with an average width of 300 metres. Late faulting has offset the southern end slightly. The serpentinite is sheared and fractured throughout and talc commonly coats the slip surfaces. Chrysotile veins, up to 5 millimetres wide, are scattered randomly throughout the body.

Chromite occurs as very fine to medium-grained granular masses and small nodules. Lenses of semimassive chromite are present at the Alocin and Cameo Lake showings. These are typically 1 or 2 metres long and 50 centimetres wide. Also, groups of nodules with each nodule a few centimetres in diameter, occur in patches 50 centimetres square. Otherwise chromite is disseminated throughout the serpentinite. All chromite mineralized zones are elongate parallel to the serpentinite body. Some mapping suggests grain size sorting, consistant with magmatic settling, that indicates tops up to the east (Whittaker, 1983).

Sampling of the chromite lenses and nodules indicates an average content of 28 per cent chromite. Samples of serpentine have yielded disseminated chromite contents of 1 to 2 per cent (von Rosen, 1977). A high-grade, cleaned sample of nodular chromite assayed:

	per cent
Cr_2O_3	52
Al_2O_3	15.1
CaO	0.3
MgO	12.8
MnO	0.21
TiO_2	1.20
SiO_2	2.56
NiO	0.10
FeO	14.1

(Stevenson, 1941)

Heavy mineral pan concentrates from a stream below the Aolcin showings, near the Alocin Creek bridge, returned the following analyses:

Sample Element	ALO #1 ppm	ALO #2 ppm	ALO #3 ppm
Cr	31300	4860	8080
Ni	1760	152	175
V	951	878	505
Co	96	34	27
Au	17	3.4	0.68
Ag	24	2.8	0.75
Pd	0.034	0.034	0.068
Pt	0.82	0.034	0.034
Rh	<0.034	<0.034	<0.034

(von Rosen, 1986)

The Chrome Ridge showings were initially staked as the Chrome-Vanadium group and prospected in the late 1920s by A.H. Raymer and Associates. In the 1930s, the Chrome Ridge Mining Syndicate held claims that covered the better part of the serpentinite containing chromite mineralization. During that time a small amount of hand trenching, sampling and prospecting was done. In 1956, Noranda Exploration (Canada) Company, Limited completed geological mapping, sampling, prospecting and aeromagnetic surveys of the area. In 1977 Nicola Copper Mines Ltd. and Buccaneer Resources Ltd. did further geological mapping, ground magnetometer surveys, soil sampling and trenching. At that time the Alocin and Cameo Lake showings were identified. In 1986, the Laramie Mining Corporation collected the three heavy mineral samples for trace and precious metal analysis, the results of which are reported above. Currently, the showings are covered by the Jack 5 claim, owned by Rea Gold Corporation. To the northwest along strike, prospecting on the Bart claims of Mineta Resources Ltd. has outlined the extension of the serpentinite and further probable chromite mineralization (W. Kovacevic, personal communication, 1990).

SOUTH CENTRAL BRITISH COLUMBIA

SCOTTIE CREEK
Scot 1 and 2 claims
Flint Group
Barbara
White Tree, Brown Tree claims
MINFILE: 092INW001 NMI: 92I 14 Cr2
LAT: 50°59′36″ LONG: 121°23′36″

The Scottie Creek chromite prospect is 20 kilometres north of Cache Creek and 4.5 kilometres east of Highway 97. The major workings are in a steep bank on the north side of the creek, just down stream from the first major fork. An old road from the highway runs along the creek and passes near the workings. This chromite deposit has been cited as a type locality for alpine-type chromite mineralization by the Geological Survey of Canada (Eckstrand, 1984).

The hostrock for the Scottie Creek chromite prospect is a serpentinite wedge in the eastern facies of the Cache Creek terrane (Figure 9). This consists of a Late Triassic accretionary prism/subduction complex associated with the Nicola volcanic arc. The mélange contains Pennsylvanian and Early Permian limestones, chert, basalt and ultramafic rocks in a matrix of Permo-Triassic chert and argillite (Monger, 1985).

Only serpentinite is exposed at the chromite showings. It is massive with abundant bastite, orthopyroxene and olivine, suggesting a harzburgite protolith. At Scottie Creek the serpentinite is 300 metres wide with an unknown strike length. The body trends northerly and has a subvertical dip. It is extensively fractured in many

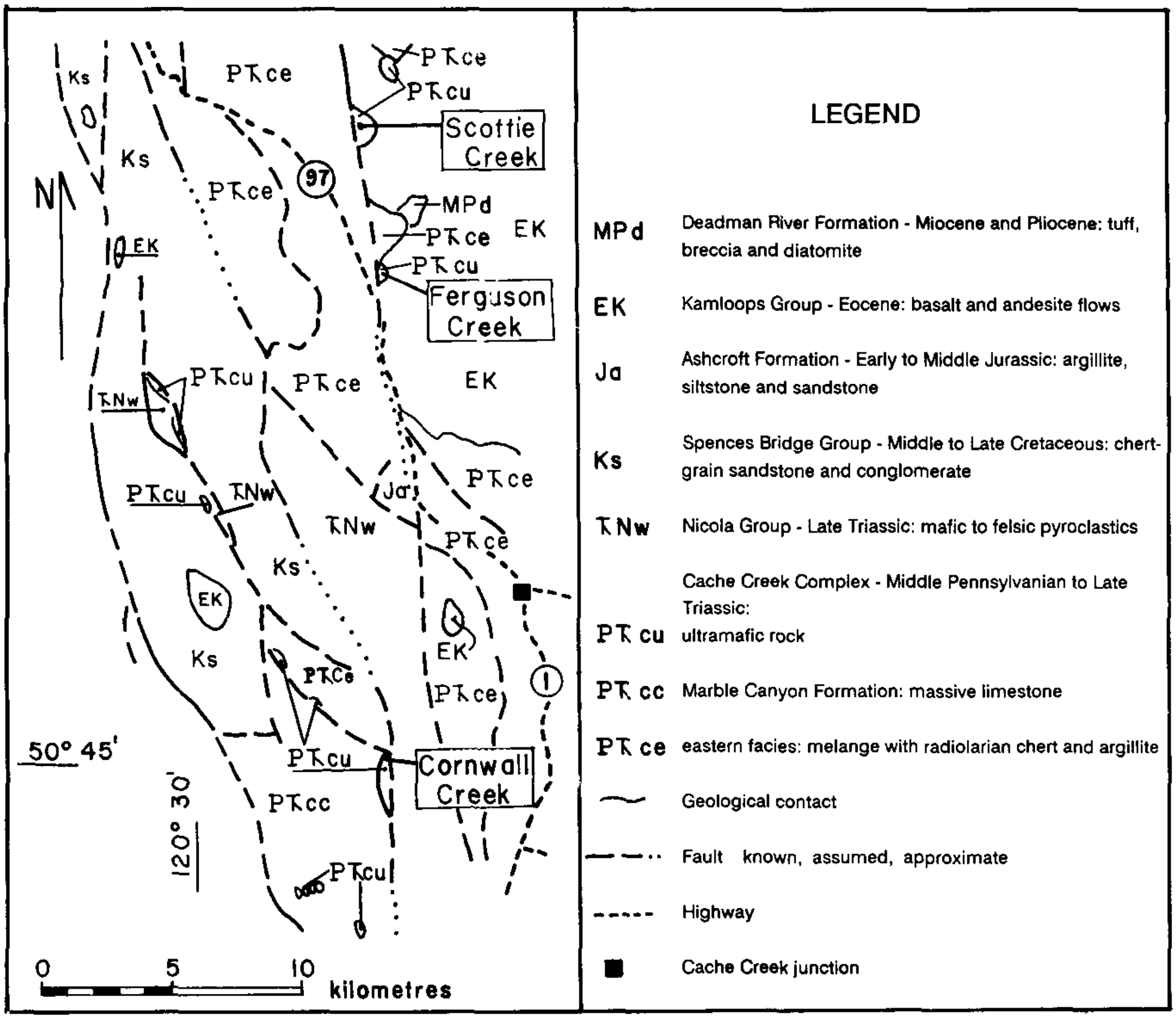


Figure 9. Regional geology of the Cache Creek area and locations of chromite showings (modified after Monger and McMillan, 1989).

directions with no dominant trend although many fractures strike north 15° and dip gently to the west (Reinecke, 1920). Dunitic zones are scattered throughout the harzburgite. Contacts between dunite and harzburgite are irregular and sharp. Locally the serpentinite is intensely altered to a quartz-carbonate-talc assemblage. The Cache Creek rocks, including the serpentinite, are overlain to the west by Teriary plateau basalts. Diamond drilling on the Barbara claim, near the old workings, has indicated a thin conglomerate unit sits directly on top of the serpentinite (Zbitnoff, 1982). The whole area is mantled by a thick cover of Pleistocene till and Quaternary alluvium (*see* Figure 10).

Chromite mineralization is restricted to the dunitic parts of the serpentinite. Chromite occurs as disseminations, narrow stringers and massive lenses. The stringers vary from vague wisps to zones 2 to 30 centimetres wide and 20 to 40 centimetres long composed of medium-grained chromite. Locally these stringers swell into massive chromitite lenses. To date exploration has failed to identify any large zones of mineralization but this could be due to the thick and extensive cover. Samples of chromitic material have yielded the following assays:

Sample of typical serpentinite	< 1 per cent	Cr_2O_3
Samples of disseminated to aggregate chromitite:	13 to 35 per cent	Cr_2O_3
		(Stevenson, 1941)
Grab sample of mineralized serpentinite:	44 per cent	Cr_2O_3
	14 per cent	Fe_2O_3

unpublished notes by H.M.A. Rice, 1942 cited in Duffell and McTaggart, 1951, page 99

Sample of cleaned chromite:

	per cent
Cr_2O_3	41.8
Al_2O_3	23.1
CaO	1.6
MgO	12.9
MnO	0.18
TiO_2	0.96
SiO_2	3.38
NiO	0.16
FeO	15.2

(Stevenson, 1941)

Approximately 454 tonnes of stockpiled ore from the adit workings graded 22.5 per cent Cr_2O_3. A further 90 tonnes of ore from a nearby open-cut graded 33 per cent Cr_2O_3 (Thomson, 1918). No platinum assays of the serpentinite have been done, however, trace amounts of platinum have been recovered in the creek below the workings (Thomlinson, 1920). Platinum group elements and nickel have also been detected in trace quantities in a soil geochemical survey (Watson, 1987).

The showings were first discovered in 1901 but were not staked until 1915. They were first staked as the Iron King and the Iron Queen claims and a small amount of trenching was done. Work continued in 1918 and an adit was driven for about 12 metres with a 6 metre crosscut. Later, in 1930, the Consolidated Mining and Smelting Company of Canada, Limited did extensive testing of the property. Five adits were driven and six major test pits excavated. Forty-five tonnes of chromitite material were shipped for testing but the results were not made public. The ground was then left for many years and the Crown granted claims were allowed to lapse. In 1980, the Scot 1 and 2 claims were staked over the showings and a small amount of prospecting and geophysical surveying was done by Granges Exploration Ltd. In 1981 two diamond-drill holes were put down to test mineralization (Zbitnoff, 1982). Further geochemical work was done in 1987, but the results did not outline any anomalies.

FERGUSON CREEK CHROMITE

Chrome 1 group
TIK 1 group
Joe Henry and Henry Joe
Iron King and Iron Queen
MINFILE: 092INW035 NMI: 92I 14 Cr1
LAT: 50°57′12″ LONG: 121°23′37″

The Ferguson Creek chromite occurrences are located near its headwaters, about 32 kilometres north of Cache Creek and 3 kilometres east of Highway 97. The showings are on and near a prominent bluff on the northwest side of the creek. The hostrock suite is as described for the Scottie Creek showings about 5 kilometres to the north (Figure 9).

Serpentinized dunite and harzburgite are exposed in outcrop and workings but the prospect is largely covered by a thick mantle of till and alluvium. The serpentinized dunite is massive and locally may have a granular texture. The dunite trends northerly and has a steep eastward dip (Stevenson, 1941). It has been traced across the creek and is inferred to continue further north and south. This rock type is exposed across 61 metres and is bounded by serpentinized and extensively fractured harzburgite with a flaky texture and abundant bastite.

Chromite occurs as parallel layers of grains in the dunitic rock. Two showings in open cuts are lenticular pods consisting of closely packed grains and stringers of chromite. These pods measure 4.5 by 1.2 by 0.3 metres and 7.6 by 0.6 metres. Chip samples from the pods by Stevenson (1941) yielded 17.9 per cent Cr_2O_3 across 0.3 metres, 18.9 and 16 per cent Cr_2O_3 across 0.6 metres. A selected sample of cleaned chromite from the first site assayed 28.2 per cent Cr_2O_3. A third exposure, in the exploration adit in the bluff, shows 30 by 0.6 by 0.1 metres of stringer chromite. These are the only reported showings at the site.

The Ferguson Creek showings were first staked in 1939 as the Henry Joe and Joe Henry. Page (1986a) states that the Consolidated Mining and Smelting Company of Canada, Limited drove the adit in the bluff in 1931, probably in association with the testing of the Scottie Creek showings at that time. The property was examined by Rice in 1942 and several samples were taken for analysis. The results are as follows:

Sample	% Cr_2O_3	% Fe_2O_3	Cr/Fe
Ferguson West	50	15	2.25
Ferguson East	44	15	2

(*ibid.*)

A resource potential of 18 000 tonnes of 'reasonably assured' material with 15 per cent chromite and a further 18 000 tonnes of equivalent material was estimated by Rice.

In 1977 the showings were staked as the TIK 1 claim group and a ground magnetometer survey was done. The claims were allowed to lapse and in 1986 the ground was restaked as the Chrome 1 group by Equinox Resources Ltd. A soil geochemical survey was done for nickel, chromium and platinum group metals but the results were not encouraging (Page, 1986a). No further work has been recorded.

MIKA

Winnifred
McKay prospect
MINFILE: 092P090
LAT: 51°07′26″ LONG: 121°25′35″

The MIKA claims are located 8 kilometres northeast of Clinton on the Mound Ranch. The showings are on the west bank of the Bonaparte River just south of its confluence with Fifty-seven Creek.

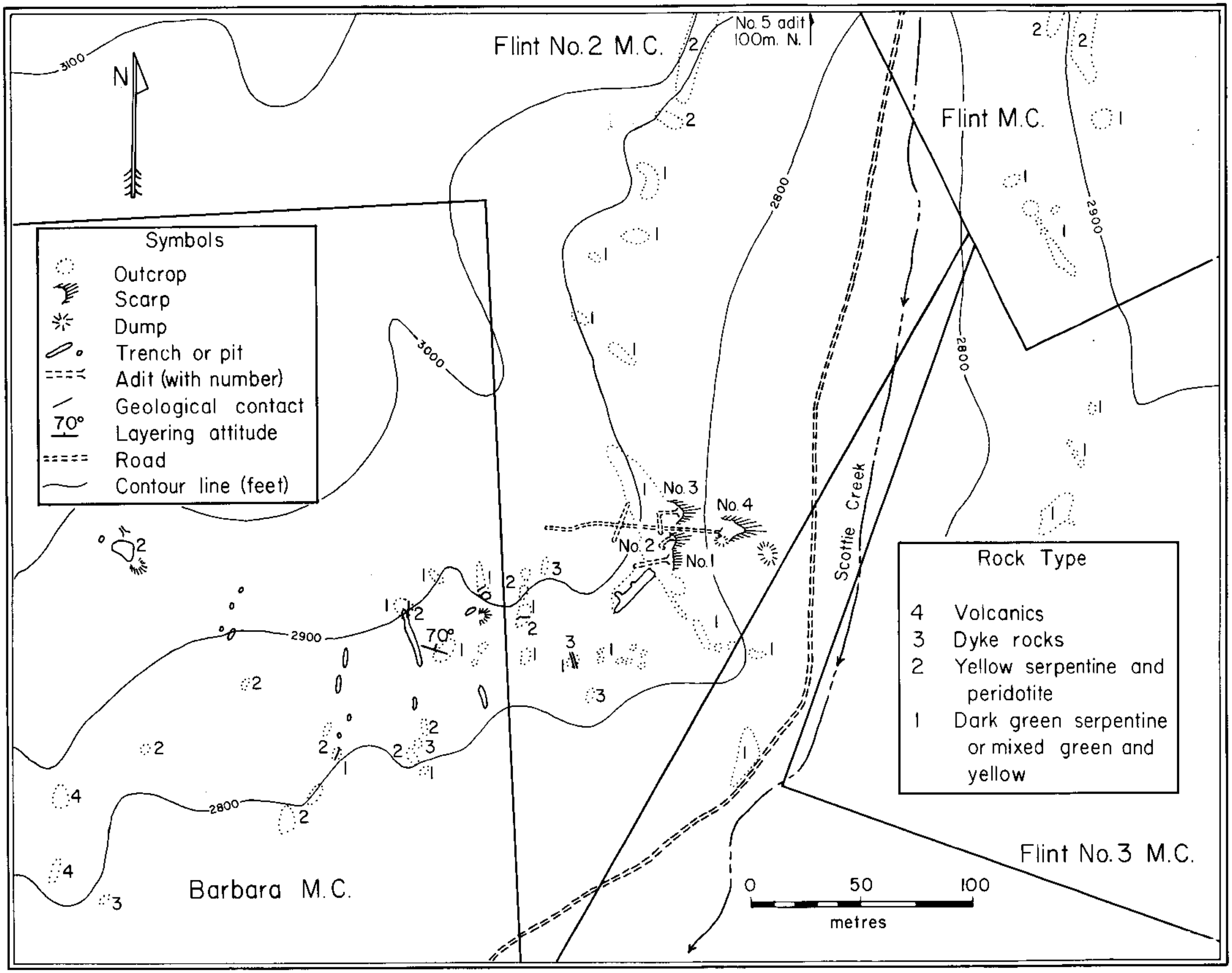


Figure 10. Outcrop map and location of workings at the Scottie Creek chromite showings (from Stevenson, 1941).

The hostrocks for the chromite prospect are the same suite as at the Scottie Creek and Ferguson Creek prospects, already discussed.

A large serpentinite body with dunitic and harzburgitic zones has been mapped at the property (Wilson, 1980). The serpentinite is massive, sheared and is locally quite friable. Late chrysotile veinlets, up to 2 millimetres wide, locally web the serpentinite. Bastite is abundant throughout the body. Dunite and harzburgite zones have been identified but are of limited areal extent. Where exposed, serpentinite is in contact with metasediments and the contact trends 160°-165° with an undetermined dip (Wilson, 1980). Regional mapping indicates that serpentinite outcrops northwest and southeast of the MIKA claims. Within the area there is a conglomerate with harzburgite, dunite and serpentinite clasts 1 to 20 centimetres in diameter in a calcareous matrix. It has been suggested by Wilson that this represents a late, covering conglomerate that is present now in small relict patches. Overlapping the serpentinite are vesicular basalt flows capping hills and considered to be Miocene flood basalts and a thick mantle of till and alluvium covers the area (Wilson, 1980).

Chromite mineralization is restricted to the dunitic phase of the serpentinite. Chromite occurs as disseminations, small pods and lenses. Stevenson (1941) identified two pods 1.5 to 2 square metres in area. A sample of the chromitite assayed:

	per cent
Cr_2O_3	52.8
Al_2O_3	12.1
CaO	0.20
MgO	13.2
MnO	0.17
TiO_2	1.44
SiO_2	3.48
NiO	0.12
FeO	13.9

(Stevenson, 1941)

The old workings are mostly caved in, including the adit and shaft, and little chromite is exposed in outcrop. Platinum and gold geochemical surveys have provided poor results, although this may be due to the amount of cover material (Wilson, 1980, 1981; McNaughton, 1986).

Exploration of the chromite showings on the MIKA claims has been sporadic over many years. The showings were staked before 1932 as the Winnifred claims by W.N.D. McKay. At that time the majority of the trenches, open cuts, shafts and the adit were put in. By 1938, when J.S. Stevenson examined the showings, the claims had lapsed and no work had been done for many years. In 1952, the area was staked for asbestos potential but no work was done. The area was restaked in 1957 for the New Jersey Zinc Exploration Co. Ltd. Between 1957 and 1959 a magnetometer survey was done and some trenches were made to evaluate asbestos potential. In 1967 the JO claims were staked and a small amount of geological mapping was done. In 1979 the MIKA 1-4 claims were staked by CCH Resources Ltd., a subsidiary of Campbell Chibougamau Mines Ltd. Geological and geochemical surveys were completed between 1979 and 1981 to examine the chromite potential of the property. Only the MIKA 1 claim was retained after this work and it was sold to Campbell Resources Ltd. in 1980. In 1986 a geochemical survey for platinum and gold was run with discouraging results. In the same year the MIKA 1 claim was sold to a predecessor company of Corona Corporation, the present owners. No work has been recorded since 1986.

CACHE CREEK

Blue Rock 1-8 claims
Oppenheim
MINFILE: 092INW002 NMI: 92I 14 Cr3
LAT: 50°48′15″ LONG: 121°19′55″

The Oppenheim chromite showings are in a small gully that opens up on the west side of the old Cariboo wagon road, 9.6 kilometres southwest of Cache Creek. Only a small amount of development was done in the early part of this century and the exact location and condition of the showings are now unknown.

The hostrock for the chromite prospect is inferred to be serpentinite of the eastern facies of the Cache Creek terrane, as already described (Scottie Creek prospect). Serpentinite and sediments are exposed in the gully. A section up the gully from the wagon road is as follows:

Distance from Road (metres)	Rock Type
0 - 106	Sediments
106 - 137	Serpentinite
137 - 244	Sediments
244 - 305	Serpentinite
305 - 366	Sediments
366 - 607	Serpentinite
607 - 640	Sediments
640 - 762	Serpentinite

(Stevenson, 1941)

The general strike of the rocks is northwest with an approximate 45° southwest dip. The serpentinite is extremely sheared, creating abundant flaky talus in the gully. Contacts between the serpentinite and the sediments have not been seen. Trenching in 1918 and 1939 to 1941 exposed two small chromite pods estimated to contain three tonnes of chromite-bearing material (Ferrier, 1920) and a second measuring 2 by 1 by 0.6 metres (Stevenson, 1941). Chromite is described as massive pods. A chip sample by Stevenson returned an assay of 37.1 per cent Cr_2O_3. Beneficiation tests were completed by the Department of Mines, Ottawa on a 97-kilogram sample in 1918. Prelminary tests on a small sample assaying 10.70 per cent Cr_2O_3 yielded a concentrate grading 47.34 per cent Cr_2O_3, with a recovery of 55.3 per cent of

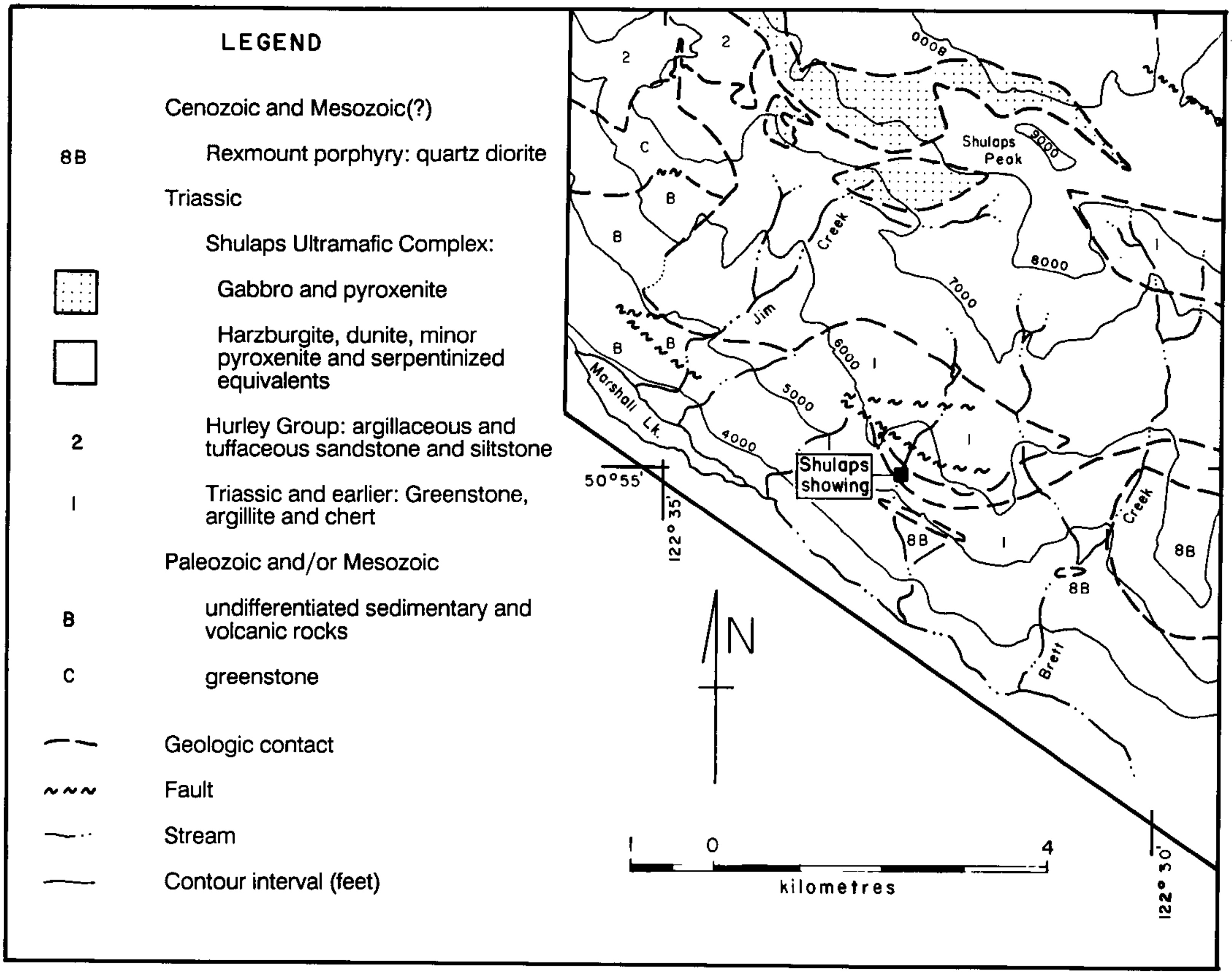


Figure 11. Geology of the Shulaps Ultramafic Complex in the area of the Shulaps chromite showing (after Leech, 1953).

the chromite. Subsequent tests on the balance of the bulk sample showed that practically all the chromite is freed from the gangue by grinding to 50 mesh and that a satisfactory concentrate can be made by gravity concentration on Wilfley tables. Two-stage concentration produced 16.8 kilograms of concentrate assaying 48.88 per cent Cr_2O_3 and 13.2 kilograms assaying 42.10 per cent Cr_2O_3 for an overall recovery of 72.7 per cent (W.B. Timm *in* Ferrier, 1920).

Analysis for nickel and platinum were not made.

The showings were first staked in 1918 by Mr. P. Oppenheim at which time some trenching and test pitting were done. The ground was restaked by R. Langdon in 1935 but there are no records of work done, if any. From 1939 to 1941, sampling, diamond drilling and a magnetometer survey were done by Ardens Ltd. of Calgary (Duffell and McTaggart, 1951). Since 1941 there is no further record of work on the property.

CORNWALL CREEK

Chrome Ore 1-4 and 11-14 claims
Williams chromite deposit
MINFILE: 092INW004 NMI: 92I 16 Fe1
LAT: 50°44'48" LONG: 121°22'00"

The showings are on Cornwall Creek, about 5 kilometres upstream from Ashcroft Manor and about 11 kilometres west of Ashcroft (Figure 9). The workings and exposures extend along the northwest side of the creek for several hundred metres.

The hostrock is inferred to be serpentinite of the eastern facies of the Cache Creek terrane, as for previously described showings in the same general area. Two large bodies of serpentinite abut greenstones, ribbon cherts and limestone. The greenstone consists of fragmental debris flows and lesser amounts of massive vesicular flow rocks. The ribbon chert is highly contorted with layering up to several centimetres thick. Some thin argillite lenses are interbedded with the chert. Limestone is generally white, massive and recrystallized. Layering trends 120° and dips steeply to the northeast. A section described from top to bottom, travelling upstream, is as follows:

"Limestone, 61 m; ribbon chert, 122 m; serpentinite which contains the workings, 457 m; fragmental and flow greenstone, 229 m; second serpentinite, 76 m; greenstone, thickness not mapped" (Stevenson, 1941).

The serpentinite is massive, well fractured to sheared and contains abundant bastite, relict pyroxene and olivine, indicating harzburgite as the protolith. Contacts with the surrounding rocks are not described.

Chromite occurs as disseminated grains in serpentinite float. This material assayed 0.3 per cent Cr_2O_3 (Stevenson, 1941).

The original claims, the Chrome Ore 1-4 and 11-14, were staked in 1938 for the Calgary Minerals Claims Syndicate - Chrome Ore by L. Starnes and were managed by J.O. Williams. In 1939 ten open cuts exposed serpentinite, some minor chromite mineralization and adjacent sediments. One adit was driven into the bank at 080° for 16 metres with a 10 metre open-cut approach. This working exposed sheared serpentinite and a major fault zone trending 075°/70°S (Stevenson, 1941). The original claims were allowed to lapse and the showings were subsequently restaked (Duffell and McTaggart, 1951). There is no other recorded work on the showings.

SHULAPS RANGE

MINFILE: 092JNE099 NMI: 92J 15 Cr1
LAT: 50°54'44" LONG: 122°32'23"

The Shulaps Range chromite occurrence is the largest and most significant of several in the Bridge River area. It is 2200 metres east of the south end of Marshall Lake, at an elevation of 1675 metres. Chromite is hosted by dunites of the Shulaps ultramafic complex. The chromite occurrence has received only academic examination to date. The other chromite occurrences in the Bridge River area consist of disseminations in small slivers of harzburgite or disseminations in the President intrusion.

The Shulaps ultramafic complex has been structurally emplaced on rocks of the Bridge River complex and the Cadwallader Group (Figure 11). The Cadwallader Group consists of Late Triassic marine sediments: sandstone, siltstone, conglomerates; and mafic volcanics: pillow basalt, greenstone, greenstone breccia. The Bridge River complex comprises marine cherts, clastic rocks, limestone and mafic intrusive and extrusive rocks. This complex has been structurally dismembered and imbricated but is believed to represent the uppermost part of an ophiolite sequence, possibly the upper part of the Shulaps Complex (Schiarizza, *et al.*, 1989).

All contacts between units and many internal contacts are faults, the result of many deformational events. This complex faulting has commonly led to structural inversion and interleaving of units. The Shulaps ultramafic complex has been divided into two parts, a structurally higher harzburgite with some dunite and a structurally lower serpentinite mélange containing exotic blocks. The harzburgite makes up 85 per cent of the upper unit with dunite comprising the remainder. The harzburgite is layered, frequently outlined by thin orthopyroxene layers and thin planar sheets of chromite grains. Occasionally, dunite outlines layering but more commonly it occurs as randomly oriented pods and lenses. Boundaries between dunite and harzburgite are usually sharp or gradational over a few centimetres. Dunite layers are generally a metre or two thick and extend along strike for 20 to 30 metres, although a few lenses measure up to 120 by 180 metres (Leech, 1953).

The lower serpentinite mélange is a complex mass that contains many exotic blocks. Serpentinite is massive

TABLE 5
ULTRAMAFIC ROCK SAMPLES FROM THE SHULAPS RANGE

UTM No.	Au ppb	Pt ppb	Pd ppb	Se ppm	Cu %	Ni %	Cr %	S %	Easting	Northing
GBB-159	610	11	4	0.6	0.002	0.27	0.36	0.04	532800E	5642950N
GBB-195	7	4	2	0.1	0.001	0.23	0.68	0.01	533110E	5648500N
GBB-276	53	19	3	0.1	0.001	0.13	0.28	0.01	514680E	5650780N
GBB-277	8	2	4	0.1	0.001	0.28	0.12	0.03	515350E	5650820N
GBB-401	6	1	4	0.1	0.001	0.09	28.10	0.01	534250E	5640050N

Sample GBB-401 is from the chromitiferous dunite at the Shulaps showing. Analyses from B.N. Church, samples taken 1988.

and sheared. The exotics consist of ultramafic, gabbroic, sedimentary and volcanic rocks. Some of the blocks are up to several hundred metres across, many are recognisable Bridge River Complex lithologies. Some of the exotics are not readily identified but may be from the Cadwallader Group. It is believed that the exotic blocks represent lithologies plucked from the sole of the thrust on which the Shulaps Complex was emplaced (Schiarizza, *et al.*, 1989).

Chromite mineralization is ubiquitous throughout the Shulaps Complex. Though commonly seen as short, less than 1 metre, trains of disseminated grains in harzburgite, larger concentrations in dunite have been reported. These are commonly small nodules, less than fist size, or short, thin massive stringers. Unfortunately, only a few of these heavier concentrations have been identified. The largest area of significant chromite mineralization is at the Marshall Creek location. First described by Leech (1953) it was reexamined and sampled by Ministry geologists in 1988. Leech found one zone of eight separate massive chromitite lenses. R. Gaba, upon reexamination of the locality, only identified two pods with a total surface exposure of 6 by 4 metres (R. Gaba, personal communication, 1990). Original chemical analysis of the chromitite yielded the following results:

Oxide	Weight Per Cent
Cr_2O_3	57.43
Al_2O_3	7.44
Fe_2O_3	5.08
FeO	12.09
MgO	13.57
MnO	0.43
CaO	trace
H_2O+	0.40
TiO_2	0.08
SiO_2	3.58
TOTAL	100.10

(Leech, 1953)

Other samles of chromitiferous dunite from the Shulaps Complex were taken in 1987 by Ministry geologists and analysed for base and precious metals plus sulphur and selenium. The results, provided by B.N. Church, have not been previously released and are presented in Table 5.

Chromite and platinum potential has not been extensively pursued in the Shulaps Range area. A few reconnaisance sampling programs have been done but no concentrated work has taken place to date. Results of a private regional geochemical survey done in the Yalakom River valley are presently confidential.

CENTRAL AND NORTHERN BRITISH COLUMBIA

FORT ST. JAMES AREA: REGIONAL GEOLOGY OF THE ULTRAMAFIC ROCKS

A series of serpentinized, thrust-bounded ultramafic blocks occurs along a northwest trend from Fort St. James to the Mitchell Ranges. These blocks are variably mineralized with chromite. Exploration in the area has been light, dominated by prospecting for mercury in the late 1940s after the close of the Pinchi Lake mercury mine and for porphyry molybdenum-copper in the 1970s following the Endako mine development. Exploration for chromite and associated platinum group metals has been very limited and cursory.

The two major rock packages in the Fort St. James area are marine rocks of the Pennsylvanian-Permian Cache Creek Group and mafic to intermediate volcanic rocks of the Triassic-Jurassic Takla Group. The boundary between these two suites is the Pinchi fault system. Ultramafic rocks occur solely within the Cache Creek Group. Locally it consists of limestone and carbonaceous rocks, marine cherts and ribbon cherts, argillites and serpentinized ultramafic rocks.

Seven major ultramafic bodies are exposed in the Fort St. James area. They were known for many years as the Trembleur Intrusions (Armstrong, 1949). This is a misnomer as the ultramafics are actually thrust slices of the lower part of an ophiolite series.

Geographically these bodies are exposed in the Mitchell Ranges (two) and at Tsitsutl Mountain, Mount Sidney Williams, Cunningham Lake, Mount Pinchi and Murray Ridge (Figure 12). Each block, except Cunningham Lake which appears barren, contains small chromite occurrences, some with trace amounts of

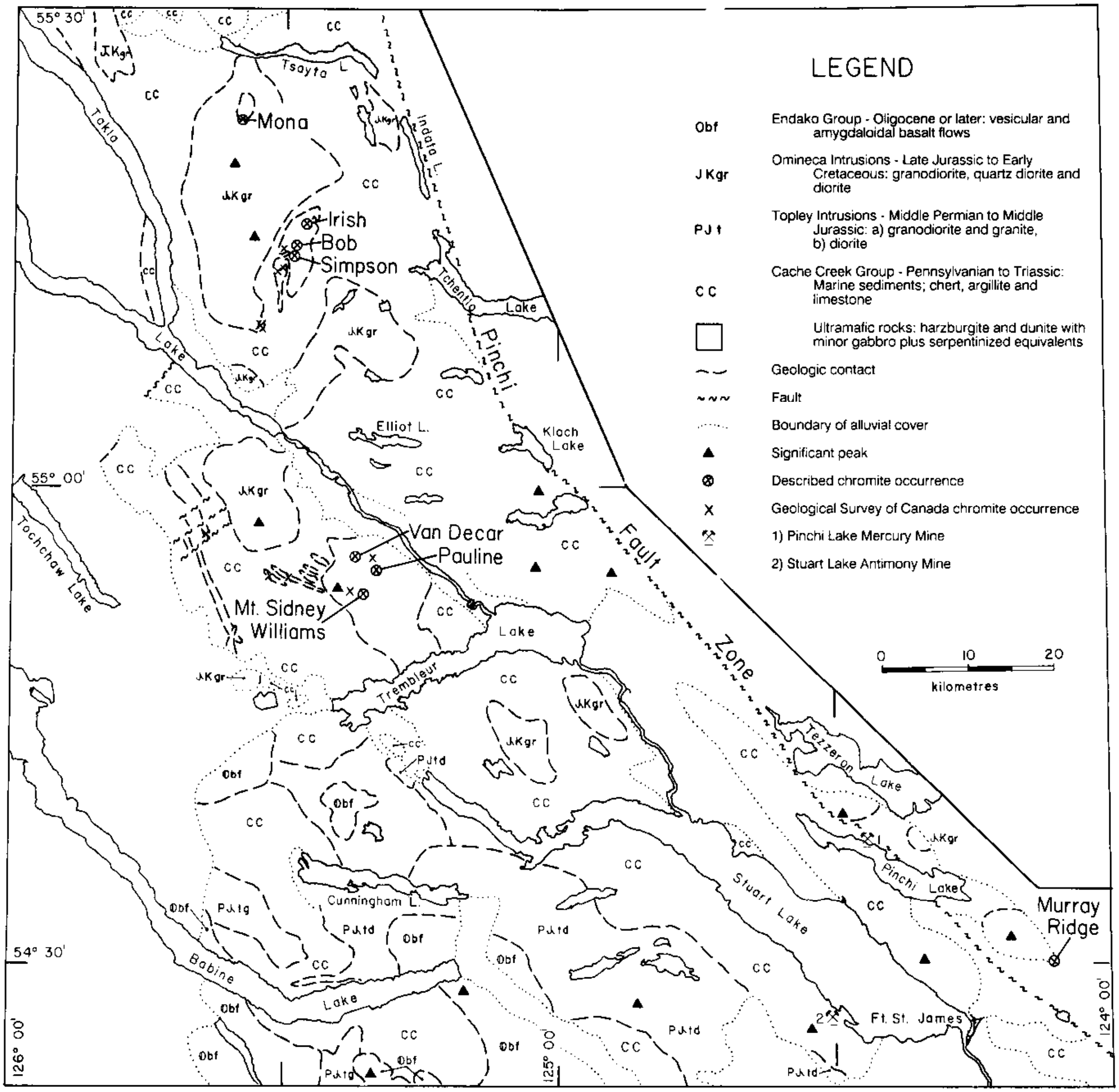


Figure 12. Simplified geology and locations of chromite showings in the Fort St. James area (after Armstrong, 1949).

platinum. The occurrences will be described below. Each ultramafic block is bounded by faults, predominantly thrusts, but some also have bounding high-angle, lateral-movement faults. Regional high-angle lateral and vertical fault movement has also structurally emplaced slices of marine rocks within the ultramafics.

Individually the ultramafites consist of 80-90 per cent harzburgite with variable amounts of pyroxenite, gabbro, dunite and chromitite (Whittaker, 1982a; 1982b; 1983). The rock is generally massive and tectonized. Locally, however, some cumulate textures such as crude layering have been identified in the harzburgite. Also poikilitic orthopyroxene enclosing olivine is present. Dunite occurs in discrete zones within the harzburgite, forming about 4 per cent of the total rock mass. The dunite zones are either thin tabular bodies up to 1.5 metres thick or irregular bodies up to 100 metres in diameter (Paterson, 1977). The dunite is massive, follows the deformation of the harzburgite and hosts the significant chromitite occurrences.

There are two phases of mafic dikes in the ultramafic suite. The first phase is represented by pre-tectonic gabbros that are massive, serpentinized and tectonized with the host harzburgite. These dikes are frequently stretched, boudinaged and, locally, isoclinally folded. Serpentinization is often complete with only the deformation features preserved. The second phase of dikes are massive unserpentinized norites. They are undeformed and crosscut the ultramafic rocks but do not extend beyond the limits of the ultramafites. This leads to the conclusion that the norite dikes are late stage with respect to the formation of the ultramafics and tectonic deformation but preceed the latest stages of emplacement onto the marine rocks (Whittaker, 1983).

Alteration of the ultramafic packages consists of two major types, serpentinite and rodingite. The degree of serpentinization is variable from moderate to intense and is pervasive throughout all the rock types except the norites. The alteration assemblage is primarily serpentine (antigorite) and bastite with lizardite in the dunite and minor talc, chlorite, brucite, augite and actinolite. The lack of alteration in the norites suggests that the majority of alteration took place while the ultramafics were in the upper mantle (Whittaker, 1983). Nephrite (B.C. Jade) has been identified locally in the Mitchell Ranges ultramafic bodies. Rodingite alteration occurs as tabular masses that crosscut the ultramafic rocks. Rodingite is a calcsilicate alteration assemblage comprising grossularite, wollastonite, quartz and feldspar. The loci of this alteration are the gabbro dikes which are locally completely replaced by rodingite. Chlorite selvages, 1 to 3 centimetres thick, bound the rodingite zones. The calcsilicate alteration preceeds the serpentinization and the iron-magnesium alteration represented by the chlorite selvages, and probably occurred in the upper mantle (Whittaker, 1983).

The ultramafic bodies have undergone a series of deformational events. Two early subparallel phases of ductile deformation are present, consistent with mantle tectonism. The ultramafic rocks, predominantly the harzburgite, are extensively sheared with braided foliation, ribboning and mylonitization. The deformation has flattened, stretched, kink-banded and cracked olivine and pyroxene grains. Individual crystals are elongate parallel to the subvertical, east-trending foliation and lineation that plunges gently in that direction. Isoclinal folding of mineral layers, such as pyroxenite, and the gabbro dikes is also part of the intense mantle deformation (Ross, 1977).

Three later phases of deformation have been identified by Paterson (1973). Two are subparallel folding events, associated with emplacement of the marine and ophiolite sequence, that have easterly trending, subvertical axial planes and gentle eastward plunges. These two events are similar in orientation to the mantle deformation and may have been generated by the same stress regime (Ross, 1977). The base of the ophiolite sequence is frequently marked by a zone of brecciation. This breccia is believed to be part of the thrust sole upon which the ophiolites were emplaced. Latest stage, brittle deformation features trend northwest parallel the Pinchi fault system and are related to movement along it.

Chromite Occurrences: Mitchell Ranges Ultramafites

SIMPSON SHOWING

Alloy group
MINFILE: 093N 033 — NMI: 93N 04 Cr1
LAT: 55°13'53" — LONG:125°30'15"

BOB

MINFILE: 093N 034 — NMI: 93N 04 Cr1
LAT: 55°15'05" — LONG: 125°30'00"

IRISH

MINFILE: 093N 035 — NMI: 93N 06 Cr1
LAT: 55°16'40" — LONG: 125°27'25"

CYPRUS 1 AND 2 CLAIMS

Mona
MINFILE: 093N 016 — NMI: 93N 05 Cr1
LAT: 55°23'13" — LONG: 125°35'04"

LEO CREEK

MINFILE: 093N 040 — NMI: 93N 04 Cr2
LAT: 55°10'20" — LONG: 125°32'52"

The Mitchell Ranges ultramafites are two adjacent blocks, about 120 kilometres northwest of Fort St. James. The northern body hosts one small chromite occurrence, the Cyprus 1 and 2 (Mona) showings. The balance of the showings are in the southern block within an area of a few square kilometres.

There are 22 individual showings. The majority were identified by C.S. Lord in 1942 during regional mapping of the Manson Creek - Fort St. James area by the Geological Survey of Canada (Armstrong, 1949). Further mapping of the ultramafites by Whittaker (1983) identified the remaining occurrences and reexamined the previously known showings (*see* Figure 12).

Throughout the ultramafites, chromite is common as disseminations and forms up to 2 per cent of the rock. At the individual occurrences, chromite is found in layers, nodules, massive crystal aggregates or disseminations. Layered chromite is generally massive with some aggregate zones. The layers are elongate parallel to foliation, up to 75 centimetres across and frequently fractured. Aggregate chromite zones are either layers or irregular bodies elongate with foliation. Chromite forms greater than 75 per cent of the rock mass in the aggregate zones. Disseminated chromite, less than 75 per cent of the rock, forms irregular layers up to 25 centimetres thick. The chromitite layers are frequently deformed into tight folds, with some pinch and swell or boudinage features. The massive chromitite zone has been fractured. Chromite nodules are usually massive with some aggregate chromite and range in size from 1 to 130 centimetres in diameter. The more massive nodules show some fracturing. Whittaker (1983) describes each chromite showing and only the three largest will be detailed here. The three major showings were sampled by C.S. Lord (Armstrong, 1949) and results are summarized as follows:

BOB		(X4 - X7) Composite grab samples (2)	
	Cr_2O_3	28.6 %	31.2 %
	Cr	19.6 %	21.4 %
	Fe	17.1 %	14.5 %
	Cr/Fe	2.01	1.48
SIMPSON (ALLOY)		(X12 - X14) Composite chip sample (1)	
	Cr_2O_3	45.7 %	
	Cr	31.3 %	
	Fe	15.55 %	
	Cr/Fe	2.01	
IRISH		(X1 - X2) Channel samples (17) Average length: 1.7 metres	
	Cr_2O_3	35.6 %	
	Cr	24.3 %	
	Fe	10.7 %	
	Cr/Fe	2.30	
		Channel samples (10) on single lens 9.7 by 2.7 metres	
	Cr_2O_3	38.0 %	

Numbers *ie.* X 12, in parentheses are location names from Whittaker (1983).

In 1941 the Simpson showings were staked by Hunter Simpson and Associates but no work was recorded and the claims were allowed to lapse (Armstrong, 1949). In the northern ultramafite some exploration work was done by the Magnum Corporation on the Mona claim but no specific records are available. In 1987, Imperial Metals Corporation staked the Cyprus 1 and 2 claims over the same showing. A geochemical survey was done for gold, copper, nickel and chromium but no significant anomalies were detected and the claims were allowed to lapse. No other work has been recorded on the ultramafites in the area and their platinum potential has not been examined.

CHROMITE OCCURRENCES: MOUNT SIDNEY WILLIAMS ULTRAMAFITE

The Mount Sidney Williams ultramafite hosts three known chromite occurrences: Van Decar Creek, Pauline and Mount Sidney Williams. These showings were discovered in the course of Geological Survey of Canada mapping in 1940 (Armstrong, 1949). The individual showings are described below:

VAN DECAR CREEK
MINFILE: 093K 041
LAT: 54°55'40" LONG: 125°22'08"

PAULINE
MINFILE: 093K 040
LAT: 54°55'35" LONG: 125°20'22"

The Van Decar Creek and Pauline showings are on the northeastern slopes of Mount Sidney Williams. These appear to be the only two showings in the area which have been re-identified and prospected since the original mapping.

The Van Decar Creek showing is on the west side of a small knob about 1 kilometre south of the major fork in Van Decar Creek, at an elevation of 1110 metres, 4 kilometres upstream from Middle River. It is the largest known chromite body in the Fort St. James area.

The main showing is a lens of massive and aggregate chromitite measuring 1.5 by 12 metres. The chromitite is hosted by serpentinized dunite. Prospecting in 1975 yielded one sample of chromitite containing 9.8 per cent Cr_2O_3 (Stelling, 1975). Further prospecting and hand trenching of the showing have yielded samples containing:

% Fe	% Cr	Cr/Fe
10.50	32.9	3.9
9.35	32.1	3.4
12.30	38.9	3.2
7.60	17.7	2.3

(Guinet, 1980)

The Cr/Fe ratios shown here are some of the highest in the province.

A second showing of serpentinized dunite, approximately 300 metres south of the main showing is recorded as measuring 1 by 12 metres and containing about 10 per cent disseminated chromite (Armstrong, 1949). Prospecting in 1979 failed to find this showing.

Higher on the same ridge, at an elevation of 1525 metres and southeast of the Van Decar location, is the Pauline showing. This is a large zone of serpentinized harzburgite with dunite that contains one pod of massive chromite and one zone of aggregate chromite. The massive pod measures 2.4 by 1.5 metres and the aggregate zone, 20 metres to the west, is 1 by 3.6 metres containing 20 to 30 per cent chromite. The rest of the dunite contains 2 to 5 per cent chromite (Armstrong, 1949).

Work on the Van Decar Creek and Pauline showings began in 1974 when they were staked as the Pauline 1-4 claims and a small amount of prospecting was done. Later, the Cr 1-6 claims were staked, covering the northeast flank of Mount Sidney Williams and the lapsed Pauline claims. Prospecting in 1979 identified the two showings and they were sampled at that time. In 1982, a low-level airborne aeromagnetic survey was flown over the Cr 1-6 claims by Western Geophysical Aero Data Ltd. The survey outlined several regional features but the results were inconclusive due to a lack of geological corroboration (Pezzot and Vincent, 1982). The showings were most recently covered by the PG-1, P.G.3 and P.G.5 claims. No evaluation of the platinum potential of the showings has been recorded.

MOUNT SIDNEY WILLIAMS

MINFILE: 093K 039
LAT: 54°53′19″ LONG: 125°21′15″

A body of serpentinized dunite is located about 3200 metres east-southeast of the peak of Mount Sidney Williams. The dunitic body measures approximately 9 by 85 metres, bounded by harzburgite. Disseminated chromite is found throughout the dunite in concentrations of 3 to 5 per cent with one zone, 2 by 9 metres, containing 6 to 9 per cent chromite (Armstrong, 1949). No work has been recorded on the showings which were most recently covered by the VAN 1, P.G.4 and PG-3 claims.

MURRAY RIDGE ULTRAMAFITE

MURRAY RIDGE

MINFILE: 093K 012
LAT: 54°31′53″ LONG: 124°11′24″

The Murray Ridge ultramafite is exposed over the whole of the ridge above 300 metres elevation, 11 kilometres northeast of Fort St. James. A downhill skiing facility occupies the lower western slopes of the ridge and a Ministry of Forests radio repeater station and fire lookout tower are on the crest of the ridge. No known exploration for chromite was done prior to 1987.

The ultramafite consists of 97 per cent harzburgite and 3 per cent dunite and rare coarse-grained orthopyroxene veins. Dunite occurs as elongate, irregularly shaped bodies parallel with the northwesterly trending ridge crest. The dunite zones vary in size from 10 centimetres to 25 metres across. The orthopyroxene veins trend parallel to easterly directed structures (Whittaker and Watkinson, 1981). The rock is massive and moderately to intensely serpentinized. Mantle tectonism features and later high-level deformation features are present, as described in the regional geology section.

Chromite occurs as disseminations of less than 0.5 per cent in harzburgite and as disseminations and stringers in dunite. Chromite stringers are no more than 1 metre in length and contain, on average, 5 per cent chromite. Microprobe work by Whittaker and Watkinson (1981) has determined Cr/Fe ratios of 3.06. A geological mapping, geochemical survey and prospecting program was carried out in 1986 and 1987 by Morrison (1987) for chromite and platinum group elements on the MR claim group which covers most of the ridge. The initial results were not encouraging as the best values for platinum, palladium and iridium were 38, 13, 13 ppb respectively from 30 chip samples (Morrison, 1987). Detailed mapping by the British Columbia Geological Survey Branch in the Murray Ridge area concluded that the chromite and associated platinum group element potential was very poor.

CASSIAR AREA

ANVIL CHROMITE

Ice Lake chromite
Blue River ultramafite
MINFILE: 104P 100
LAT: 59°33′28″ LONG: 130°00′00″

The Ice Lake chromite showings are located adjacent to Ice Lake, 28 kilometres north-northwest of Cassiar. The showings were discovered by Ministry geologists during regional mapping of the area in 1987. The hostrocks are dunite of the Blue River ultramafic complex, part of the Sylvester allochthon (Nelson *et al.*, 1988; Nelson and Bradford, 1989). The showings have not been evaluated for their platinum group metals potential and examination of the chromite has only been cursory.

The Blue River ultramafite occupies the core of the McDame synclinorium. It consists of two thin thrust sheets in the upper part of Division II of the Sylvester allochthon as defined by Nelson *et al.* (1988) and Nelson and Bradford (1989) and is considered the lower part of an ophiolite sequence. The complex has been complicated by prethrust transform-fault serpentinization and serpentinite diapiric intrusion as described by Saleeby (1979, 1984). It is structurally overlain by a crudely layered gabbro that is correlative with the Zus Mountain gabbro to the east. The ultramafite consists of serpentinized and rodingitized dunite and peridotite sheeted dikes. These rocks are composed of greater than 90 per cent olivine (dunite) and up to 10 per cent orthopyroxene and clinopyroxene (harzburgite to wherlite) and are intruded by fine-grained gabbro dikes. Chromite is ubiquitous, but only as disseminations of up to 1 per cent of the rock.

The lower thrust layer consists of a dunite-peridotite body that appears to be soled by a brecciated and serpentinized shear zone. Large blocks of dunite, gabbro and pelagic sediments are included in this zone and it is postulated to be a major sole thrust (J.L. Nelson, personal communication, 1990). The upper thrust slice comprises the gabbro unit which has limited extent due to erosion. The complex rests on a stack of pelagic sediments, limestone, chert, basalt breccia and flows, diabase and diorite. The structural setting and position leads to the correllation between the Blue River ultramafite and the Zus Mountain ultramafite where a more complete section is preserved (Nelson *et al.*, 1988).

Alteration of the ultramafite varies from moderate to intense and four alteration types are present. The first and most extensive is serpentinization. This is best developed around the margins and base of the ultramafite but is present throughout the body. The serpentinite is usually sheared with the greatest intensity of deformation developed along its base and edges. Unrotated or slightly rotated blocks of serpentinite and peridotite are present in the sheared zones. The second most common type of alteration is represented by secondary amphibole and tremolite found scattered throughout the dunite. The third alteration type is talc developed from retrograde metamorphism of the dunite. It is most commonly developed within 300 to 450 metres of the nearby Cassiar granitic intrusions. Large talc crystal rosettes and masses form zones comprising 10 to 30 per cent of the rock, frequently overprinting the tremolite alteration. The fourth major type of alteration is regenerated dunite containing a more forsteritic olivine (Fo92-94) than the primary dunite (Fo88-92). The regenerated olivine grains are up to 3 millimetres in diameter with rims of serpentinite. This alteration is readily identified in the field by its 'spotty' appearance. Locally rodingite zones, often tabular masses up to 100 metres in length and occasionally discrete pods 0.5 metre across, occur in the dunite.

The mineralization at Ice Lake consists of two pods of aggregate chromite in dunite, found during regional mapping. One pod on the north side of the lake measures 1 by 20 metres and contains 50 per cent chromite. The second pod is at the southeast end of the lake and consists of a 1 square metre pod containing 50 per cent chromite (Bradford, J., 1987, unpublished field notes). To the southeast, in a small gully between the heads of Heazelwood and Claimjumper Creeks, is a zone of massive chromitite boulders. It is believed that the boulders have a local source (J.L. Nelson, personal communication, 1990). No chemical analyses of the chromitites have been made and there has been no work done on the showings since their discovery.

ALASKAN-TYPE ULTRAMAFIC BODIES

TULAMEEN ULTRAMAFIC COMPLEX

Grasshopper Mountain
Grasshopper 1 & 2 claims
Olivine Mountain
J numbered claims
D numbered claims
R numbered claims
MINFILE: 092HNE014, 035, 038, 116, 128
LAT: 49°31′38″ LONG: 120°54′03″

The Tulameen ultramafic complex is located about 30 kilometres west-northwest of Princeton, on the Tulameen River between Britton and Lawless creeks. Access is by good all-weather logging roads from Princeton via Coalmont or from Hope via Coquihalla Lakes. The complex is an Alaskan-type, zoned ultramafite. It has been the source of most of the platinum placer production in the province and has also been the site of lode chromium and iron ore exploration since the turn of the century.

The Tulameen ultramafite is an elongate body, 17 kilometres long and varying in width from 2.5 to 6.5 kilometres, oriented along a northwest trend. The country rocks to the intrusion are andesitic metavolcanics and metasediments of the Triassic Nicola Group, locally metamorphosed from greenschist to amphibolite grade. To the northwest and north, Eagle granodiorite of the Mount Lytton complex truncates the northern margin (Figure 13).

The Tulameen complex has a dunite core mantled by pyroxenites and surrounded by a marginal gabbro phase. It is unusual compared to typical Alaskan complexes in that the mafic rocks are syenogabbros and syenodiorites rather than tholeiitic basalts (Findlay, 1963). The dunite core is composed of olivine with disseminated and nodular chromite. The platinum of the complex appears concentrated in discontinuous chromite layers. Olivine is variably serpentinized and often small (less than 1 centimetre) asbestiform serpentine joint and fracture fillings web the core. Peripheral to the core is an olivine clinopyroxenite zone. This unit comprises olivine and bright green diopside. In contrast with the core, this rock is much less serpentinized, generally less than 20 per cent altered. Surrounding this is a hornblende clinopyroxenite unit composed of diopsidic augite, hornblende and magnetite with minor amounts of biotite, apatite and vermiculite. Syenogabbro is exposed at the southern and southeastern end of the complex. The primary mineralogy is plagioclase (andesine), clinopyroxene, hornblende and potassium feldspar, with minor amounts of apatite and sphene.

The whole complex has been cut by northwest-trending transcurrent faults associated with the Fraser River - Straight Creek fault system (Monger, 1985). Several strike-slip faults cut the complex along a northwest trend and it is transected by northeast-trending extensional faults. All of the contacts with the Nicola group country rocks appear to be high-angle faults or ductile shear zones, possibly grading to mylonite zones (Nixon and Rublee, 1988).

Chromite mineralization is restricted to the dunite core of the intrusion. This is located on and between Grasshopper and Olivine mountains which are separated by the Tulameen River. Chromite occurs as small blebs, massive pods and lenses up to 6 by 100 centimetres in size. These are scattered randomly throughout the dunite core and no major concentrations of chromite have been found to date. A few areas of relative chromite enrichment, 4 to 36 square metres in size, were identified during work for Newmont Exploration of Canada Ltd. in 1986. These chromite zones in dunite are on the southwestern slopes of Grasshopper Mountain. Rock chip sampling of these areas yielded the following results:

Zone	Cr (avg) %	Pt (avg) ppb
A	1.200	1150
B	1.144	2210
C	17.427	2915
D	4.712	2340
E	0.883	1355

(Bohme, 1987)

Further work for Tiffany Resources Inc. in 1987 located two more zones of anomalous chromium and platinum in chip samples in the same area. No concentrations were defined, only broad areas of enrichment (Chamberlain, 1988). Sampling of chromitites by many workers has shown that platinum is enriched in some chromitite concentrations and not in others with no apparent controls. This has led to difficulties in identifying platinum targets. The major land holder on the Tulameen complex is Tiffany Resources Inc., which owns or has optioned most of the claims in the area. Present status of the claims has not been determined by the author.

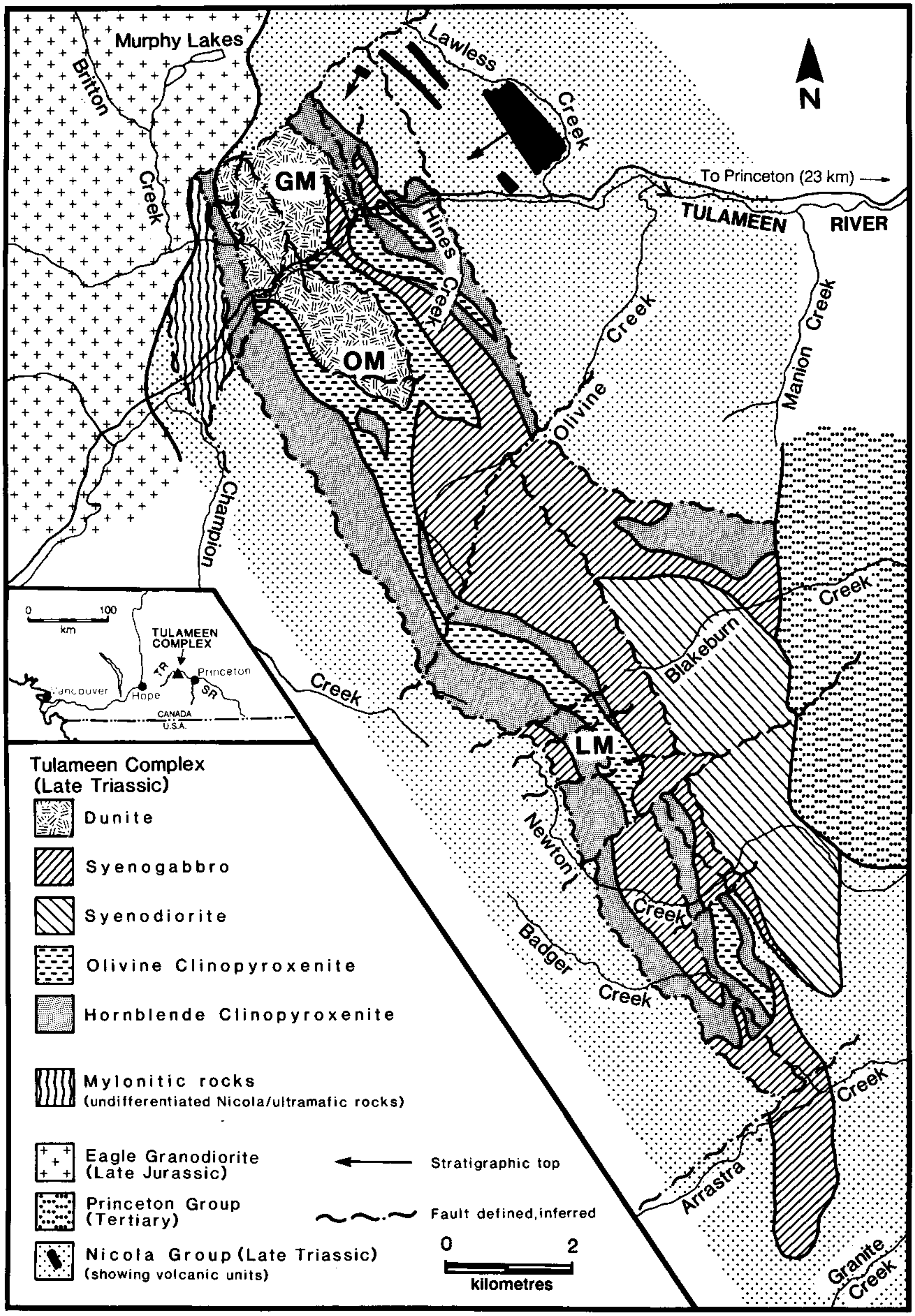


Figure 13. Geology of the Tulameen Ultramafic Complex (from Nixon and Rublee, 1988).

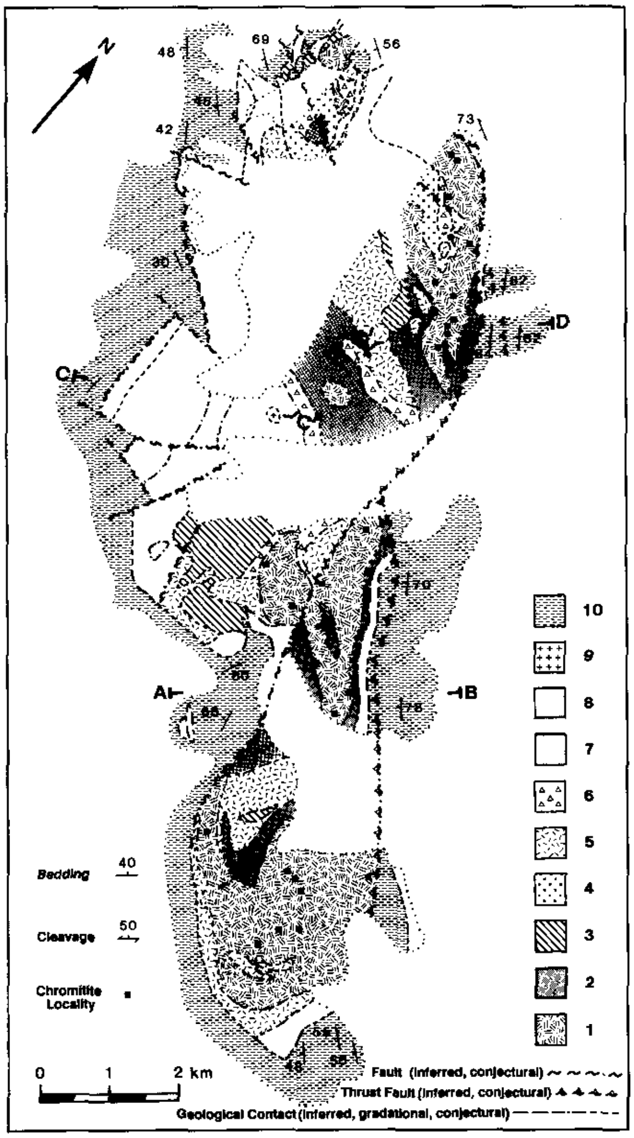


Figure 14. Geology of the Polaris Ultramafic Complex (from Nixon *et al.*, 1990). Key to map units: 1 dunite; 2 olivine wehrlite; 3, wehrlite; 4, undifferentiated olivine wehrlite and wehrlite; 5, olivine clinopyroxenite and clinopyroxenite; 6, mixed clinopyroxenitic and wehrlitic (with minor dunite) unit; 7., *hornblende clinopyroxenite, clinopyroxene hornblendite,* hornblendite and minor gabbro 8, gabbroic rocks; 9, syenite/leuco-monzonite; 10, metasedimentary rocks of the Lay Range assemblage (Harper Ranch tectonostratigraphic terrane). Solid boxes indicate chromite localitites. A-B and C-C'-D'-D are cross sections, not shown in this report.

POLARIS ULTRAMAFIC COMPLEX

Aiken Lake
Pole 1 and 2 claims
Lay claims
Polaris claims
MINFILE: 094C 090
LAT: 56°30'00" LONG: 125°38'36"

The Polaris ultramafic complex is exposed along the Mesilinka River, 10 kilometres northeast of Aiken Lake and 490 kilometres north-northwest of Fort St. James. The body is a layered Alaskan-type ultramafite and outcrops over an area of 45 square kilometres. Exploration has been for platinum group metals within the body and for gold in its contact aureole. Chromite mineralization occurs within dunite and locally forms pods and stringers.

The Polaris complex is exposed as a northwesterly elongate body, 14 by 4 kilometres in surface dimension, parallel to the regional structural trend (Figure 14). It is one of several Late Triassic layered ultramafic intrusions in the Quesnellia terrane, which includes the Tulameen and Wrede Creek complexes (Nixon, *et al.*, 1990). Rock types exposed in the intrusion include dunite, olivine wehrlite and wehrlite, olivine clinopyroxenite and pyroxenite, hornblende pyroxenite, hornblendite, gabbro and late-stage pegmatites and fine-grained feldspathic rocks (*ibid.*). The rocks are variably fine to coarse grained and layered with cumulate structures preserved. Serpentinization is weak to moderate and occurs throughout the body. The Polaris ultramafite is a large layered sill that intrudes metasediments of the Late Permian Lay Range assemblage. The intrusive stratigraphy, from bottom to top, consists of dunite to wehrlite, clinopyroxenite with hornblendite and hornblenditic gabbro forming the upper most layers. Layer contacts vary from sharp to gradational. The complex faces west, trends northwest and dips moderately to the southwest. Late-stage syenitic dikes crosscut layering and are most abundant in the gabbroic rocks.

Surrounding the complex is an amphibolitic contact aureole in the host pelites. The aureole is estimated to be 50 to 150 metres wide with hornfels extending beyond that. Recrystallization of Lay Range metasediments and metavolcanics has formed a mineral assemblage of hornblende, plagioclase and quartz with minor amounts of biotite and potassium feldspar. Locally, at the south end of the of the intrusion, porphyroblasts of andalusite are formed in carbonaceous schists in contact with the complex.

Structurally, the ultramafite sits in a fault-bounded block of metasediments. The major regional fault trend is northwest with subvertical southwest dips. Faulting postdates emplacement of the complex and has left it an allochthonous, rootless sill. Movement has been dextral along the faults with some east-vergent thrusting associated with tectonic emplacement of Quesnellia against

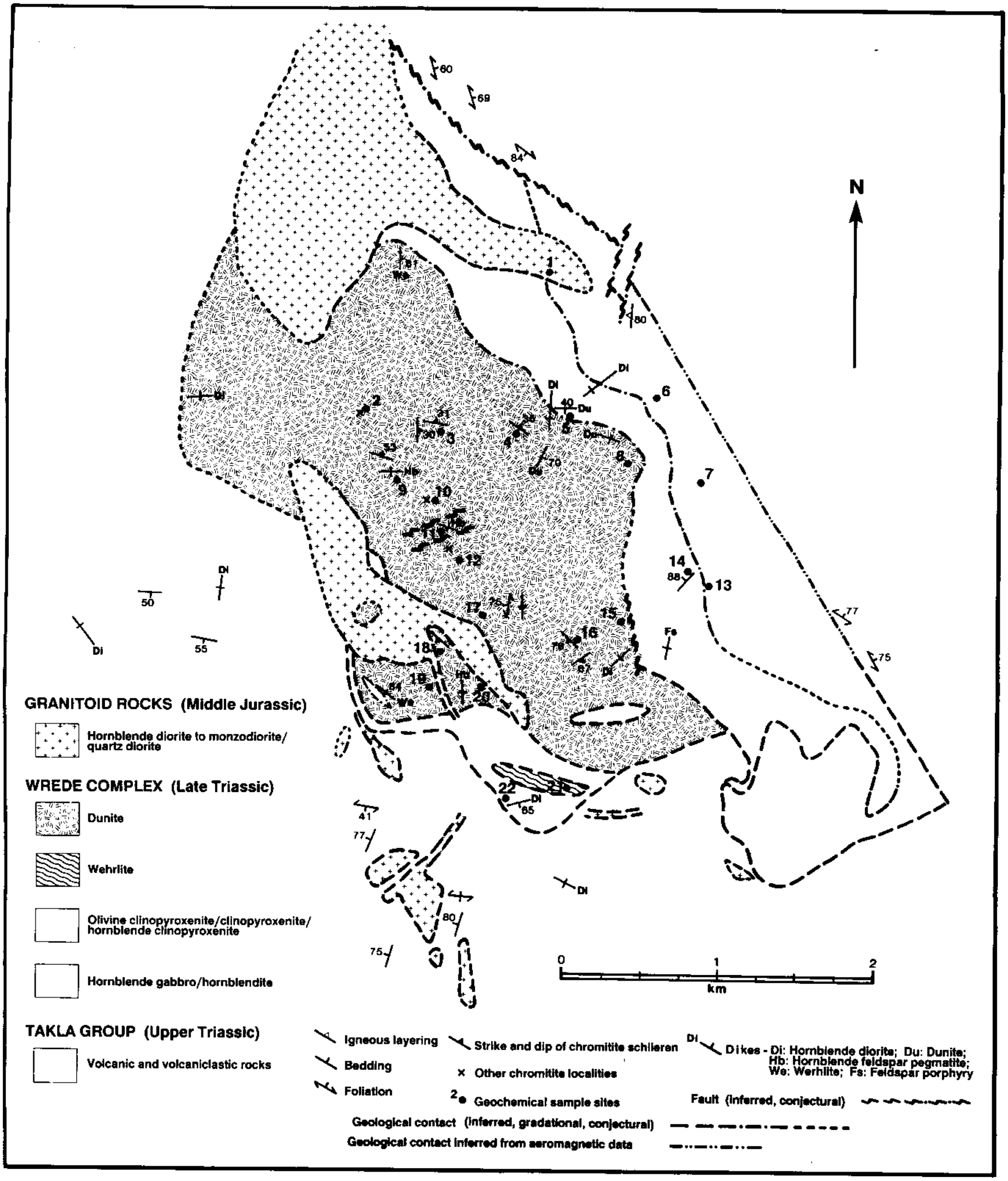


Figure 15. Geology of the Wrede Creek Ultramafic Complex (from Hammack *et al.*, 1990).

North America. The complex itself has been partially disrupted by the faulting but it is not severely dismembered, (geology after Nixon, *et al.*, 1990).

Mineralization within the Polaris complex consists primarily of chromite with associated platinum group elements and rare sulphide concentrations. Sulphides present are net-textured pyrite and some pyrrhotite that occur in a very few localities in the centre of the intrusion, hosted by clinopyroxenite. The presence of magmatic sulphides is unusual in British Columbian Alaskan-type intrusions.

Chromite occurs exclusively within the dunitic part of the complex and the general content of chromite is about 1 per cent. Some small disseminations have been identified in wehrlite immediately adjacent to dunite. Locally, chromite is concentrated in small pods, lenses, stringers and schlieren of fine to medium-grained crystal aggregates and disseminations. The chromitite zones are widely spaced and generally less than 1 metre long and 0.5 to 4 centimetres wide. The largest single zone was identified by Roots (1954) and is 3.7 metres long and 13 centimetres wide. Locally, a few blocks of chromitite in dunite, up to 30 centimetres across, have been found in float. Undeformed chromitite zones are characteristically lensoid in shape with the maximum curve on the lower side, relative to the original sill bottom, and taper to a thin edge. Roots described these shapes as 'festoons'. However, most chromitite concentrations are distorted into irregular shapes due to remobilization by mechanical processes such as slumping of the cumulates during the early stages of the formation of the sill. Unfortunately, this remobilization of the chromitites has had a detrimental effect on the mineral potential of the complex. The dispersion of chromitite and its related platinum group elements has greatly reduced the potential for any major accumulations as shown by the fact that none have been identified to date even after detailed mapping (G.T. Nixon, personal communication, 1990).

Platinum group elements are intimately associated with chromite mineralization. Lithogeochemical and soil geochemical analysis by Nixon *et al.* (1990), Johnson R.J. (1987), Johnson, D. (1987) and Page (1986b) have all found general, slightly elevated platinum group element levels with spot highs within the complex. Palladium, irridium, osmium and ruthenium are only found at slightly above detection limit values. Gold is largely absent in the ultramafite but some anomalous values have been detected in its contact aureole.

Exploration for platinum group metals in the Polaris complex has been brief and recent. Claims were staked in 1985 and 1986 with follow-up reconaissance geochemical and prospecting programs. The results were not encouraging and the claims were allowed to lapse (Johnson, D., 1987; Johnson, R.J., 1987). The area has been mapped regionally by Lay (1932), Roots (1954) and Irvine (1974b) and in detail by Nixon *et al.* (1990).

WREDE CREEK COMPLEX

NIK Claims
MINFILE: 094D 026 NMI: 94D 09 Cu1
LAT: 56°40'20" LONG: 126°08'00"

The Wrede Creek complex is 8 kilometres north-northeast of Johanson Lake and 280 kilometres north-northwest of Fort St. James. It is a layered Alaskan-type mafic-ultramafic intrusion that is elongate north-northwesterly, 5 kilometres long and 2 kilometres in maximum width (Figure 15). Mineralization consists of chromitite with associated platinum group elements in dunite. Exploration in the area has been primarily along the southern margin of the complex for porphyry copper-molybdenum mineralization. Other exploration in the complex has been cursory. The platinum group element potential has only recently been recognized and should be examined more closely (Hammack *et al.*, 1990).

The complex intrudes andesitic to basaltic tuffs, breccias and flows of the Mesozoic Takla Group. Potassium-argon dating of hornblende from the complex has yielded two Late Triassic ages of 219±10 (1) and 225±8 Ma (Wong *et al.*, 1985). Its northwest margin has been intruded by Middle Jurassic granitoid rocks associated with the Hogem batholith (Eadie, 1976). Regional metamorphism has altered the host Takla Group rocks to middle greenschist grade.

Mapping of the Wrede Creek complex by Hammack *et al.* (1990) suggests that it is a high-level stock, comagmatic and coeval with Late Triassic volcanism. The boundaries are poorly defined due to sparse outcrop although trenching and diamond drilling along the southern margin indicate a 30° to 40° southerly dipping contact.

The complex has a crude concentric zonation from a core of dunite through to an outer margin of hornblende gabbro, typical of other Alaskan-type intrusions. The core consists of medium-grained, equigranular massive dunite that is only slightly serpentinized, generally less than 5 per cent. Chemical analyses of the dunite show no zonation from the core to its contact with the clinopyroxenite zone. The clinopyroxenite grades from olivine rich through to hornblende-rich against the outer gabbro phases. It is generally coarse grained with a variable content of olivine and hornblende. This unit forms an almost continuous ring around the dunite core and varies in width from 50 metres in the south to 900 metres in the north. Hornblendite, hornblende gabbro and gabbro form the outer portion of the complex. Poor exposure along the eastern side allows only part of this unit to be examined. Contacts, where seen, show inner hornblende-dominant phases and the outer contact with country rocks is gabbro. Within the intrusion, inter-unit contacts are narrow gradational zones a few metres wide and intra-unit contacts are broad gradations. Contacts with country rocks are irregular and sharp. Serpentinization is weak and is developed primarily along fractures and some grain boundaries.

Surrounding country rocks have been metamorphosed to a broad hornblende hornfels aureole which is best exposed along the southern margin of the intrusion. Here it is 400 metres wide but the shallow dipping contact indicated by diamond drilling suggests that the true width is probably much less (Mustard and Wong, 1979). Elsewhere around the complex sparse outcrop information suggests the contact aureole is not as wide as in the south. Regional upper greenschist metamorphism postdates the intrusion of the complex and some retrograde metamorphic features are seen in the contact aureole.

Chromite mineralization is restricted to the core of the intrusion that is about 5 square kilometres in area. Chromite occurs as fine, disseminated grains with concentrations of 2 to 5 per cent, and in scattered locations as small massive pods, lenses and schlieren usually 1 to 15 centimetres across. These zones are scattered throughout the dunite core. There appears to be no structural control of the mineralization and there are large areas essentially barren of chromite. There appears to be no surface continuity of the chromitite mineralization and it has not been tested to depth.

Mapping and sampling by Hammack *et al.* (1990) has found that platinum is significantly enriched with chromitite mineralization. Five samples of higher grade chromitite yielded 120 to 2400 ppb platinum and all samples have high Pt:Pd ratios with some enriched in rhodium. To date there has been no significant private sector evaluation of the PGE potential of the complex. So far, mineral exploration has been for porphyry type molybdenum mineralization in the contact aureole at the southern margin of the complex. The NIK claims cover the aureole and some of the complex and have been most recently worked by BP Minerals Canada Inc. Some reconaissance geochemistry sample pulps from early exploration have been reanalysed for platinum and palladium but the results have not been encouraging (Hoffman and Wong, 1986).

MAFIC-ULTRAMAFIC-HOSTED NICKEL OCCURRENCES IN BRITISH COLUMBIA

SOUTHERN BRITISH COLUMBIA

ROSSLAND ULTRAMAFICS

MIDNIGHT
MINFILE: 082FSW118
LAT: 40°04′20″ LONG: 117°50′19″

IXL
Golden Drip
MINFILE: 082FSW116
LAT: 49°04′23″ LONG: 117°50′31″

VANDOT
Ivanhoe Ridge
JOB, ROSS, Mar Land
Skin, Ross, Cal
MINFILE: 082FSW130
LAT: 49°02′11″ LONG: 117°52′50″

The Rossland ultramafics are located approximately 7 kilometres southwest of Rossland. There are several bodies in the area, two of which have been explored for precious metals, base metals, platinum, chrome and nickel over the last century. The largest body lies roughly across Ivanhoe Ridge and is rhombic in shape with an area of about 7.5 square kilometres. The next largest body outcrops in Little Sheep Creek east of and on O.K. Mountain and is about 1 square kilometre in area (Figure 16). Exploraton for platinum, chromite and nickel has been sporadic.

The Rossland ultramafic bodies consist of pervasively serpentinized dunite, with an almost complete loss of primary mineralogy and textures. The ultramafics are located along the Rossland break which is an ancient regional fault. The boundaries of the ultramafic bodies are fault or shear zones with the Coryell intrusions truncating some of the contacts. The serpentinites are associated with the Mount Roberts Formation and have been assigned a Pennsylvanian age by Little (1982). The serpentinites are upthrust slices of an ophiolite sequence.

Mineralogically the serpentinites are massive antigorite with accessory magnetite. Narrow veinlets of chrysotile, 2 to 6 millimetres across, occupy joints and fractures (Stevenson, 1935). Relict olivine grains have been identified in thin section by Little (*ibid.*). No quartz-carbonate-talc retrograde alteration has been identified.

Chromite has been identified as small blebs, disseminations and stringers in the serpentinite. Spatially, the largest distribution of chromite occurs southwest of Sophia Creek on Ivanhoe Ridge. Selected samples from the area yielded assays of 30 per cent Cr_2O_3, 17 per cent Fe_2O_3 and 0.08 per cent TiO_2 (Morrison, 1979). Nickel values, contained in nickeliferous chrome spinel and magnetite are low, ranging from 0.16 to 0.23 per cent. Some selected rock samples have assayed up to 0.45 per cent nickel with some contained millerite. A representative suite of 10 serpentinite samples averaged 0.24 per cent nickel (Fyles, 1984). What was probably selective sampling of serpentinite for platinum returned an assay of 1.02 grams per tonne (Addie, 1973). Subsequent work by other companies has failed to reproduce the platinum results.

Exploration for chromite, nickel and platinum group elements has not been extensive in the Rossland mining camp. Most recently, in the late 1970s and early 1980s, the majority of the work has been done by small operators.

BRIDESVILLE - ROCK CREEK AREA

OLD NICK
Nickel
Mission I
MINFILE: 082ESW055 NMI: 82E/3W Ni 1
LAT: 49°02′30″ LONG: 119°06′10″

The Old Nick nickel showings are 4 kilometres east-northeast of Bridesville, astride the old Great Northern Railway grade. The showings have been prospected for nickel and precious metals and development includes trenching, shallow shafts and diamond drilling.

The showings occur in rocks of the Anarchist Group. Mapping has identified seven map units that trend roughly east-northeast. First is fine to medium-grained biotite schist with quartzite layers that form up to 15 per cent of the rock. The included quartzite occurs as either 2 to 30-centimetre or 3 to 4-metre layers. The mineral assemblage includes biotite, quartz, plagioclase with minor hornblende, tourmaline and sphene. The second unit is a metasediment, with minor layers of epidote and zoisite, estimated to be 122 metres thick. The metasediment is essentially massive tremolite with remnant pyroxene and includes minor amounts of sericite, chlorite and chrome mica (Cr-phengite). It carries disseminated pyrite, usually 1 to 2 per cent and locally occurs in zones of up to 20 per cent. This unit contains the majority of the nickel

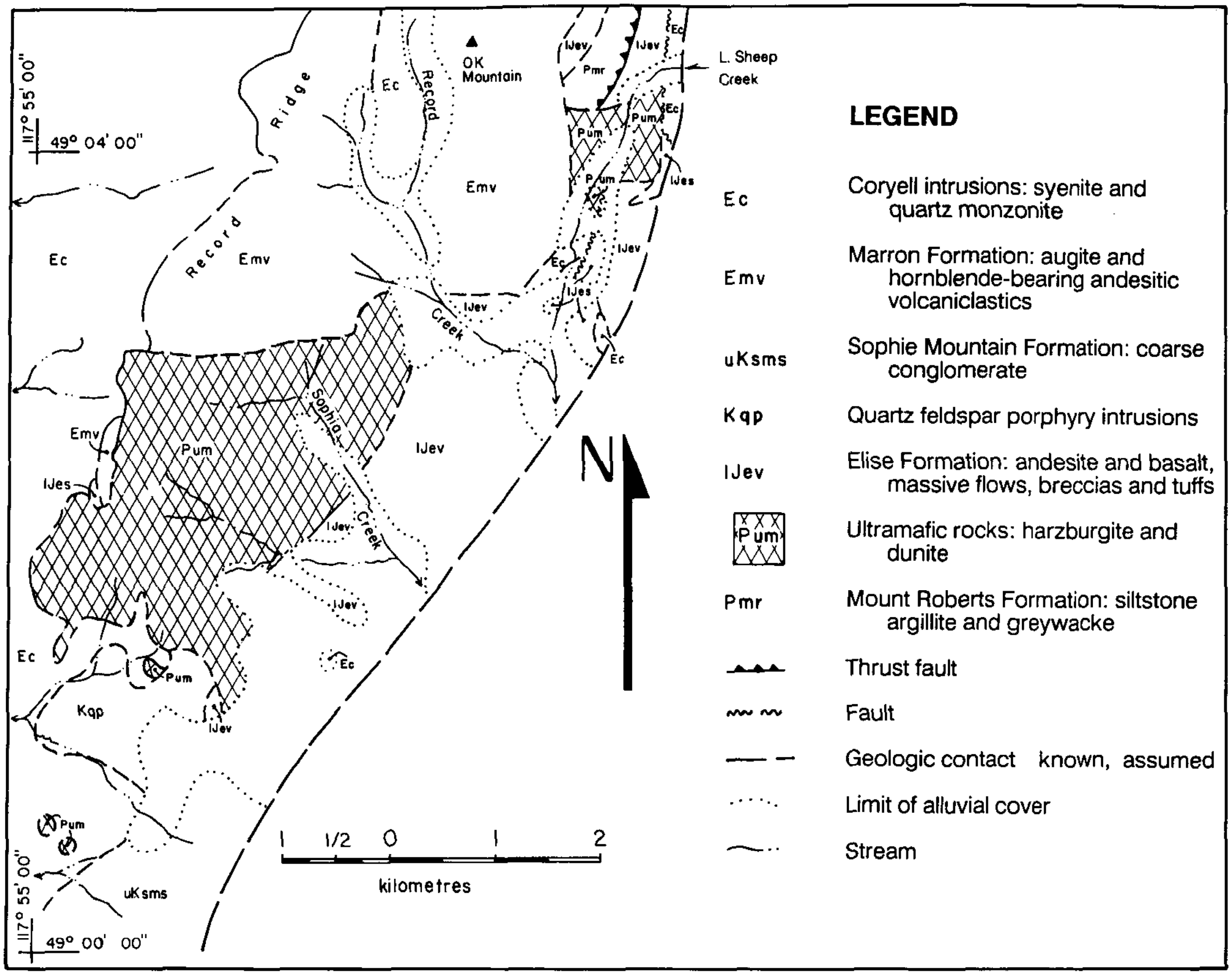


Figure 16. Regional geology of the Sophia Creek area and the Rossland ultramafic bodies (after Little, 1982).

mineralization. Third is a quartzite and schist unit, similar to the first, however, here the quartzite forms 60 per cent of the rock. Fourth is a massive greenstone that is probably metavolcanic rock. Fifth is a banded quartzite that contains thin layers of biotite and chlorite. Finally, there are two altered ultramafic units. Both are comprised of antigorite with accessory talc, anthophyllite and tremolite. The protolith has been identified as dunite. The rocks are massive and contain some disseminated pyrite, pyrrhotite and pentlandite. The serpentinite has been divided into two units, based on crosscutting relationships, as 'sills' and 'dikes'. The dikes follow northwest-trending interconnected fracture zones that cross stratigraphy. The serpentinite occurs in the thick metasediments (Unit 2) as zones 0.10 to 10 metres thick (Coope *et al.*, 1968; Eastwood, 1968). These serpentinites may actually be thin fault slices of ultramafic material; this would be more consistant with the regional occurrence of serpentinite in the area.

The layered rocks are folded into a subhorizontal antiform with the axial plane trending east-northeast and dipping about 30° south. Minor folds are open with a 35 to 50 centimetre wavelength and superimposed centimetre-scale crenulations indicating upright tops. Subvertical faults transect the property. The major set strikes west-northwest, controlling the serpentinite emplacement. A second set strikes northeast and offsets the earlier major faults and serpentinite.

Nickel is associated with pyrrhotite and pentlandite. These sulphides are found as widely spread disseminations in the serpentinite and the major metasedimentary (Unit 2) package. Pentlandite has been identified as microscopic grains intergrown with pyrrhotite and pyrite. There is no correllation between pyrite and nickel mineralization. Diamond-drill core assay results show a range of 0.01 to 0.15 per cent nickel in the serpentinite. Assay results from the metasediment (Unit 2) package range from 0.07 to 0.26 per cent nickel (Coope *et al.*, 1968). The mineralized area examined measures approximately 800 by 120 metres, following the metasediment (Unit 2) package and nickel content is fairly uniform throughout averaging 0.15 to 0.20 per cent.

Exploration of the Old Nick showings has been ongoing for many years. The original claims were staked in 1955 and prospected for several years. They were allowed to lapse and the ground was restaked in 1966 as the Old Nick Group. Aggressive programs of diamond drilling, trenching, mapping, geochemical and geophysical surveys were executed by Utica Mines Ltd., Copper Ridge Mines Ltd. and Newmont Mining Corporation of Canada Limited between 1966 and 1968. The work outlined a potential low-grade nickel reserve. Metallurgical testing of the metasediment in 1968 yielded nickel recoveries of 56 per cent. At that time, Newmont Exploration Ltd. decided the property was uneconomic and dropped its option. Subsequently, various operators have done reconnaisance geochemical, geophysical and radiometric surveys as well as extensive prospecting through to 1989. The showings have been variously staked as the Nickel and the Mission I claims, but at the time of writing, the showings are unstaked.

Vancouver Island

TOFINO NICKEL GROUP

Job, Lorne, Nickel, Super
MINFILE: 092F 029
LAT: 49°14'28" LONG: 125°35'25"

The Tofino nickel showings are at the head of Tofino Inlet, approximately 25 kilometres east-northeast of Tofino. The claims cover a southeast-facing slope, west of Tofino Creek and north of Similar Island. Exploration of the nickel showings has been done in conjunction with exploration of nearby iron-copper-molybdenum skarns known as Hetty Green, Jumbo, White and Copper King (Hancock, 1988).

The hostrocks for the nickel showings are quartz-feldspar gneisses of the Paleozoic Sicker Group. The protolith is determined to be interbedded sandstones and mafic tuffs correlated with the Myra Formation. The gneiss is shot through with amphibolite dikes, thought to be metamorphic equivalents of mafic and ultramafic Karmutsen dikes and sills as well as some relatively unaltered pyroxenites and peridotites. To the north and east metabasalts bound the quartz feldspar gneiss. Contained in the metabasalts are limestone and marble layers, possibly of the Mount Mark Formation (Buttle Lake limestone). All units are truncated to the south by a diorite of the Island plutonic suite of Jurassic age. The hostrocks are variably foliated and show warping due to regional deformation. Associated joints and the foliation trend 125° to 145° with subvertical dips (Muller, 1980; LeCouteur, 1985; Lambert, 1988).

The main nickel showing is an elongate southeast-trending ultramafic sill exposed over an area of 30 by 10 metres, that was intruded into quartz feldspar gneiss. Mineralization consists of a variety of sulphides that form 1 to 5 per cent of the rock as disseminations or 15 to 50 per cent as massive pods, laminations and dense disseminations in the ultramafite. The relative abundances are: pyrite, 75-95 per cent; chalcopyrite, 2-5 per cent; violarite, 2-3 per cent; millerite, 2-5 per cent; pentlandite, 9 per cent and pyrrhotite, trace (LeCouteur, 1985). A grab sample of well mineralized rock assayed: gold, trace; silver, 48 grams per tonne; platinum, trace; palladium, 6.2 grams per tonne; copper, 3.6 per cent and nickel, 3.55 per cent (Eastwood, 1963). Later analyses are in the range 0.02 to 4.30 ppm for platinum and 0.02 to 15.40 ppm for palladium. The Pd:Pt ratio is approximately 5:1. Palladium is contained in a species of merenskyite [$Pd(Te,Sb)_2$; TeSb]. Microscopic analysis indicates that the violarite is

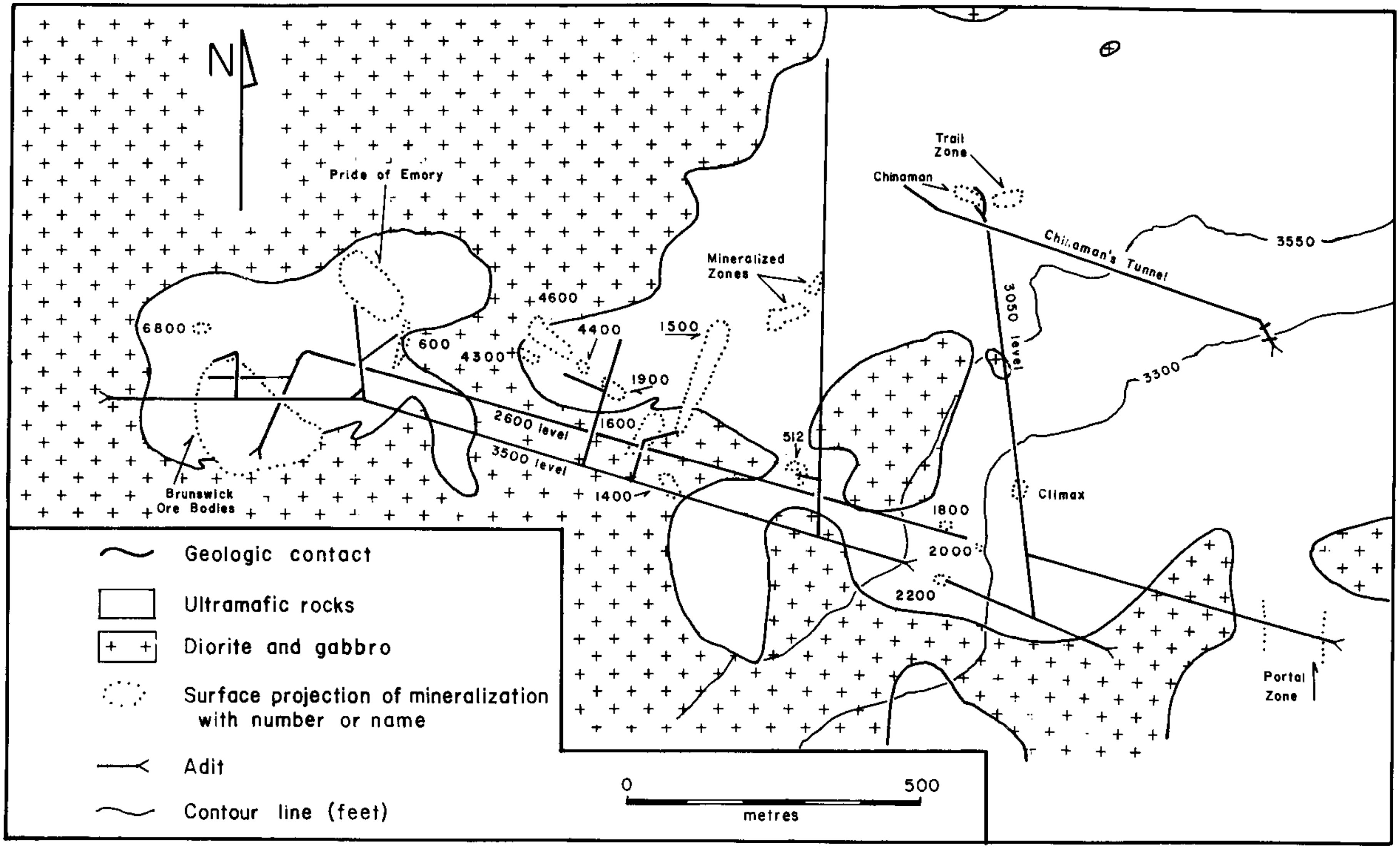


Figure 17. Map showing surface geology and surface projections of ore bodies and underground workings of the Pacific Nickel (Giant Mascot) nickel-copper mine (after Anonymous, 1965).

secondary after pentlandite. No platinum minerals were found but it is probably associated with the nickel or copper sulphides and possibly with the merenskyite (LeCouteur, 1985).

Initial exploration in the area was for copper-iron skarns along Tofino Creek, beginning in 1898. The work led to the staking of the Hetty Green, White and Foremost showings and prospecting has continued through to the present. Sun West Minerals Limited staked the Foremost claims in 1962 and subsequent work resulted in the discovery of the nickel showings in 1963 on the northwest shore of Deer Bay. Most of the exploration work, however, was directed at the skarn mineralization. In 1983, until 1987, Cominco Limited held the claims covering the nickel showings under option and did extensive geological mapping, rock and soil geochemical and geophysical surveys, trenching and detailed petrographic analysis. Most recently, Stag Explorations Ltd. has continued the geochemical, geological and geophysical exploration and evaluation of the nickel and platinum group element potential.

HOPE AREA

PACIFIC NICKEL MINE

(Giant Mascot)
Pride of Emory (L. 739)
B.C. Nickel mine
Western Nickel
MINFILE: 092HSW004 NMI: 92H/5 Ni1
LAT: 49°28′42″ LONG: 121°30′54″

The Pride of Emory - Pacific Nickel mine is located at the head of Texas Creek, approximately 12 kilometres north of Hope on the west side of the Fraser River. Access is by good mine road from the TransCanada Highway. The mine operated during the period 1958 to 1974 and is presently undergoing re-evaluation by Corona Corporation. The mine produced nickel and some associated copper.

The Pride of Emory mine developed sulphide mineralization in a Middle Cretaceous ultramafic intrusion hosted by metasediments (Figure 17). The metasedimentary package consists of amphibolites with a protolith of marine cherts and pelagic sediments of the Triassic Hozameen Group. Immediately north, east and south, the ultramafite is truncated by diorite of the Late Cretaceous Spuzzum intrusions. Potassium-argon dating has placed the ultramafite at 119 to 95 Ma and the adjacent Spuzzum intrusions at 79 to 89 Ma (McLeod *et al.*, 1976).

The host to mineralization is a multiphase ultramafic intrusion and has been classed as a layered intrusion. The major intrusive phases include a core of peridotite, harzburgite/dunite, and a rim of olivine-pyroxenite, separated by a bronzite which grades outward to hornblende-pyroxenite, with minor phases of gabbro. Alteration, seen as orthopyroxene and olivine grains with hornblende rims or total replacement, occurs in an annulus 100 metres wide around the ultramafite. This appears to be the result of a late-stage magmatic process, probably associated with the Spuzzum intrusions. The principal alteration type is uralitization, alteration of pyroxene to actinolitic hornblende, in pegmatitic zones along the contact with the Spuzzum intrusions. Locally peridotite has been pervasively altered to serpentinite, up to 50 per cent by volume, but serpentine is generally much less abundant. Some serpentine-talc-magnetite-carbonate-anthophyllite alteration is present along shear zones and joints and is often referred to as 'crumbly alteration'. Much of this is attributed to late-stage near-surface low-temperature alteration by meteoric water (Aho, 1956).

The ultramafite is extensively fractured and faulted with displacements generally small, commonly a few metres but occasionally several tens of metres (Aho, 1957). Detailed mapping has defined three sets of fractures at the following orientations:

Set	Orientation
X	350°/40°E
Y	035°/80°NW
Z	318°/55°W

The fracture sets appear to be genetically related; at any specific location, one fracture set is well developed and the other sets are poorly developed. The diorite dikes follow the 350° fractures and hornblendite dikes follow the 318° fractures (Aho, 1956).

Three types of sulphide mineralization are present within the intrusion; massive sulphides, zoned sulphides and vein sulphide. Massive sulphide mineralization is restricted to dunitic pipes which generally follow a trend of 285° and plunge steeply to the northeast. The pipes are irregular in shape, varying from crescentic to ellipsoidal in cross-section, 15 to 40 metres across with a vertical extent of five to ten times the diameter. There are few surface exposures of the pipes and they are not connected. Exploration and development required detailed drilling as most of the known mineralized zones are blind. This has made resource evaluation difficult as there are no obvious clues to the location of mineralized pipes.

Zoned sulphide mineralization is also restricted to pipelike bodies. Silicate zonation within these pipes usually consists of a dunitic core with bronzite rims. These pipes are generally regular in cross-section and similar in diameter to the massive pipes and may extend up to 400 metres vertically. Sulphides form concentric rings and the zoning pattern is complex. Occasionally, veinlike sulphide bodies, up to 0.5 metre wide, are found with pyroxenite or hornblendite borders, suggesting either late-stage magmatic injection or secondary remobilization of the sulphides.

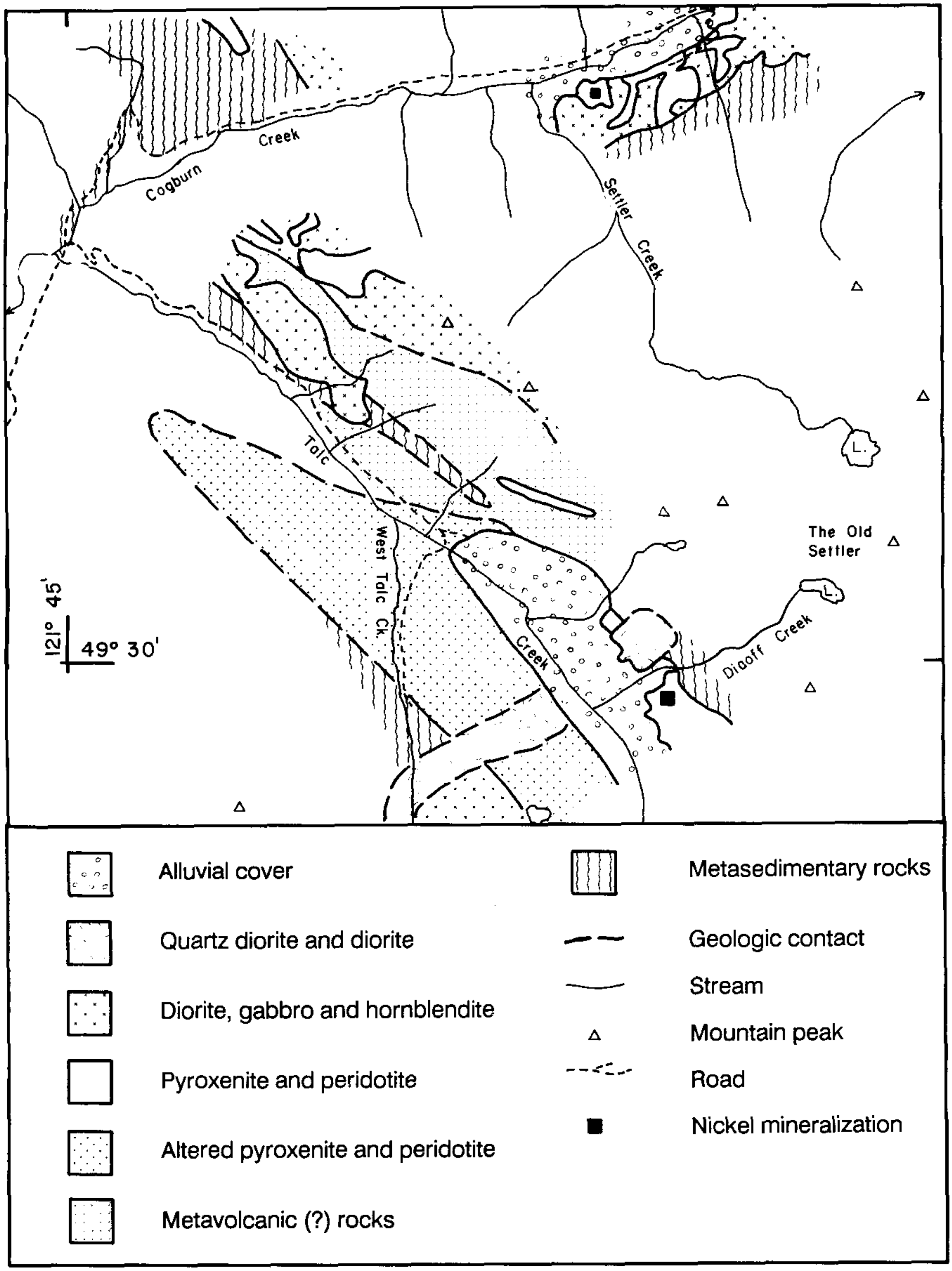


Figure 18. Geology of the Diaoff and Settler Creek area showing locations of nickel mineralization (after Eastwood, 1971).

Ore consists of nickeliferous pyrrhotite, pentlandite, violarite after pentlandite and minor amounts of pyrite and chalcopyrite. The most significant metal present is nickel with copper forming a minor constituent. Platinum and palladium are present in low concentrations but did provide a small production credit. Typical mineralization and ore grades are described below:

Mineral	Disseminated Ore Ore:Gangue 1:3	Massive Ore >60% of rock
Pyrrhotite (nickeliferous)	45%	55%
Pentlandite	25%	30%
Violarite	10%	—
Pyrite	10%	10%
Chalcopyrite	5%	5%

(Clarke, 1969)

Ore Grades:

	1.4% Ni	Ni/Cu = 2.7
	0.5% Cu	
	1.0% Cr	
	0.1% Co	
	0.68 g/t Au	
	0.34 g/t PGM	
for the 1500 body, 1966	2.05 g/t Pt	
	7.20 g/t Pd	
	0.90% Cu	
	2.6% Ni	

(Eastwood and Waterland, 1966)

Nickel primarily occurs substituting for iron in pyrrhotite ($Fe_{1-x}NiS$) with an average replacement of 2 per cent. In the 1600 orebody the nickel content in pyrrhotite was 13 per cent, the approximate limit of nickel solubility (Aho, 1956). The Ni:Cu ratio varies with the host silicates. In dunite the ratio was as high as 4 and as low as 2.5 in olivine pyroxenite and bronzite. Chalcopyrite tended to occur along the margins of orebodies, lowering the Ni:Cu ratio. Mineralization in the hornblendite is erratic and generally limited to disseminated sulphide grains and blebs with a very low Ni:Cu ratio. Chromite occurs as discrete, disseminated grains throughout the peridotite and pyroxenite with concentrations of usually less than one per cent (Aho, 1956).

The Pride of Emory deposit has had a long history. The original showings were staked and prospected in 1923 by Carl Zafka. In 1926 the B.C. Nickel Co. Ltd. staked more ground and began underground development. Development continued through to 1938 until poor market conditions forced the closure of the prospect. Developed reserves at that time consisted of 1.08 million tonnes containing 1.38 per cent nickel and 0.5 per cent copper. In 1952, Newmont Mining Company and Pacific Nickel Mines Ltd. formed Western Nickel Mines Ltd. to reopen the workings and drive the 2600 main haulage level and other adits. Mine and mill development proceeded to 1958 when commercial production began. Giant Mascot Mines Ltd. purchased Newmont's 51 per cent interest in 1959 and bought out the Pacific Nickel Mines Ltd. 49 per cent share in 1961. Production continued from 1959 to 1974 during which time 26 orebodies were mined to produce 26.8 million kilograms of nickel, 14 million kilograms of copper from 4.2 million tonnes of ore having a millhead grade of 0.77 per cent nickel and 0.33 per cent copper (Christopher, and Robinson, 1974). Mining was by long-hole stoping methods with a mix of tracked and trackless equipment. The economic limit of mining was reached in 1974. 'Reserves' in place at that time consisted of sixteen mineralized bodies totalling 2.72 million tonnes. The largest single body is the Portal zone containing 2.15 million tonnes with grades of 0.25 per cent nickel and 0.11 per cent copper. The total of the other bodies is 568 000 tonnes with an average grade of 0.92 per cent nickel and 0.37 per cent copper (Christopher, 1975). Corona Corporation presently owns the mine and has been re-evaluating its potential.

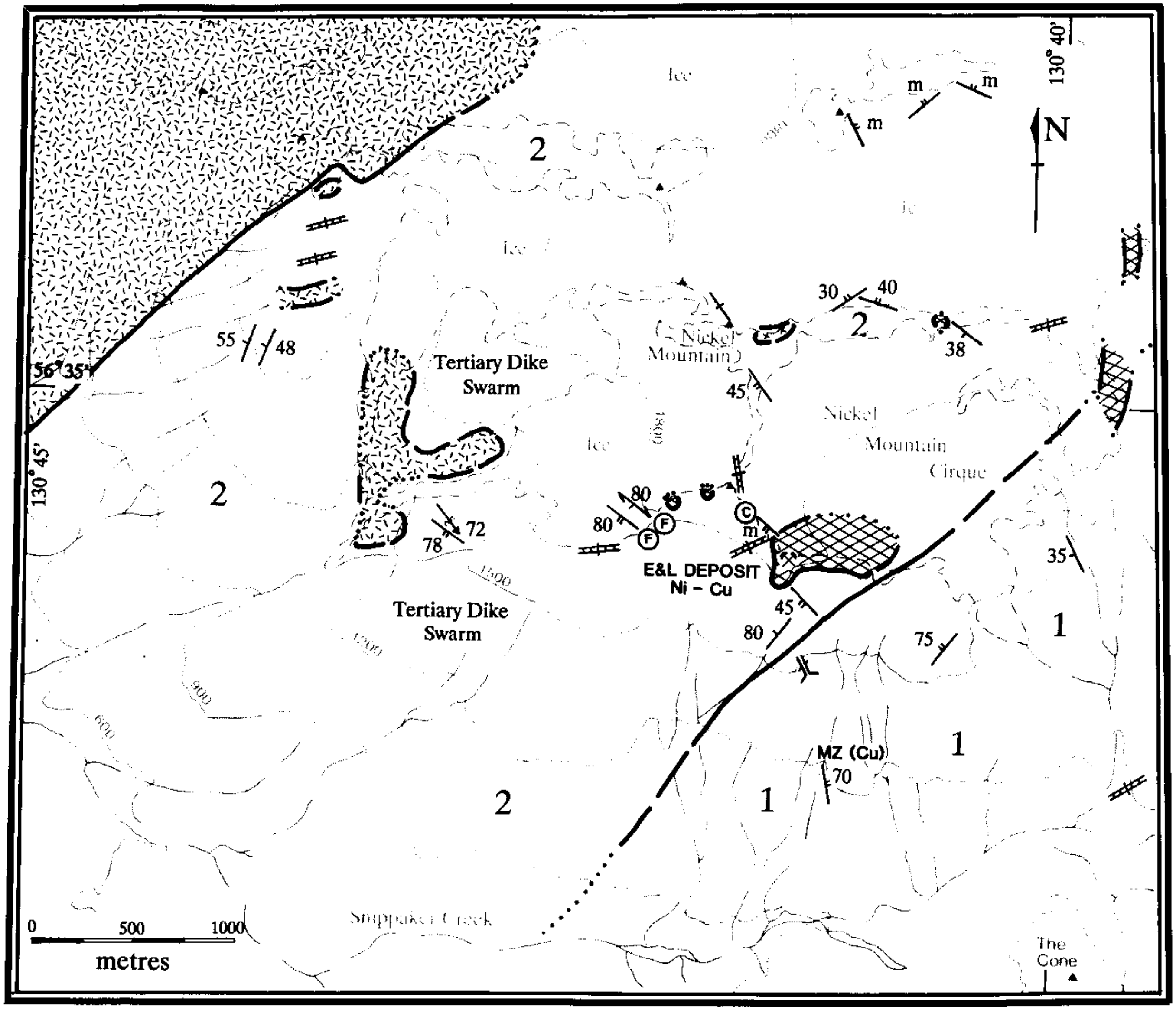
NI GROUP

Settler Creek
Diaoff Creek
MINFILE: 092HNW042, 045
LAT: 44°33'23" LONG: 121°40'12"

The Settler Creek and Diaoff Creek showings are hosted by extentions of ultramafic rocks northwest from the Pacific Nickel mine. The Settler Creek showing is immediately east of the confluence of Cogburn Creek and Settler Creek on the lower hill slope. The Diaoff Creek showing is on the southeast bank of Diaoff Creek on the southwest slope of the Old Settler. These prospects were discovered during regional exploration in the early 1970s in an attempt to extend the life of the Pacific Nickel mine. The two showings are the largest found in the area were too small to warrant development at that time.

Country rocks to the intrusions are metasediments, comprising Permo-Pennsylvanian quartz-muscovite-garnet schists, and metavolcanics consisting of hornblende and hornblende-feldspar schists (Monger, 1970). The regional foliation varies from 320°/45°NE to 290°/85°NE and is generally parallel to layering although some foliation across layering suggests isoclinal folding (Eastwood, 1971). These rocks are intruded by quartz diorite plugs and dikes associated with the Spuzzum intrusions and serpentinized pyroxenites and peridotites probably associated with the Pacific Nickel intrusion (Figure 18).

The felsic intrusive rocks are only seen in contact with the metamorphic rocks, although exposure is very poor. The ultramafic rocks intrude both the metasediments and metavolcanics. The largest body, composed of generally undeformed pyroxenite, extends southeasterly along the northern slope of Talc Creek. However, at its southeastern end the rock is more sheared and altered. The sheared zone consists of 85 per cent pyroxenite and



LEGEND

TERTIARY

Medium-grained, grey diorite dikes and small plugs (?), 1 to 10 metres across.

MIDDLE JURASSIC TO MIDDLE CRETACEOUS

NICKEL MOUNTAIN GABBRO

Medium to coarse-grained olivine gabbro; composed of plagioclase, pyroxene and olivine. Orbicular textures are present in both pyroxene and plagioclase.

JURASSIC

LEHTO PORPHYRY

Medium to coarse-grained quartz monzodiorite; composed of white plagioclase, pink potassium feldspar, grey quartz, black hornblende and minor biotite. Locally, the potassium feldspar phenocrysts are up to 3 centimetres long. The border phase is commonly a grey/green diorite.

LOWER TO MIDDLE JURASSIC

SALMON RIVER FORMATION

2 Rusty weathering, black, well-laminated, very fine grained argillaceous sandstones, siltstones and mudstones. Locally contains small lenses of limestone-chip breccia. The basal calcareous grit and limestone are not present. Ammonoid fossils are present but not abundant.

BETTY CREEK FORMATION

1 Felsic to intermediate volcanics; light to medium green, dacitic ash tuffs and lapilli tuffs, commonly plagioclase porphyritic. Contains interbeds of black siltstone and very fine grained sandstone. Also contains some hematitic clastic layers.

SYMBOLS

Contact (known, approximate, assumed)
Bedding (tops known, tops unknown, vertical)
Mineral prospect
Mineralized showing — MZ (Cu)
Macrofossil sample location — Ⓕ
Conodont sample location — Ⓒ
Adit
Stream
Contour (in metres) — 1800
Peak
Permanent snow/ice boundary

Figure 19. Interpreted geology of the Nickel Mountain area and the E&L nickel-copper showings (from Hancock, 1990).

15 per cent tremolite, talc and chlorite, generally concentrated along fractures and shear zones. Mineralization consists of about 1 per cent pyrrhotite and trace chalcopyrite.

The Diaoff Creek intrusion is further to the southeast. It is partially exposed on the south side of the creek. The body consists of pyroxenite and peridotite that is only slightly altered. Mineralization identified on surface and in drill holes consists of pyrrhotite up to 4 per cent with trace chalcopyrite and pyrite. Sulphides occur primarily along fractures, joints and shear zones in the ultramafic rock. Samples of mineralized rock returned assays of 0.19 to 0.22 per cent nickel and trace copper (Eastwood, 1971).

The Settler Creek showings are very similar to those at Diaoff Creek although more gabbro and diorite are present. Sulphides occur along fracture and shear zones in the ultramafite. Assays are similar to those at Diaoff Creek. The body is poorly exposed and its full extent is unknown.

Regional exploration began in 1969 as mineable reserves at the Pacific Nickel mine were approaching depletion. Extensive geochemical and rock sampling programs were followed by diamond drilling at favorable locations. Exploration continued through to 1975 but did not locate any promising showings. Since that time most of the original NI-numbered claims have been allowed to lapse. The Diaoff Creek showing is covered by the NI 752 claim and the Settler Creek showing is unstaked at the time of writing. Only minor amounts of prospecting have been done since 1975.

Central and Northern British Columbia

SOVEREIGN

Sovereign Mountain
Dodo Creek
MINFILE: 093A 013
LAT: 52°59′15″ LONG: 121°51′46″

The Sovereign nickel occurrence is on the southwest flank of Sovereign Mountain, about 35 kilometres east of Quesnel. Access is by the Swift River forestry road. It is covered by are the WIM, WIM-TA, and TOM claim groups owned by Trifco Minerals Ltd. (Trifaux, 1986).

The basement geology consists of three units, described from west to east. The first are Late Triassic phyllites and argillites of the Quesnel trough. These sit unconformably over ultramafic rocks of the Mississippian to Permian Crooked amphibolite of the Slide Mountain terrane which are thrust over undivided quartzites, phyllites and limestones of the Hadrynian to Paleozoic Ramos succession in the Barkerville terrane. Locally, folding has caused repetition and thickening of beds. The area is heavily mantled by Quaternary alluvium (Struick, 1988).

Nickel and talc mineralization are localized in sheared ultramafic rocks. Exploration to date has identified a small reserve of good quality talc (MacLean, 1988); nickel mineralization is minimal. It has been identified in sulphide form as pentlandite finely disseminated throughout the ultramafics. Investigation of the talcose rock indicates total sulphide content reaches a maximum of 2 per cent. Seventeen undocumented grab samples from the claims averaged 0.22 per cent nickel with a range of 0.15 to 0.26 per cent, these however probably represent selected samples (Findlay, 1971). Seven other representative ultramafic samples collected in 1971 indicated nickel values of 0.11 to 0.20 per cent (*ibid.*). Geochemical and chip sampling in 1972 detected only spot anomalies of nickel and further exploration was not recommended (Sinclair, 1972). Analyses of talc concentrates returned 0.08 to 0.15 per cent nickel. Testing of flotation and magnetic separates of nickel from talc indicated a maximum recovery of 33 per cent (DeGraff, 1988).

E & L

Nickel Mountain
MINFILE: 104B 006 NMI: 104B 10 Ni 1
LAT: 56°34′41″ LONG: 130°41′35″

The E & L deposit, the second largest nickel resource in British Columbia, is located on Nickel Mountain in the Iskut River district north of Stewart. Nickel Mountain is situated in the headwaters of Snippaker Creek (Figure 21) 27 kilometres east-southeast of the Bronson Creek airstrip and 300 kilometres northwest of Smithers. The deposit consists of pyrrhotite, pentlandite and chalcopyrite hosted in an olivine gabbro stock that intrudes Lower Jurassic sediments and volcanics. Exploration has identified 2.9 million tonnes grading 0.80 per cent nickel and 0.62 per cent copper with anomalous values in gold, silver and platinum group elements (Quartermain, 1987; Sharp, 1968). Fieldwork for the present study was completed in 1988 and 1989 as part of an ongoing regional mapping project in the Iskut-Sulphurets area.

The Nickel Mountain stock crops out at 1850 metres elevation along the crest of a steep ridge sloping south toward Snippaker Creek and continuing northward as a series of razorback ridges around glaciers and snowfields (Figure 19). Regionally, strata trend northeast with gentle to moderate northwest dips. The Nickel Mountain gabbro intrudes a thick sedimentary and volcanic sequence of the Lower Jurassic Hazelton Group. A large monzodiorite pluton intrudes the volcanosedimentary package 3 kilometres northwest of the deposit. Regional deformation postdates the pluton. Late postdeformation mafic dikes crosscut all rocks in the area.

Sedimentary strata hosting the mineralized gabbro stock are black, laminated shales of the Lower to Middle Jurassic Salmon River formation (Hancock, 1990). The basal calcareous grit and fossiliferous limestone member of the Salmon River formation type-section has not been identified in the Nickel Mountain area (Alldrick, 1985; Alldrick *et al*; 1987). A thick sequence of felsic to intermediate volcanics and thin interbedded sediments underlies the Salmon River formation. The package consists primarily of dacitic ash tuffs and lapilli tuffs, commonly plagioclase porphyritic. Thin sedimentary units are distributed randomly throughout the volcanics. This volcanic sequence can be correlated with the Lower Jurassic Betty Creek formation (Hancock, 1990).

The Nickel Mountain gabbro is a unique lithology in the Stewart-Iskut district. The gabbro intrusions consist of four small plugs less than 100 metres wide at surface, one large stock approximately 800 metres across and a dike swarm approximately 250 metres wide, all occurring along a 3-kilometre northeast trend. The large stock and dike swarm may be connected as they are separated by a large ice-filled cirque. The stratigraphic and structural evidence suggests the intrusion of the gabbro, and related mineralization, postdates the Lower to Middle Jurassic sediments and predates the mid-Cretaceous deformation. This brackets the age of intrusion at 185 to 110 Ma, suggesting it is unrelated to the main Lower Jurassic and mid-Tertiary plutonic suites of the region and that the extensive Jurassic Bowser Basin stratigraphy to the east may be prospective terrain for similar deposits.

A large pluton of porphyritic quartz monzodiorite, the Jurassic Lehto porphyry, truncates sedimentary strata of the Salmon River formation north and northwest of Nickel Mountain. The porphyry is typically medium to coarse grained with white plagioclase, pink potassium feldspar, grey quartz, black hornblende and lesser biotite. Medium-grained diorite dikes crosscut all other units in the area and are most probably Tertiary in age. They are typically rusty weathering, dark grey diorites, 1 to 10 metres wide.

Regional deformation has been dated at approximately 110 Ma in the Stewart area (Alldrick *et al.*, 1987). At Nickel Mountain there is a general northeast-southwest shortening; sediments have taken up most of the stress in open cylindrical folds. Stereonet plots indicate one phase of folding with an axis of 15°/305° and an axial plane of 126°/80°SW. Weak penetrative axial planar cleavage is present in the fine-grained sediments. Volcanic units are block faulted with individual blocks generally undeformed. Interbedded sediments show small-scale folding. Tertiary northwest-southeast extension controlled intrusion of the diorite dikes.

Nickel and copper sulphide mineralization occurs exclusively within the central gabbro body. At surface there are three major mineralized zones. The Northwest and Southeast zones are the most significant; both are roughly triangular with dimensions of 60 x 45 x 45 metres. The East zone is considerably smaller and less continuously mineralized than the other two. Surface and underground drilling indicate an irregular pipelike, possibly interconnected, form to the three zones at depth (Jeffery, 1966). Structural data collected by Sumitomo Metal Mining Corporation indicate a steep southwest plunge to the mineralized pipes (Hirata, 1972). Vertical extent of the mineralization has been proved to a depth of 210 metres and the zones remain open laterally and to depth.

Mineralization is localized along the margins of the intrusion as irregular pipelike zones of veins, disseminations and massive lenses. The mineral textures and spatial relationship of the sulphides to the gabbro indicate that the mineralization is magmatic. Pyrrhotite, pentlandite and chalcopyrite are the dominant sulphides with minor amounts of pyrite, magnetite and 'siegenite'. Nickel occurs predominantly in pentlandite, but it is also present in a secondary nickel sulphide with a composition between siegenite $(Co,Ni)_3S_4$, and violarite $(Ni,Fe)_3S_4$. Chalcopyrite shows minor supergene alteration where covellite locally forms rims around the chalcopyrite and occasionally completely replaces it. Trace amounts of cobalt, noted in assay results, probably occur in both the pentlandite, replacing iron, and the siegenite (Cabri, 1966). Gabbro within and around mineralized zones shows extensive alteration; olivine grains are partially or totally altered to serpentine, most plagioclase is altered and abundant chlorite, amphibole, biotite, carbonate, epidote and prehnite occur throughout the matrix (Hirata, 1972).

Alteration of the host sediments is limited to an aureole, less than 20 metres wide, of intense bleaching to a light green colour and partial loss of textures. Some previous mappers have misidentified these thermally altered sediments as either chert, siliceous tuffs or metadiorite.

Nickel Mountain was initially prospected in 1958 by Ed and Lela Freeze for the BIK syndicate (Silver Standard Mines Limited, Kerr Addison Gold Mines Limited and McIntyre Porcupine Mines Limited.) The E & L claims were staked at that time and geological mapping, geochemical sampling, hand trenching and packsack drilling were carried out (Sharp, 1965). Sumitomo Metal Mining Corporation optioned the claims in 1970 and began an underground exploration program. A 450-metre adit was collared 390 metres below the surface showings and driven toward the mineralized zone (Hirata, 1972). Nine underground diamond-drill holes tested the downward extent of mineralization. Subsequent activity on the property has been minor. In 1986 and 1987 ground magnetometer and airborne magnetic/VLF electromagnetic surveys were conducted by Western Geophysical Aero Data Ltd. to outline mineralization beneath the cirque to the northeast. Platinum group element values ranging from less than 50 to 400 ppb platinum and from less than 5 to 415 ppb palladium were obtained from grab samples collected in trenches by Consolidated Silver Standard Mines Limited in 1986 (Quartermain, 1987) and Ministry geologists in 1988.

Work on the E & L claims has identified three zones of nickel-copper mineralization exposed at surface and three additional zones underground. Published indicated and inferred reserves are:

Category	Tonnes (000s)	Ni %	Cu %	Au g/t	Ag g/t
Trench and drill-indicated	1734	0.80	0.62	0.34	6.8
Inferred	1734	0.80	0.62	0.34	6.8

(Anonymous, 1976; Quartermain, 1987; Sharp, 1968).

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APPENDIX 1

CHROMITE, NICKEL AND PLATINUM OCCURRENCES IN BRITISH COLUMBIA

The following tables are listings of other chromite, nickel and platinum occurrences in the British Columbia Ministry of Energy, Mines and Petroleum Resources MINFILE database, excluding those already described in this volume. These occurrences have not been described because they (a) are not ultramafic-mafic hosted mineralization and therefore inappropriate for inclusion in this paper, (b) lack sufficient geological information to provide a reliable description or (c) have been determined to be of nominal significance as a potential resource of the specific elements considered here. The mineral occurrences are listed by MINFILE number, unique to each occurrence, together with the occurrence name, commodities present, and locations (latitude and longitude).

CHROMITE OCCURRENCES

MINFILE Number	Name	Commodities	NTS Map	Latitude	Longitude
082FSW130	Vandot	Cr Ni Pt Co Ti Fe	082F 04W	49°02′11″	117°52′50″
082FSW298	Malde	Au Ag Cu Pb Zn Mo Cr	082F 04E	49°00′12″	117°46′00″
082LNW079	Mt. Ida Chrome	Cr	082L 11W	50°37′00″	119°20′00″
092HNE012	Bonanza	Cr Pt Cu	092H 10W	49°32′42″	120°53′54″
092HNE188	Fraser Gulch	Cr	092H 10E	49°30′47″	120°44′38″
092HSE165	Highway #3	Cr	092H 07E	49°25′37″	120°33′09″
092HSE166	Bromley Vale	Cr	092H 07E	49°25′15″	120°35′37″
092HSE167	Tailings RR Grade	Cr	092H 07E	49°25′07″	120°31′14″
092HSE168	Sunday Creek	Cr	092H 02E	49°14′58″	120°34′57″
092HSW125	Choate	Cr	092H 06W	49°29′00″	121°29′00″
092HSW126	Coquihalla	Cr	092H 06W	49°23′00″	121°21′00″
092INW086	Lillooet Area	Cr	092I 12W	50°41′00″	121°56′00″
092ISW065	H	Ni Ag Cr	092I 04E	50°03′24″	121°38′12″
092JNE100	Taylor Basin	Cr Ni	092J 15W	51°00′00″	122°52′00″
092P 082	Bonaparte River	MT Cr AB	092P 03W	51°07′48″	121°28′30″
092P 084	Clinton	Ni Cr	092P 04E	51°02′00″	121°34′00″
093B 030	NI	Ni Cr	093B 01E	52°05′56″	122°02′54″
093K 012	MR	Cr	093K 09E	54°31′53″	124°11′24″
093K 037	Tsitsutl Mountain Cr	Cr	093K 13E	54°57′00″	125°38′00″
093K 038	Tildesley Creek	Cr	093K 13E	54°54′30″	125°32′00″
093K 072	Sidney	Cr	093K 14W	54°53′30″	125°23′00″
093K 073	O'Ne-ell Creek	Cr	093K 14W	54°54′20″	125°29′38″
093K 036	Occurrence	Cr	093N 06W	55°16′30″	125°27′54″
093N 037	Occurrence	Cr	093N 06W	55°15′30″	125°28′42″
093N 038	Occurrence	Cr	093N 03W	55°14′42″	125°28′12″
093N 039	Occurrence	Cr	093N 04E	55°13′36″	125°30′48″
093N 128	Occurrence	Cr	093N 06W	55°16′00″	125°26′24″
093N 129	Occurrence	Cr	093N 03W	55°14′06″	125°29′24″
093N 135	Manson Creek	Cr	093N 09W	55°39′36″	124°29′54″
094C 040	DD	Cr	094C 05E	56°26′48″	125°34′48″
094D 022	Mesilinka River	Cr	094D 08E	56°23′30″	126°04′12″
094D 060	Carruthers Creek	Cr	094D 01E	54°13′24″	126°12′36″
104I 004	Wheaton Creek	Au JD Cr	104I 07W	58°24′06″	129°00′00″
104I 039	JJR	Cr	104I 06E	58°20′54″	129°05′18″
104I 085	Garnierite	Ni Cr	104I 07W	58°22′00″	128°57′00″
104N 099	Eagle Creek	Au Cr	104N 11W	59°35′19″	133°19′16″
104N 101	Anna	Au Ag Cr	104N 12E	59°33′00″	133°37′00″
104N 118	Utopia	Pb Zn Cr	104N 12E	59°35′21″	133°35′47″
104P 055	Wolfe	Cr OL AB	104P 12W	59°33′25″	129°59′20″
104P 068	Creek	Cr	104P 05E	59°27′30″	129°44′20″

Abbreviations used other than standard element symbols: AB - asbestos; JD - jade; MT - magnetite; OL - olivine.

NICKEL OCCURRENCES

MINFILE Number	Name	Commodities	NTS Map	Latitude	Longitude
082ENE016	BS	Cu Mo W Ni	082E 15W	49°56′54″	118°48′18″
082ESE199	Riff	Cu Ni	082E 02W	49°04′42″	118°59′06″
082ESE201	Bubar	Cu Ni	082E 02W	49°04′18″	118°54′06″
082ESW013	Bullion (L. 3116)	Cu Ni	082E 05W	49°16′06″	119°48′54″
082ESW100	Boot	Cu Ag Ni	082E 04E	49°13′48″	119°42′42″
082ESW104	Capco	Cu Ni	082E 06E	49°29′18″	119°08′54″
082ESW120	Cobo	Cu Ni	082E 03E	49°02′36″	119°12′00″
082ESW121	Ray	Ni Cu	082E 03E	49°01′00″	119°01′00″
082FNE051	Great Dane (L. 5285)	Ag Pb Cu Co Ni	082F 16W	49°46′00″	116°26′36″
082FNE075	Cottage	Ni MB DO	082F 10W	49°38′54″	116°49′12″
082FNE099	United Copper	Cu Ag Pb Zn Ni Au	082F 10E	49°43′18″	116°36′00″
082FSE004	Topaz	Cu Ni Sn Ag Pb Zn	082F 02W	49°08′48″	116°45′48″
082FSE040	Empire State	Cu Ni	082F 01W	49°10′54″	116°21′24″
082FSE069	Blue Rain	Ag Ni	082F 01W	49°13′06″	116°19′00″
082FSE073	Tigar 1	Cu Ni	082F 01W	49°11′36″	116°20′48″
082FSW097	War Eagle (L. 680)	Au Ag Cu Mo Ni	082F 04W	49°05′00″	117°48′29″
082FSW101	Monte Cristo (L. 802)	Au Cu Ag Ni Co	082F 04W	49°05′22″	117°47′55″
082FSW102	Evening Star (L. 801)	Au Ag Cu Ni Co Mo Bi	082F 04W	49°05′23″	117°47′40″
082FSW109	Giant (L. 997)	Au Mo Ag Cu Pb Zn Co	082F 04W	49°05′01″	117°49′25″
082FSW150	Columbia (L. 694)	Au Ag Cu Ni Bi	082F 04W	49°05′13″	117°56′53″
082FSW151	Kootenay (L. 697)	Au Ag Cu Ni Bi	082F 04W	49°05′16″	117°46′48″
082FSW298	Malde	Au Ag Cu Pb Zn Mo Cr	082F 04E	49°00′12″	117°46′00″
082GNW076	War Eagle (L. 6119)	Co Ni Cu	082G 13W	49°53′32″	115°52′20″
082KNW108	New Zone Copper	Cu Ni	082K 11W	50°41′18″	117°27′12″
082KSW064	SB	Ni	082K 03E	50°05′06″	117°10′06″
082KSW101	JK	Cu Ni	082K 03E	50°02′48″	117°06′30″
082LNW015	Iron Pot	Au Pb Zn Ni Cu	082L 14W	50°58′18″	119°28′00″
082LNW028	Galaxy	Cu Ni	082L 11W	50°41′30″	119°23′54″
082LNW039	Zett	Ni	082L 11E	50°38′36″	119°01′24″
082M 117	Fennell Zone	Cu Au Mo Ni	082M 05E	51°17′10″	119°44′15″
082M 163	Avola	Ni	082M 14W	51°46′20″	119°19′40″
092C 052	Sudbury Pacific	Ni	092C 14E	48°58′00″	125°03′12″
092F 204	Lone Cone	Cu Ni Mo	092F 04W	49°11′00″	125°53′30″
092F 230	HM	Cu Ni Sb Hg	092F 06E	49°18′54″	125°07′12″
092F 466	Hoop	Cu Au Ni	092F 02E	49°00′05″	124°32′30″
092GSE016	How	Ni Cu Ag	092G 01E	49°13′06″	122°09′00″
092GSE017	April	Au Ni Cu Fe	092G 07E	49°25′54″	122°34′06″
092HNE128	D	Fe Cr Pt Cu Ni	092H 10W	49°31′42″	120°54′06″
092HNW021	Clayton	Ni Cu	092H 11W	49°34′00″	121°26′30″
092HNW029	Ole	Ni Cu	092H 14W	49°51′42″	121°25′36″
092HNW039	Victor	Ni Cu	092H 11W	49°33′30″	121°28′06″
092HNW046	Citation	Cu Ni	092H 11W	49°30′48″	121°27′00″
092HSE145	Adco Silver	Ag Ni Cu Pb Zn	092H 08E	49°27′54″	120°14′48″
092HSW003	Mammoth	Ni Cu Zn Mo Ag	092H 03E	49°13′30″	121°05′36″
092HSW005	Bea	Cu Ni	092H 06W	49°25′00″	121°27′00″
092HSW038	Last Chance (L. 574)	Mo Au Ag Cu Ni	092H 05E	49°19′54″	121°39′30″
092HSW040	Forks	Ni	092H 03E	49°13′54″	121°05′06″
092HSW067	Clover Leaf	Au Ag Ni To TC	092H 05E	49°21′24″	121°37′00″
092HSW071	NIK	Ni Cu	092H 05W	49°17′18″	121°49′54″
092HSW081	NI	Ni Cu	092H 05E	49°39′24″	121°29′48″
092HSW082	Swede	Ni Cu	092H 05E	49°26′00″	121°30′36″

Nickel Occurrences (Continued)

092HSW100		Hilton 1 and 2	Cu Ni	092H 03W	49°09′12″	121°25′24″
092HSW116		Flood	AE Ni JD	092H 05E	49°22′00″	121°31′00″
092HSW135		Tax	Ni Co	092H 06W	49°29′00″	121°16′00″
092HSW136		Toy	Ni Co	092H 06W	49°26′00″	121°14′00″
092INE155		Marg	Mo Pb Ag Ni Co	092I 16E	50°48′24″	120°07′30″
092INW022		Rickhill	Cu Mo Ag Ni	092I 12W	50°31′00″	121°47′18″
092ISW065		H	Ni Ag Cr	092I 04E	50°03′24″	121°38′12″
092ISW071		Keefers	Ni Cu Co Pt	092I 04E	50°00′06″	121°33′00″
092JNE100		Taylor Basin	Cr Ni	092J 15W	51°00′00″	122°52′00″
092K	085	Contact	Cu Au Ag Ni	092K 03W	50°10′30″	125°15′06″
092K	086	WFP	Cu Au Ag Ni	092K 03E	50°09′18″	125°14′48″
092L	144	Sinker	Cu Ni Co	092L 05E	50°18′54″	127°44′18″
092N	048	AT 2	Cu Ni	092N 10E	51°30′19″	124°42′52″
092P	044	Fortuna	Au Ag Pb Cu Pt Ni	092P 01E	51°05′54″	120°01′12″
092P	084	Clinton	Ni Cr	092P 04E	51°02′00″	121°34′00″
093A	135	Pontiac	Ni	093A 05W	52°17′13″	121°49′41″
093B	030	NI	Ni Cr	093B 01E	52°05′56″	122°02′54″
093B	045	Williams	Ni Cu	093B 01E	52°07′15″	122°02′00″
093G	002	Ray	Ni AB	093G 11W	53°37′27″	123°27′35″
093L	003	Grubstake	Ag Cu Au Zn Fe Ni Mo	093L 02W	54°08′47″	126°52′25″
093M	072	Victoria (L. 3303)	Au Co U Mo Cu Ag As	093M 04E	55°10′20″	129°39′00″
093N	116	Ah Hoo Creek	Ni Pt	093N 10E	55°43′18″	124°38′54″
094D	111	Shred	Cu Mo Ni	094D 09W	56°42′12″	126°15′36″
094E	034	Bower Creek	Cu Pb Zn Sb Co Ni	094E 08E	57°22′00″	126°05′06″
094E	056	Banshee	Cu Mo Ni Zn Pb	094E 13E	57°56′30″	127°40′00″
103B	016	Johnson Nickel	Ni Cu	103B 06W	52°24′55″	131°21′35″
103B	017	Alder Island	Au Cu Ni Mo As	103B 06W	52°26′40″	131°19′00″
103B	018	Nick's Showings	Cu Mo Ni	103B 06W	52°25′40″	131°18′35″
103I	172	Joan	W Fe Cu Ni	103I 02E	54°05′00″	128°43′00″
103P	110	Sea Otter	Ni Cu Co Ag Pt	103P 05E	55°25′30″	129°41′06″
104I	014	Turn	Cu Ni	104I 07W	58°28′42″	128°49′48″
104I	028	WT	Cu Ag Ni Fe	104I 07E	58°17′12″	128°35′00″
104I	030	GB	Cu Ni AB	104I 15W	58°54′48″	128°52′12″
104I	047	Lux	Ni	104I 06E	58°21′00″	129°02′12″
104I	051	Flat	Ni Cu	104I 07W	58°27′54″	128°50′36″
104I	085	Garnierite	Ni Cr	104I 07W	58°22′00″	128°57′00″
104J	001	Opal Lake Nickel	Ni	104J 13W	58°46′54″	131°48′36″
104J	017	AL	Ni	104J 13W	58°45′18	131°51′12″
104K	017	Council	Sb Au Ag Ni	104K 12E	58°35′54″	133°34′31″
104K	045	Chastot Creek	Ni MT GS	104K 16E	58°50′12″	132°00′40″
104K	046	Goat	Ni MT GS	104K 15E	58°56′32″	132°40′17″
104K	068	Grag	Cu Ag Ni	104K 11W	58°30′55″	133°21′39″
104M	017	Anyox-Rodeo	Cu Ni	104M 08E	59°26′20″	134°13′45″
104N	013	Mount Barham	Ni Cu	104N 11W	59°44′25″	133°23′02″
104P	001	Blue River Nickel	Ni	104P 12W	59°33′00″	129°59′00″
114P	031	C and E North	Cu Ni	114P 15W	59°55′20″	136°46′20″

Abbreviations used other than standard element symbols: AB - asbestos; AE - agate; DO - dolomite; GS - gemstones; JD - jade; MB - marble; MT - magnetite; TC - talc.

PLATINUM OCCURRENCES

MINFILE Number	Name	Commodities	NTS Map	Latitude	Longitude
082ENE009	Kingfisher	Au Ag Cu Pb Zn Cd	082E 09W	49°33′54″	118°21′24″
082ESE081	Mother Lode	Au Pb Zn Cu Mo Pt	082E 01E	49°10′48″	118°07′54″
082ESE147	Sappho	Cu Ag Pt	082E 02E	49°00′18″	118°42′24″
082FNE118	Dykes Option	Cu Pt Pd	082F 10W	49°41′24″	116°51′30″
082FNW108	Cable (L. 6503)	Ag Pt Au Cu Pb Zn	082F 14E	49°49′30″	117°04′20″
082FSW130	Vandot	Cr Ni Pt Co Ti Fe	082F 04W	49°02′11″	117°52′50″
082N 044	King David	Ge Ur An Pt	082N 07W	51°18′10″	116°53′10″
092GNE013	PML 811	Au Pt	092G 16W	49°57′42″	122°25′30″
092GNE019	PML 813	Au Ag Pt	092G 16W	49°58′24″	122°26′30″
092HNE008	Mary Jenson	Cu Pt	092H 10W	49°30′36″	120°52′18″
092HNE009	Sootheran's	Cu Pt Pb Zn Ag	092H 10W	49°31′42″	120°53′42″
092HNE012	Bonanza	Cr Pt Cu	092H 10W	49°32′42″	120°53′54″
092HNE038	Cathy	Pt Fe Cr Cu	092H 10W	49°31′06″	120°54′24″
092HSE130	PML 2027-2030	Pt	092H 07E	49°29′24″	120°39′36″
092HSW043	Master Ace	Au Ag Cu Mo Bi Pt	092H 06E	49°17′30″	121°09′30″
092HSW044	St. Patrick	Au Pt	092H 06E	49°24′36″	121°14′00″
092HSW114	PL 1065-7	Au Pt Ag	092H 06W	49°27′30″	121°25′12″
092INW050	Glasgow	Au Pb Pt	092I 13W	50°59′42″	121°54′54″
092ISW071	Kefers	Ni Cu Co Pt	092I 04E	50°00′06″	121°33′00″
092JSE012	Margery	Cu Zn Fe Au Pt	092J 07E	50°20′54″	122°39′30″
092JSE022	Hemrick Mines	Au Pt Ag	092J 02E	50°03′12″	122°32′00″
092P 044	Fortuna	Au Ag Pb Cu Pt Ni	092P 01E	51°05′54″	120°01′12″
093G 025	Cottonwood	Au Pt	093G 01E	53°05′18″	122°14′30″
093J 007	McDougall River	Au Pt	093J 14W	54°56′47″	123°17′01″
093J 012	McLeod River	Au Pt	093J 14E	54°55′54″	123°11′54″
093L 109	Glacier Gulch	Au Ag Bi Te Pt	093L 14W	54°49′30″	127°16′50″
093N 116	Ah Hoo Creek	Ni Pt	093N 10E	55°43′18″	124°38′54″
093O 003	Bill Cust's Bar	Au Pt	093O 13E	55°45′18″	123°41′48″
093O 005	Rainbow Cr.	Au Pt	093O 04W	55°13′24″	123°57′42″
094B 001	Pete Toys Bar	Au Pt	094B 04W	56°00′42″	123°53′54″
094B 002	Branham Flat	Au Pt	094B 02E	56°06′48″	122°38′42″
094D 007	McConnell Creek	Au Pt	094D 16W	56°50′00″	126°27′30″
094D 008	Ingenika River	Au Pt	094D 16W	56°48′54″	126°23′54″
103B 009	Swede	Cu Ag Co Pt	103B 12W	52°42′35″	131°49′45″
103F 026	Blue Jacket Creek	Au Pt Fe Ti Zr	103F 16E	53°59′40″	132°08′20″
103P 110	Sea Otter	Ni Cu Co Ag Pt	103P 05E	55°25′30″	129°41′06″
104J 007	Thibert Creek	Au Pt	104J 16E	58°49′12″	130°09′42″