INTRODUCTION

The Rossland mining camp in southwestern British Columbia (Figure 5.1) ranks historically as the second largest lode gold producer in the province. Between 1894 and 1957 the camp produced more than 73 860 kilograms of gold, 107 000 kilograms of silver and 54 295 tonnes of copper (Fyles, 1984). Most of this gold was recovered from copper-gold sulphide fissure veins contained within Early Jurassic Rossland Group hypabyssal, subvolcanic rocks marginal to the Middle Jurassic Rossland monzonite (Höy and Dunne, 2001). Appreciable gold (1060 kilograms) has also been recovered from gold-quartz veins associated with ultramafic and mafic hypabyssal or volcanic rocks on the O.K., I.X.L. and Midnight Crown-granted claims to the southwest of the sulphide-rich vein system. Fyles (1984) reports that between 1899 and 1974, 10 492 tonnes of ore were mined from these veins with an average grade of 101 grams per tonne gold and 14 grams per tonne silver. Some of the veins have exceptionally high gold grades. The Snowdrop vein, for example, produced only 6 tonnes of ore but had an average grade of 1150 grams per tonne gold. Drysdale (1915) indicates that during September 1893 the three owners of the mine extracted 6 kilograms ($4000.00 = 193.7 ounces) of gold in one week by means of a hand mortar alone. This chapter discusses the character, origin, and tectonic setting of associated ultramafic rocks and their bearing on the genesis of the gold-quartz veins.

During the 1991 field season three weeks was spent in the Rossland area. Investigations focused primarily on mapping the ultramafic rocks to determine their type, origin and possible relationship to the spatially associated gold-quartz veins. Two isolated ultramafic bodies, one to the immediate west of Rossland and the other several kilometres to the southwest, were mapped at 1:10 000 scale (Figure 5.2). Dan Wehrle is gratefully acknowledged for providing several days of his time to give an overview of Rossland mine geology.

Aspects of the tectonic and lithologic controls of gold-copper sulphide-rich vein mineralization in the Rossland camp are part of an on-going study by Höy and Dunne (2000) and are summarized here for the purposes of comparison. A number of their unpublished dates have been used to help constrain geological relationships in the area.

PREVIOUS WORK

The first comprehensive overview of the geology and mineral deposits of the Rossland camp was presented by Drysdale (1915) which built on the earlier work of Brock (1906). More recent studies of the camp have been conducted by Thorpe (1967), Fyles (1984) and Höy et al. (1992). Most of this research, as well as descriptive reviews of the camp (Barr, 1980; Panteleyev, 1992) have focused specifically on the copper-gold sulphide vein mineralization. Gold-quartz vein deposits on the O.K., I.X.L. and Midnight claims have been described by Drysdale (1915) and Stevenson (1936). The regional geology has been described by Little (1963, 1982), Höy and Andrew (1991a, b) and Höy and Dunne (1997). Regional 1:100 000-scale geological and mineral deposit compilation maps for the Rossland-Trail area have been published by Andrew et al. (1991) and Höy and Dunne (1998).

GEOLOGICAL SETTING

Ultramafic rocks and spatially associated gold-quartz veins are exposed along a regional tectonic boundary which separates late Paleozoic continental margin slope and rise sedimentary rocks of Mount Roberts Formation to the west (Little, 1982) from the Early Jurassic Rossland Group arc volcanic rocks (Höy and Dunne, 1997) to the east (Figure 5.1). This boundary is interpreted as an eastward directed thrust fault (Höy and Andrew, 1991b) related to late Early to Middle Jurassic collision of the eastern edge of Quesnellia with the North American craton between 184 and 174 Ma (Murphy et al., 1995; Colpron et al., 1996).

Ultramafic rocks, of probable ophiolitic affinity are considered correlative with the Permian Kaslo Group or preferably “Kaslo Assemblage”, and part of the oceanic Slide Mountain Terrane.

The late Paleozoic Mount Roberts Formation consists of metamorphosed, lower greenschist to amphibolite grade siliceous clastic rocks including grey to black siltstone and slate, argillaceous quartzite, argillite and lithic greywacke, with lesser limestone, conglomerate and volcanic rocks (Little, 1982; Höy and Dunne, 1997; Roback et al., 1994). It is included with the Harper Ranch subterrane (Monger et al., 1991) and contains Early Proterozoic and Archean detrital zircons suggesting that the unit is in part derived from the adjacent North American craton (Roback and Walker, 1995).

The Early Jurassic (Sinemurian) Rossland Group (Little, 1982; Höy and Dunne, 1997) in the Rossland area is dominate by mafic and intermediate volcanic and volcanioclastic rocks locally interbedded with marine sediments consisting of siltstone and argillite. Hypabyssal, subvolcanic intrusions that occur as augite porphyritic sills and dikes (e.g. Rossland sill) are also a component part of the Rossland Group and the primary host for the richest Cu-Au sulphide veins.

Both the Early Jurassic Rossland Group and late Paleozoic Mount Roberts Formation are affected by two major
ROSSLAND
0 2
kms

Peridotite cumulates
Granodiorite
Rainy Day Pluton, hornblende-augite quartz diorite
Rossland monzonite

Elise Formation sedimentary rocks; siltstone and argillaceous siltstone
Rossland sill. augite porphyritic monzogabbro

Middle Jurassic (162-172 Ma)
Granodiorite
Rainy Day Pluton, hornblende-augite quartz diorite
Rossland monzonite

Cu-Au sulphide veins
Intrusive contact
Faulted contact
Thrust Fault

Eocene
Coryell intrusions, syenite, quartz monzonite and Marron Formation.

Early Jurassic (~195Ma)
Rossland Group
Elise Formation volcanic rocks; andesite and basalt, massive flows and breccia
Elise Formation sedimentary rocks; siltstone and argillaceous siltstone
Rossland sill. augite porphyritic monzogabbro

Late Paleozoic
Slide Mountain Terrane (Kaslo Fm)
Peridotite cumulates

Devonian(?) to Triassic
Harper Ranch (Mount Roberts Fm)
Siliceous siltstone and arillite

Figure 5.4
Figure 5.6

Figure 5.2. Geological map of the Rossland gold camp (after Little, 1982; Fyles, 1984; Höy and Andrew, 1991b).
episodes of post-collisional magmatism in the Rossland area. The earliest post-collisional intrusions belong to the Middle Jurassic Nelson suite and are intimately associated with mineral deposits in the Rossland camp. These occur as batholiths, plutons, stocks and dikes that range in composition from granodiorite, which is dominant, to quartz diorite, diorite and monzonite (Little, 1982). Available age constraints indicate that they formed during a roughly 10 Ma period of magmatic activity between ca. 172 and 162 Ma (Ghosh, 1995; Höy and Dunne, 1997, 2001) subsequent to middle Jurassic accretion of Quesnellia to the North American craton (Figure 5.3) (Murphy et al., 1995; Colpron et al., 1996; Höy and Dunne, 1997).

The Middle Eocene Coryell Intrusions and related Marron volcanics (Little, 1982; Ghosh, 1995) are the latest magmatic episode recorded in the vicinity of the Rossland mining camp. These rocks form a large batholith, which underlies a vast area west of the camp (Figure 5.1 and 5.2). They also occur as dikes and small stocks that intrude all older lithologies and form a north-trending linear, dike-like body along the Jumbo fault. Coryell intrusions include syenites, granites, quartz monzonites and monzonites with quartz monzonite being dominant.

ULTRAMAFIC ROCKS

RECORD RIDGE ULTRAMAFIC BODY

The Record Ridge ultramafic body (Figures 5.2 and 5.4) underlies an area of approximately 6.2 square kilometres, 7 kilometres southwest of the town of Rossland. It extends from the southern tip of Record Ridge, south to the foot of Mount Sophia and east to Ivanhoe Ridge and is the larger of the two ultramafic bodies mapped. Unlike the smaller ultramafic body to the north, there are no known lode-gold prospects associated with the Record Ridge ultramafic body; however, it provides more extensive exposure and variation in rock types and is therefore more informative in defining the nature and possible origin of these units. Mapping was facilitated by an assessment report map of the immediate area (Morrison, 1980), which provides details of outcrop distribution.

The Record Ridge body comprises variably serpentinized and locally carbonatized ultramafic cumulates. Rock types include dunite, pyroxene-bearing dunite, olivine-bearing wehrlite and wehrlite, each type varying simply as a function of the relative proportion of cumulate olivine (65-100 modal percent) to intercumulate pyroxene (0-35 modal percent) (Figure 5.5). Disseminated chrome spinel is present in all the ultramafic rocks, usually as minor, subhedral to euhedral accessory grains (< 1 to 3 %). Within the dunite, concentrations of chrome spinel increase to over 5 modal percent locally. Areas with 5% chrome spinel or more have been mapped separately and are designated as chrome-bearing dunites. Contact relationships between all these ultramafic rock types are everywhere gradational.

Within the ultramafic body a mappable transition exhibiting a reduction in the modal abundance of cumulate olivine and chrome, combined with an increase in the modal abundance of intercumulate pyroxene, defines a differentiated stratigraphy towards higher elevations that corresponds to an east-west transition. The exposed lower and eastern parts of the ultramafic body are dominated by dunite with localized areas of chrome dunite and chrome bearing dunite (Photo 5.1). This unit grades upward through clinopyroxene-bearing dunite into olivine wehrlite (Photo 5.2) with localized concentrations of wehrlite.

Cumulate layering, defined by alternating 1 to 2 centimetre chrome-rich (50 to 80 %) and chrome-poor planar bands (Photo 5.3), was identified at three separate localities within the dunite. Layering is typically randomly oriented with limited lateral extent up to several metres.

Contacts of the ultramafic body were not identified in outcrop. Along its northern, western and southern margins the ultramafic rocks are covered by Middle Eocene rhyolitic volcanic rocks of the Marron Formation or intruded by co-

Figure 5.3 Relative age and tectonostratigraphic relationships for lithologies in the Rossland camp.
GQV - gold quartz veins; CGSV - Cu-Au sulphide fissure veins
Data sources used to constrain age relationships for the elements depicted are as listed following: 1 Little 1982; 2 Tipper, 1984; Höy and Andrew, 1991a; 3 Höy et al., 1992; Höy and Dunne, 1997; 4 Fyles, 1984; 5 Corbett and Simony, 1984; 6 Ghosh, 1995; 7 Roback and Walker, 1995; 8 Höy and Dunne, 2001.
Figure 5.4. Geology of the Record Ridge ultramafic body.
eval Coryell subvolcanic plutonic rocks (Little 1982). The inferred northern contact of the body is marked by a linear topographic depression which Fyles (1984) interpreted as a faulted contact. A minor increase of alteration intensity in the ultramafic rocks towards the contact suggests that the fault has been affected by only limited movement or is restricted to late, high level brittle faulting. The lobate nature of its western and southern margins, combined with the presence of small isolated ultramafic bodies that are possibly xenoliths or rafts within the Coryell batholith several kilometres to the south (Little, 1982), suggest an intrusive relationship. Along its eastern margin the body is in contact with massive fine-grained, aphanitic mafic volcanic rocks correlated with the Rossland Group by Little (1982) and Höy and Andrew (1991a). This contact is not exposed but the presence of fish-scaled serpentine with localized carbonate-altered shear zones near the margin of this body indicates a faulted contact.

**O.K. ULTRAMAFIC BODY**

The O.K. ultramafic body is the smaller, but economically more significant of the two ultramafic bodies examined (Figure 5.6). It underlies an area of approximately 1.0 square kilometre roughly two kilometres west-southwest of Rossland in the valley of Little Sheep Creek between O.K. Mountain and Deerpark Hill. Data and linework illustrated in Figure 5.6 is taken directly from an air photo of the immediate map area investigated and therefore is not immediately transferable to existing topographic base maps.

The ultramafic rocks are similar to the larger Record Ridge body and consist of variably serpentinized olivine-bearing cumulates with variable contents of intercumulate pyroxene. A lack of continuous exposure as well as the limited size of the body preclude recognition of any systematic variation in the rock types that might indicate a primary magmatic stratigraphy as defined in the larger body to the south. The dominant lithology consists of olivine wehrlite with erratically distributed, localized areas of dunite and pyroxene-bearing dunite.

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**Figure 5.5.** Classification and nomenclature of ultramafic rocks in the olivine-orthopyroxene-clinopyroxene prism (after Streckeisen, 1975).

**Photo 5.1.** Chrome bearing dunite, on the eastern slope of Record Ridge.

**Photo 5.2.** Olivine wehrlite, displaying textural character of intercumulate pyroxene and cumulate olivine.

**Photo 5.3** Cumulate chromite layering in dunite. From trench in showing No. 2, Figure 5.3.
The western margin of the body is faulted against Marron volcanic rocks along the O.K. fault (Fyles, 1984), a late, steeply-dipping structure. Ultramafic rocks exposed near this fault contact are characterized by a slight and localized increase in the degree of serpentinization, with little or no shearing, suggesting limited or localized high level fault displacement. To the east, the body is in part against a linear north-trending dike-like intrusion of Coryel rocks along the Jumbo fault. Siliceous siltstones correlated with the Mount Roberts Formation by Fyles (1984) and mafic metavolcanic rocks of uncertain association crop out farther south along the eastern margin. Their distribution is erratic in this poorly exposed area and their contact relationship with the ultramafic rocks is not well defined, but is inferred to be tectonic. The presence of serpentinized ultramafic rocks, separate from the main O.K. body, between these sediments and the adjoining mafic volcanic rocks to the southeast suggests that this is most likely a tectonic contact. Based on this relationship the belt of siliciclastic metasediments along the southeast margin of the ultramafic body are tentatively correlated with the Mount Roberts assemblage.

Along its northern contact, the O.K. ultramafic body is faulted against Mount Roberts siltstones to the west and fine-grained aphanitic mafic metavolcanic rocks correlative with the Rossland Group (Little, 1982; Höy and Andrews, 1991a; Höy et al., 1992) to the east. Fyles (1984) mapped these rocks as greenstones of unknown age and correlation and distinguished them from Rossland Group greenstones. Close to the contact, these mafic metavolcanic rocks host the majority of the gold-quartz veins in the Rossland Camp. In the north the ultramafic-metavolcanic contact is not well exposed but Stevenson (1936) has described the nature of the contact in underground workings. He writes:

“A contact zone intervenes between the black serpentine and the andesite; it is best seen in the second and third crosscuts to the north from the main fault-drift in the lower O.K. adit. The zone strikes roughly east and varies from 20 to 30 feet in width. Over this width irregular areas of hard, chocolate-coloured andesite are interspersed with irregular areas of serpentine. ”

Hard, chocolate coloured andesites as described by Stevenson (1936) are interpreted to be carbonate altered mafic volcanic rocks.

A large pit excavated to serve as a holding pond near the entrance to the O.K. No. 350 adit exposes brecciated ultramafic rocks close to the metavolcanic contact (Photo 5.5). The breccia consists of blocks of talcose serpentine ranging from several centimetres to several tens of centimetres in size within a schistose talc-serpentine matrix (Photos 5.6a and b). The more massive blocks contain from 2 to 5 % disseminated euhedral pyrite. Blocks of schistose talc-carbonate rock are also common in several dumps located near the portal of the O.K. lower adit, which transects the faulted contact. The altered ultramafic rocks adjacent to the faulted contact, and mafic volcanic rocks within it, reveal a carbonatized fault zone. Unfortunately quartz-carbonate-mariposite listwanite for potential dating was not identified in outcrop or in dumps.

ORIGIN OF THE ULTRAMAFIC ROCKS

Suggestions as to the origin of the ultramafic rocks in the Rossland camp have varied. Early workers (Brock, 1906; Drysdale, 1915) interpreted them to be altered augite porphyrite stocks. Little (1982) was the first to suggest that they are most likely contemporaneous with the Paleozoic, oceanic Mount Roberts Formation, and part of an ophiolitic assemblage. Fyles (1984) interpreted the ultramafic rocks to be much younger, possibly of Late Cretaceous age, inferring that they are post-collisional intrusions. Höy and Andrews (1991b) recognized that the ultramafic rocks are most probably tectonically emplaced.

Mapping confirms that these rocks are plutonic with well-preserved primary cumulate textures. Similar rock types are found in ophiolitic and Alaskan-type ultramafic complexes. The close association of the ultramafic rocks in the Rossland camp with both arc volcanic rocks and oceanic sedimentary and possibly volcanic rocks suggests that either association is possible; field evidence is insufficient to draw any firm conclusions. In order to discriminate between these alternatives, massive chromitite collected from the Record Ridge ultramafic body was analyzed for the com-

Photo 5.4. View looking towards the northwest over the Little Sheep Creek Valley depicting the setting of the IXL, Midnight.

Photo 5.5. Entrance No. 8 level portal to the IXL mine.
Figure 5.6. Geology of the O.K. ultramafic body.
plete suite of platinum group elements (PGEs); the relative abundances of these elements have distinctive signatures in rocks of the two possible affinities. Platinum group element abundances in the massive chromitite (Figure 5.7) show an enrichment in osmium, iridium and rhodium relative to platinum and palladium, a feature consistent with the PGE abundances of ophiolitic chromitites (Agiorgitis and Wolf, 1978; Economou, 1986; Legendre and Augé, 1986; Naldrett and von Gruenewaldt, 1989). Alaskan-type chromitites are characterized by the reverse relationship in which platinum and palladium are enriched relative to the other PGEs.

Petrographic study of the ultramafic rocks provides additional evidence in support of an ophiolitic affinity. Intercumulate orthopyroxene has been identified in a number of thin sections. Orthopyroxene is a common minor intercumulate phase in ophiolitic ultramafic cumulates but is characteristically absent in Alaskan-type complexes due to their strongly alkaline composition. The geochemical and petrological character of these ultramafic rocks suggests that they are most likely ophiolitic in origin and implies formation within the lower plutonic crust at an oceanic spreading centre. The present crustal level of these rocks and their juxtaposition with both sedimentary and subaerial volcanic rocks can only be the result of tectonic processes.

The tectono-stratigraphic character of the ultramafic rocks is compatible with that of the adjacent Mount Roberts Formation. Bedding attitudes in the Mount Roberts Formation, in its type locality along the lower east-facing slope of O.K. Mountain and Mount Roberts immediately to the north of the O.K. ultramafic body, indicate that the unit is homoclinal with bedding tops facing west (Little, 1982; Hoy and Andrew, 1991a). The magmatic stratigraphy defined within the Record Ridge ultramafic body indicates a similar relationship and provides evidence for a common tectonic history for the two oceanic units.

It is considered possible that the small isolated occurrence of massive metavolcanic rocks hosting the gold quartz veins may also be ophiolitic. If determined to be ocean floor basalts as opposed to arc volcanics, they should also be included with the Kaslo assemblage.

The tectonic implications of the ultramafic rocks as ophiolitic is that their current surface position marks the presence of a transcrustal fault, presumably related to suturing of oceanic crust during collapse of the Rossland arc complex in Middle Jurassic time.

**LATE SYN-COLLISIONAL MAGMATISM**

A number of distinctive intrusive bodies belonging to the Nelson Intrusive Suite are present in the local Rossland area. The Rainy Day quartz diorite (Fyles, 1984), situated several hundred metres east of the O.K. ultramafic body is the most proximal late syn-collisional intrusion to the
gold-quartz vein mineralization. Fyles (1984) described the porphyritic marginal phases of the Rainy Day pluton as being highly fractured with a network of intersecting veinlets which he considered as indicating the presence of endogenous late-stage fluids. The age of the body is poorly constrained by U-Pb dating (Höy and Dunne, 2001) which gives a broad estimate between 174.6±3.6 and 166.3±1.4 Ma. Contact relationships with the adjoining Rossland monzonite (Figure 5.2) may provide additional age constraints. Fyles (1984) identified, though not definitively, dike-like masses of quartz diorite that appeared to extend from the Rainy Day pluton into the Rossland monzonite which is dated at 167.1±0.5 Ma (Höy and Dunne, 1997, 2001).

The Rainy Day pluton has been traditionally interpreted (Brook, 1906; Little, 1982; Fyles, 1984; Höy and Andrew, 1991a, b; Andrew et al., 1991) as a satellite stock of the larger Trail pluton to the northeast of Rossland (Figure 5.2). Available U-Pb zircon data for this larger granodiorite body (Corbett and Simony, 1984) and for an isolated, north-trending linear satellite stock (Fyles, 1984), referred to informally as the Topping Creek pluton (Figure 5.2) indicate coeval ages at ca. 163 Ma. These ages are within the ca. 172 to 162 Ma range defined for the magmatic suite regionally (Ghosh, 1995). The late Early to Middle Jurassic contractional event that imbricates Mount Roberts Formation, Kaslo Assemblage and Rossland Group rocks is bracketed by regional considerations (Murphy et al., 1995; Colpron et al., 1996) between late Early Jurassic and Middle Jurassic (186 to 174 Ma). On the basis of relative timing between magmatism and tectonism the Middle Jurassic Nelson suite may be typified as late syn-orogenic.

LODE GOLD MINERALIZATION

There are two distinctive styles of gold vein mineralization in the Rossland camp: copper-gold sulphide-rich fissure veins and gold-quartz veins (Drysdale, 1915; Fyles, 1984; Höy and Dunne, 2001). The two distinctive styles of vein mineralization are separated by the north-trending Jumbo Fault (Fyles, 1984) (Figure 5.2). This is a lithologically and structurally complex north-trending fault zone that has been affected by later faulting and episodic felsic intrusion subsequent to the Middle Jurassic thrusting.

The setting of the latter vein type is the primary focus of this discussion. The character of the sulphide rich copper-gold veins is described in detail by Höy and Dunne (2001) and only briefly described here for purposes of comparison.

MASSIVE PYRRHOTITE-CHALCOPYRITE FISSURE VEINS

Sulphide-rich veins of the Rossland camp are hosted mainly in fissure zones cutting Early Jurassic Rossland Group, and hypabyssal subvolcanic intrusives (e.g. Rossland sill). Most of the veins are associated with, and thought to be genetically related to, irregular tongue-like protrusions that emanate from the Rossland monzonite into the Rossland Group subvolcanic augite porphyry (Fyles, 1984). These tongues are co-structural with the vein fissures, with veins occurring along the margins of the intrusive contacts or just beyond the termination of the tongues.

The ore in the veins consists mainly of massive pyrrhotite and chalcopyrite with lesser pyrite and minor arsenopyrite, with combined sulphide minerals comprising from 50 to 70% of the vein. Sulphides occur as either well defined veins or as sheeted zones of irregular lenses or tabular bands with intervening zones of barren vein material. These are associated with a gangue of altered country rock with quartz and locally a little calcite.

The range in metal values of the veins as reported by Drysdale (1915) is 12.4 to 37.3 grams (0.4 to 1.2 ounces) gold, 0.7 to 3.6% copper and 9.3 to 71.5 grams (0.3 to 2.3 ounces) silver characterizes the nature of the Rossland vein occurrences.

Höy and Dunne (2001) further refine the camp zonation model of Thorpe (1967) and demonstrate a metal zonation in which the structural style, mineralogy and tenor of the Cu-Au sulphide veins is considered to vary due to the combined effects of depth of formation, proximity to the syngenetic Rossland monzonite and nature of the host rocks.

GOLD-QUARTZ VEINS

Gold-quartz vein mineralization in the Rossland camp on the Midnight (082FSW119), I.X.L. (082FSW116) and O.K. (082FSW117) Crown-granted claims is hosted by massive greenstone and ultramafic rocks adjacent to the faulted and brecciated northern margin of the O.K. ultramafic body.

The following is summarized after Drysdale (1915) and Stevenson (1936) which are the only published descriptions of the geology in the largely inaccessible underground workings. The veins are several centimetres to 2 metres wide and follow a series of east to northeast-trending, moderately to steeply (35-75°) south dipping fissures. Visible gold is reported from most of the veins and typically occurs erratically distributed in rich pockets. The majority of the veins are contained in carbonate-altered massive greenstone, however, Drysdale (1915) reports that in 1906 the O.K. and I.X.L. furnished very rich gold-quartz ore from a vein in serpentinite but the vein lacked continuity and did not extend into the lowest levels of the mine. He reports that the average gold grade was close to an estimated 63 g/t (1.84 oz/ton; reported as $38.00 per ton). An average analysis from part of a typical ore car shipment from the mine some time during the 1890s is reported by Drysdale (1915) as; silver 0.85%, gold 140 grams (4.5 ounces) and copper 2.5%. This high-grade gold character of the ore shoots or pockets is well documented (Drysdale, 1915; Stevenson, 1935; Fyles, 1984). Sulphide minerals, including chalcopyrite, pyrite and galena are uncommon but locally have concentrations of 10 to 15% where they occur as individual 2 to 6-millimetre grains or in polymineralic lenses, 1 to 4 centimetres in size. Ankeritic carbonate is the only other gangue mineral in addition to quartz and occurs both in irregular zones within the veins and less commonly in veinlets in the altered wallrocks.
AGE AND ORIGIN OF GOLD MINERALIZATION

Various interpretations of the age and origin of Cu-Au sulphide veins have been presented throughout the long history of exploration and study in the Rossland camp, and are reviewed by Fyles (1984). Although all previous workers have consistently interpreted the veins to be intrusion related, there has been some inconsistency as to which of the local intrusions is genetically related to the vein mineralization. Drysdale (1915) suggested that the immediate association of granodioritic tongues within and alongside the mineralized vein fissures was strong evidence for a genetic association between the two. Thorpe (1967) proposed that gold-copper sulphide mineralization is related to the Rossland monzonite and/or the Trail and Rainy Day plutons.

Thorpe and Little (1973) argued that the Rossland monzonite was related to the Cu-Au sulphide veining in order to account for the camp scale mineral zoning, a view which is supported by more recent constraints defined by Höy and Dunne (2001). Fyles (1984) concluded that the pattern of mineral zoning possibly results from a complex interplay with more than one source for the metals and a succession of structural events, as well as the composition, temperature and confining pressure of the mineralizing fluids.

The timing of gold-quartz veining has been consistently interpreted to be coeval with the Cu-Au sulphide veining in the main Rossland camp. These gold-quartz veins have been viewed to form at a higher structural level, as a lower temperature, more distal expression of the overall mineral zonation pattern (Thorpe, 1967; Fyles, 1984; Höy and Dunne, 2001).

The faulted and altered contact between the O.K. ultramafic body and the massive mafic volcanic rocks is considered to be of Middle Jurassic age (Höy and Dunne, 2001) and places a lower age limit on vein formation. The widespread association of similar vein systems in which late syn-orogenic intrusive rocks are temporally and spatially associated with vein mineralization along the terrane collisional boundaries, as discussed in other chapters, adds support to this view. The relatively high copper content of the gold-quartz veins (Drysdale, 1915) relative to the trace abundances found in other gold-quartz veins described from other camps is atypical. This might suggest a metal signature that is consistent with that in the sulphide rich veins and provides additional evidence for a possible genetic link between the two vein types.

Currently the gold-quartz veins are at a lower topographic elevation than the Rossland sulphide veins, however, restoring Eocene motion on the Jumbo Fault situated between the two deposit types may solve this current contradiction.

The immediate genetic association of the gold-quartz veins with intrusive rocks is speculative.

Stevenson (1936) indicates that a small intrusion of medium-grained monzonite to diorite is intersected at several levels on the O.K. and I.X.L. adits. The rock consists of light-green chloritic hornblende and white feldspar. The only relationship indicated (Stevenson, 1936) between the gold-quartz veins and the intrusion is that the quartz vein dies out on entering the diorite. Clearly, definitive age constraints of gold-quartz veining are needed to confirm their timing and potential genetic association with the Cu-Au sulphide veins. Existing relationships, however, support such a view of coeval vein formation.

SUMMARY

- Gold quartz-veins in the Rossland camp are associated with listwanite altered ultramafic rocks assigned to the Late Paleozoic Kaslo Assemblage. These are located along a terrane collisional boundary between continental margin sedimentary rocks of the Mount Roberts Formation and volcanic arc rocks of the Early Jurassic Rossland Group.

- Ultramafic rocks consisting of magmatic cumulates are exposed in two distinct bodies along this faulted boundary. These rocks appear to be mineralogically and chemically comparable with an ophiolitic origin and are interpreted to be remnants of late Paleozoic, lower ocean crust. They have been emplaced, in the solid state, by tectonic processes and delineate a transtectal fault zone.

- Gold-quartz vein fissures are best developed in massive greenstone near the faulted and carbonated-altered contact with the O.K. ultramafic body. Veins are poorly developed in the altered ultramafic rocks but veins with the richest gold ore shoots are along side or near contacts with the ultramafic rocks.

- Little’s (1982) proposal that the ultramafic rocks might comprise some type of dismembered ophiolite suite is supported by this study. In light of this, we propose that the ultramafic rocks comprise a component of the Kaslo Group or preferably “Kaslo assemblage”. Massive greenstone in contact with the ultramafic rocks hosting the gold quartz veins, which are distinctive from Rossland Group volcanics and only found along the terrane-bounding zone, may also be part of this ophiolitic assemblage. Petrochemistry of these rocks is required to confirm any potential genetic association between the two igneous units.

- Gold-quartz veins appear to have formed late in the orogenic episode, and are inferred contemporaneous with the development of the sulphide-rich fissure vein system. Both mineralized vein systems are considered to be genetically related to intrusion of the spatially associated, late-syn collisional Middle Jurassic Nelson Nelson Plutonic Suite. Cu-Au sulphide veins show a close spatial and likely genetic association with the Rossland monzonite (see Höy and Dunne, 2001 for a detailed discussion).
Intrusive rocks of the Rossland arc complex, mainly the Rossland sill, acted to provide competent host rocks for development of continuous vein fissures. This veined and mineralized competent structural block being situated adjacent to a terrane-bounding suture is consistent with relationships for other gold vein deposits discussed in this study.