PETROLOGY OF PRE TO SYNTECTONIC EARLY AND MIDDLE JURASSIC INTRUSIONS IN THE ROSSLAND GROUP, SOUTHEASTERN BRITISH COLUMBIA (82F/SW)

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KEYWORDS: Regional geology, Rossland Group, Jurassic plutons, Eagle Creek Plutonic Complex, Rossland monzonite, Rossland sill, monzogabbro, Silver King intrusions.

INTRODUCTION

Early and Middle Jurassic plutons are recognized throughout the Rossland Group in southeastern British Columbia. They are important in understanding the tectonics and metallogeny of the group. They host a variety of mineral deposits, including the mesothermal veins of the Rossland gold-copper camp and vein and alkali porphyry deposits south and west of Nelson.

The purpose of this paper is to present data on four main intrusive suites in the Trail map area and to relate these suites to the Rossland Group or to the early deformational history of the area. The paper reviews field data, presents new petrographic and geochronological data, and discusses mineralizing events.

REGIONAL SETTING

The Rossland Group is exposed in a broad arcuate belt in the Trail map area, bounded to the east, north and west by granitic rocks of the Late Jurassic Nelson batholith and in fault contact with lower Paleozoic rocks of the Kootenay Arc on the south (Figure 1-1-1). The group forms the eastern boundary of Quesnellia and is similar in composition to rocks of the Nicola and Takla groups.

The Rossland Group is Early Jurassic in age (Frebold and Little, 1962; Frebold and Tipper, 1970; Tipper, 1984). It comprises a basal succession of dominantly fine-grained clastic rocks of the Archibald Formation, volcanic rocks of the Elise Formation and overlying clastic rocks of the Hall Formation. The Ymir Group underlies the Elise Formation in the Nelson area; its upper part is correlative with the Archibald Formation.

The Rossland and Ymir groups are intruded by a number of different plutons including a suite of synvolcanic intrusions, syncollisional early-Middle Jurassic plutons, the Middle to Late Jurassic Nelson intrusions, the Middle Eocene Coryell intrusions and numerous felsic and mafic Tertiary dikes.

EAGLE CREEK PLUTONIC COMPLEX

The Eagle Creek Plutonic Complex, referred to as 'pseudodiorite' (Mulligan, 1952), straddles the Kootenay River 3 kilometres west of Nelson. It is generally a medium to coarse-grained mafic intrusion, in part gneissic; however, it grades into leucocratic hornblende syenite (Mulligan, 1951) and locally incorporates coarse ultramafic phases (Mulligan, 1951, 1952; Little, 1982a, b; Lindsay, 1991). It is described as metadiorite by Lindsay on the basis of extensive petrography and rock geochemistry at the Moochie occurrence. It is suggested that the term Eagle Creek, originally proposed by Mulligan (1951), be retained.

Contacts of the Eagle Creek Plutonic Complex with the Rossland Group rocks are generally sharp, locally marked by coarse-grained clinopyroxenites. The southwest part of the complex is cut by the Mount Verde fault, a steep, westerly-dipping, listric normal fault that records a period of extension just prior to intrusion of the Nelson batholith (Figure 1-1-1; Höy and Andrew, 1989a, b).

The age of the Eagle Creek Plutonic Complex is not known. It is cut by the Nelson granodiorite (*ca.* 165 Ma) and by the Silver King shear zone, a wide zone of shearing along the margins and extending into the core of the Hall Creek syncline. This shearing and deformation is dated at about 180 Ma, the age of syntectonic intrusion (*see* section on Silver King intrusions). Its relationship to the surrounding Rossland Group rocks (*ca.* 190–200 Ma) is less clear. However, based on similarity with the Rossland monzonite and its pretectonic age, it is possible that the complex may be cogenetic with Rossland Group volcanism

PETROGRAPHY

The Eagle Creek Plutonic Complex is a composite intrusion with phases varying from equigranular to porphyritic and mafic to ultramafic. The mafic phases contain 10 to 30 per cent plagioclase (An_{5-84}) and minor (1 to 15%) microcline (Plate 1-1-1, Table 1-1-1). Primary quartz ranges up to 5 per cent. Most mafic minerals are variably altered to chlorite and carbonate; unaltered mafic minerals are rare and include euhedral augite (5–15%), hornblende (3%) and green biotite (10–30%). Apatite occurs frequently as an accessory mineral in the mafic phases. The ultramafite contains at least 25 per cent augite, 10 per cent amphibole and abundant alteration of remaining mafic minerals to chlorite.

The complex is variably altered and sheared close to the Silver King shear zone (Figure 1-1-1). Plagioclase is commonly saussuritized, sericitized and/or replaced in part by chlorite. Muscovite, chlorite and calcite overprint and surround plagioclase and microcline (Lindsay, 1991) and segregated albite and epidote show fine-grained cataclastic textures.

On Streckeisen's (1973) quartz-alkali feldspar-plagioclase diagram (Figure 1-1-2) phases of the Eagle Creek Plutonic Complex fall within the monzonite, quartz monzonite, quartz monzodiorite, quartz gabbro and diorite/gabbro fields. Diorite or gabbro are the most common phases in the field and because of regional metamorphism, may be referred to as metadiorite/gabbro.

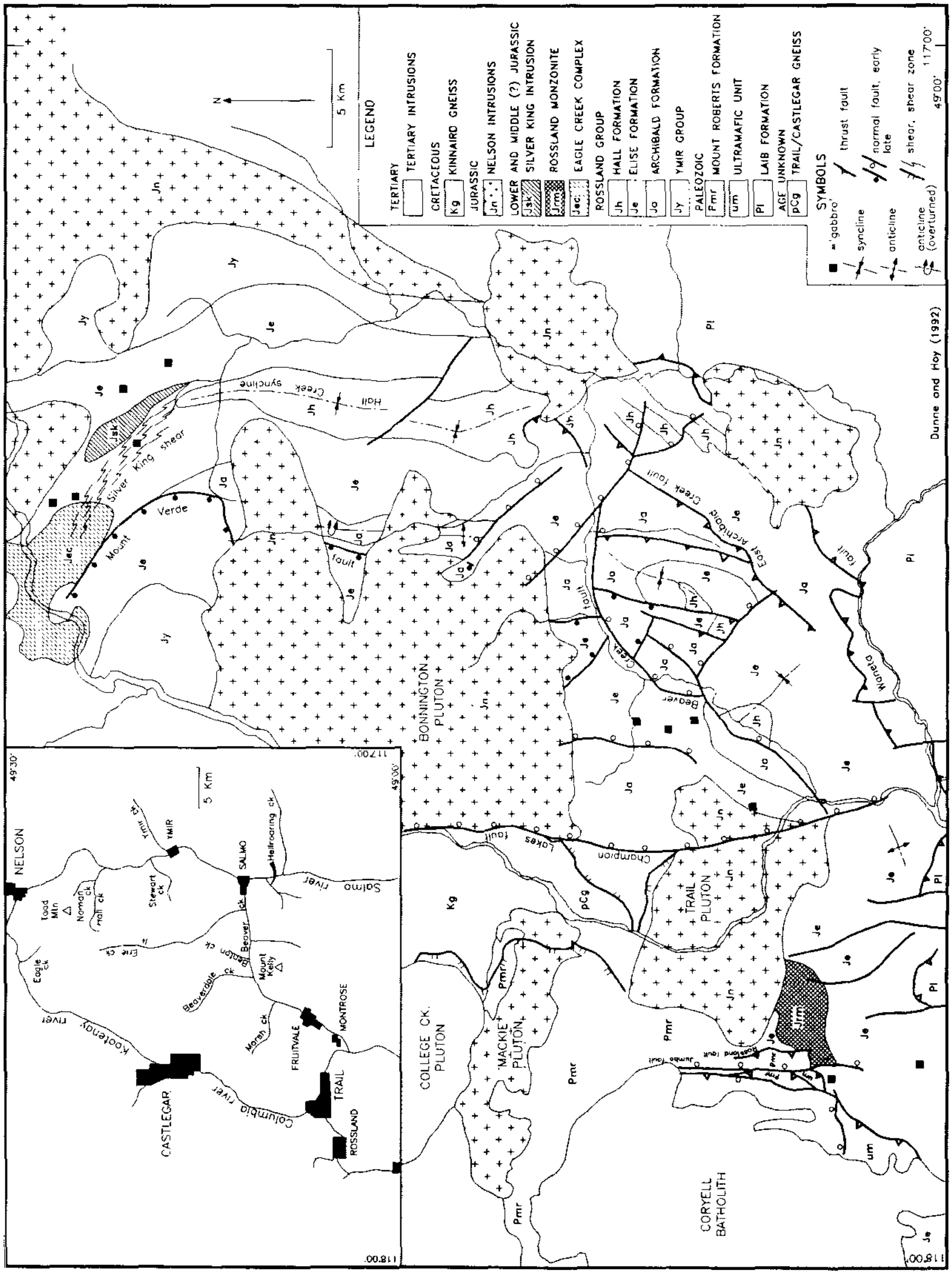

Figure 1-1-1. Distribution of Early and Middle Jurassic intrusions and main geologic and physiographic features of the Trail map area (082F/SW). 'Gabbro' intrusions are located by small squares.

Plate 1-1-1. Microcline crystal, 635 microns, in gabbro phase of the pseudodiorite (field of view = 1.48 mm).

Ultramafic phases along the margins of the complex are coarse-grained clinopyroxenite. They have similar mineral assemblages to the metadiorite/gabbro (Mulligan, 1951), comprising dominantly augite with lesser green amphibole rimming and replacing the augite, and secondary chlorite (Plate 1-1-2). Symplectite texture, comprising iron ore, probably ilmenite, intimately intergrown with clinopyroxene in a vermicular fashion, is seen in the ultramafic phases (Plate 1-1-3). Minor saussuritized plagioclase is noted in some localities (Mulligan, 1951).

Certain phases of the Eagle Creek Plutonic Complex, such as the monzonitic to syenitic rocks and clinopyroxenites, suggest affinities to Alaskan-type mafic-ultramafic complexes (Nixon, 1990). However, silica-oversaturated rocks such as the quartz monzonites, diorites and gabbros are more akin to calcalkaline plutonic suites.

Mineral Prospects

Several mineral deposits and showings occur within or adjacent to the Eagle Creek Plutonic Complex. These include porphyry copper-gold showings such as the Toughnut and Moochie occurrences and copper-gold-lead veins. Mineralization at the Toughnut zone adjacent to the complex includes disseminated chalcopyrite, tetrahedrite and pyrite in potassic-altered, carbonate and sericite-rich lower Elise Formation volcanic rocks .

The Moochie occurrence, within the complex, is characterized by disseminated chalcopyrite, magnetite and pyrite within locally potassic-altered metadiorite. Magnetite commonly encloses irregular lenses of ilmenite and cataclastic aggregates of chalcopyrite and magnetite are also noted (Lindsay, 1991). The occurrence is locally overprinted by the Silver King shear zone.

The Star and Granite Poorman occurrences are vein deposits within the complex. Quartz veins at the Star deposit carry patches of chalcopyrite, pyrite, malachite and

TABLE 1-1-1
PETROGRAPHIC COMPARISON OF TYPICAL LOWER TO MIDDLE JURASSIC INTRUSIONS IN THE ROSSLAND GROUP, TRAIL MAP AREA, SOUTHEASTERN BRITISH COLUMBIA

	Pseudodiorite (metadiorite/ gabbro)	Silver King Intrusions	Rossland Monzonite	Rossland Sill	'Gabbro' Nelson Area	'Gabbro' Fruitvale Area	'Gabbro' Rossland Area
Plagioclase	10–30	30–60	40–60	30–40	15–45	30–45	20–55
(An content)	5–84	28–60	38–48	48–54	50–67	54–69	55
Orthoclase	0	0	20–25	25	5–25	0–25	0
Microcline	1–15	0	0	0	0	0	0
Quartz	1–5	1–2	1–2	0	2–5	0	0
Augite	5–15	0	3–15	10	0	10–20	7–25
Hornblende	3	0–3	0–30	10	0–7	0–5	0
Biotite	10–30	0	5–15	10	1–25	0	0–1
Chlorite	2–35	10–15	5–25	1	5–20	0–20	10–40
Epidote	2–20	1–5	0	0	0–15	0–15	0–10
Sericite	10–20	5–60	0	0	0–35	0–35	0
Carbonate	7–25	5–30	0	0	0–10	0	0
Apatite	0–1	0–1	1	1	0–1	0–1	0–1
Sphene	0	0	0–1	0	0	0	0
Opaques	0–10	0–3	1–5	1	0–3	0–5	0–7
Matrix	0	0–60	0	0	0–25	0–35	0

Analyses incorporate, in part, work by Beddoe-Stephens and Lambert (1981), Fyles (1984), Lindsay (1991) and Mulligan (1951).

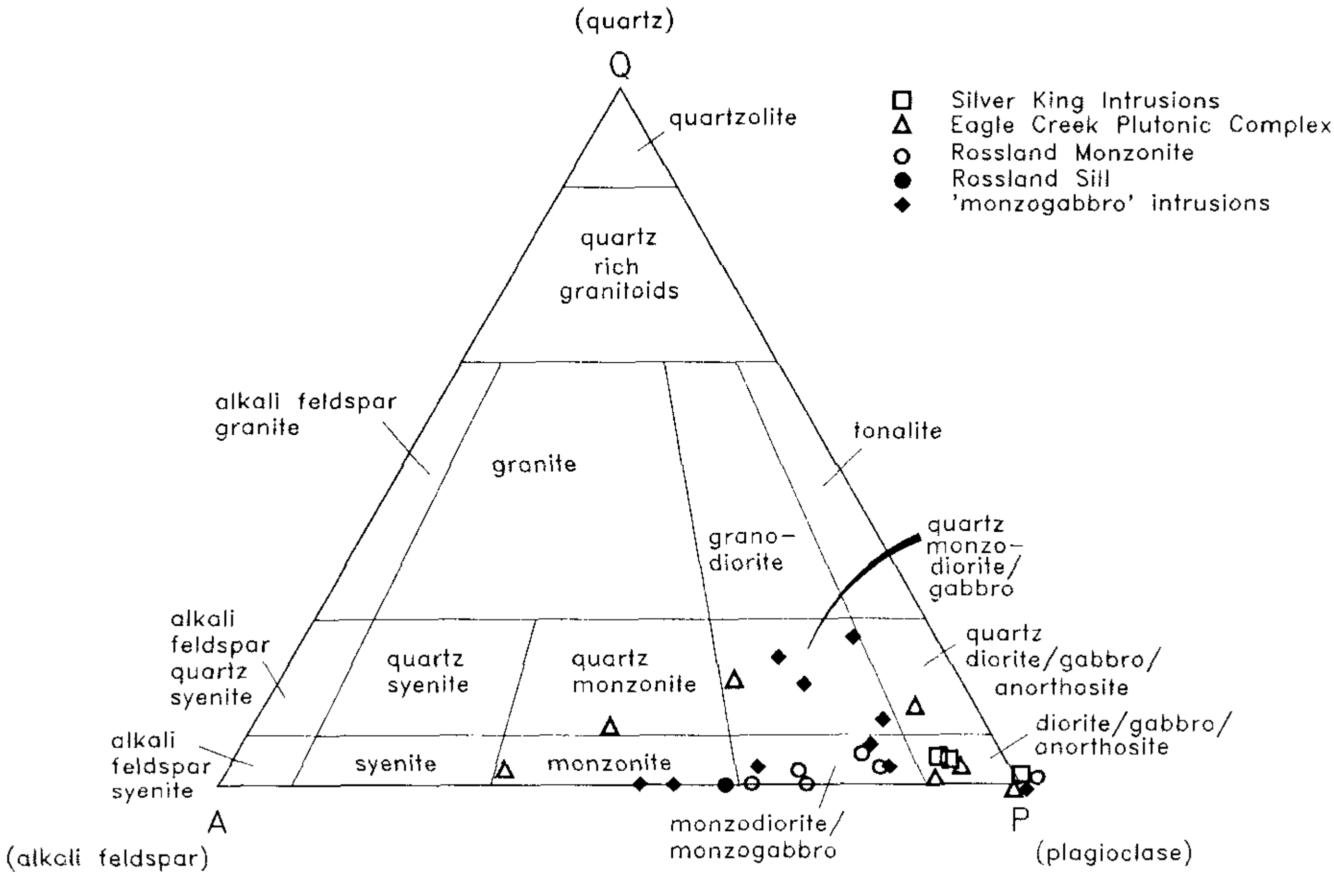

Figure 1-1-2. Quartz-alkali feldspar-plagioclase diagram of Early and Middle Jurassic intrusions in the Trail map area.

galena. The Granite Poorman mine (Dawson, 1889) is characterized by veins of quartz carrying pyrite, galena, chalcopyrite, sphalerite, minor scheelite and free gold.

ROSSLAND MONZONITE

The Rossland monzonite is centred on the town of Rossland and extends north to Monte Cristo and Columbia-Kootenay mountains and east to the vicinity of Lookout Mountain. A small fault slice of Rossland monzonite is exposed on the northwest slopes of Red Mountain. Contact relationships with the Rossland Group vary from sharp to locally gradational over several hundreds of metres, obscured by a wide thermal aureole (Fyles, 1984). The Rossland monzonite and Rossland mining camp have been studied by many previous workers including Drysdale (1915), Bruce (1917), Gilbert (1948), Little (1960, 1963, 1982b), Fyles (1984) and Höy and Andrew (1991a,b). Veins in the gold camp and their relationship to the monzonite and structures are discussed by Höy *et al.* (1992, this volume), molybdenum-skarn deposits on Red Mountain are reviewed by Webster *et al.* (1992, this volume) and studies of ultramafic bodies in fault slices just west of Rossland are outlined by Ash and MacDonald (1992, this volume).

The age of the Rossland monzonite is interpreted as Early Jurassic (*ca.* 190 Ma; J. Gabites, personal communication, 1991) suggesting that it is cogenetic with the Rossland Group (Höy *et al.*, 1992). It is cut on its west side by the Rossland fault, an east-directed thrust, and by the steeply dipping, north-trending Jumbo fault (Fyles, 1984; Höy and Andrew, 1991a,b). The Trail pluton, part of the Late Jurassic plutonic suite, obscures the Rossland monzonite contact to the north (Figure 1-1-1).

The Rossland monzonite hosts a number of different vein deposits, including the famous Le Roi, Centre Star and Evening Star mines. Gold-copper-lead-zinc veins hosted by the Elise Formation such as the Bluebird and Mayflower deposits occur mainly south of Rossland. Bonanza gold veins, including the Midnight deposit, occur adjacent to ultramafic bodies southwest of Rossland. Gold-copper skarn mineralization occurs within the Rossland monzonite adjacent to some of the main and north belt veins (Höy *et al.*, 1992).

PETROGRAPHY

The Rossland monzonite is an inequigranular intrusion. It comprises 40 to 60 per cent euhedral to subhedral andesine (An_{38-48}), with rare labradorite (An_{62-68}) in the Crown Point area, and 10 to 25 per cent orthoclase. Primary mafic minerals are only partially preserved, typically as ragged grains. Augite is replaced by hornblende in some areas but, more commonly, biotite replaces both hornblende and augite. Remnant augite comprises 3 to 15 per cent anhedral, often

Plate 1-1-2. Symplectite texture: ilmanite or magnetite and clinopyroxene intimately intergrown in a vermicular fashion in a coarse-grained clinopyroxenite phase of the pseudodiorite (field of view = 1.48 mm).

Plate 1-1-3. Coarse-grained augite crystals are pervasively rimmed and replaced by chlorite in coarse-grained clinopyroxenite phase of the pseudodiorite (field of view = 1.48 mm).

poikilitic crystals mantled by biotite and chlorite. Magnetite and apatite are ubiquitous accessory minerals; sphene is rare. Quartz, if present, ranges from 1 to 2 per cent as late, resorbed crystals which may indicate a subvolcanic origin for the intrusion (Table 1-1-1). This mineralogy indicates that the Rossland monzonite is dominantly a monzodiorite (Figure 1-1-2). Other phases include monzonite, and a large biotite clinopyroxenite xenolith is exposed at the Centre Star deposit.

Studies of metamorphism by Fyles (1984) define a wide thermal aureole around the intrusion. The northern margin, near Columbia-Kootenay Mountain, and the southern margin, south of Rossland, have a zone of well-indurated biotite hornfels, 300 to 500 metres wide, that is locally bleached, silicified and contains pyroxene and garnet (Fyles, 1984). Alteration of mafic minerals in the monzonite to ragged hornblende, biotite and chlorite may be due to superimposed regional metamorphism.

ROSSLAND SILL

The Rossland sill is exposed on the eastern slope of Red Mountain near Rossland. It has a similar mineral assemblage to the Rossland monzonite. The sill is fragmental in part, with blocks up to a metre wide with the same composition as the matrix (Fyles, 1984). Texturally, it is inequigranular to porphyritic with 30 to 40 per cent euhedral, sausseritized, oscillatory zoned calcic andesine to sodic labradorite (An_{48-54}) and 25 per cent orthoclase. Mafic minerals (30%) comprise nearly equal proportions of augite, a blue-green amphibole and biotite. The blue-green amphibole is probably secondary hornblende and may be described as uralite. The augite is oscillatory zoned and is often rimmed with hornblende (Plate 1-1-4). Accessory apatite in the sill has distinct mineral cores (Plate 1-1-5).

Symplectite textures of magnetite or ilmenite and clinopyroxene are common in the Rossland sill (Plate 1-1-6). On Monte Cristo Mountain, opaque oxide has symplectite textures and is mantled by biotite.

EARLY JURASSIC MONZOGABBRO UNIT

A number of monzogabbro/gabbro sills or small stocks occur throughout the exposures of the Elise Formation and are interpreted to be high-level syn-Rossland Group intru-

Plate 1-1-4. Augite rimmed by hornblende in the Rossland sill (field of view = 1.48 mm).

Plate 1-1-5. Accessory apatite crystal, 30 microns, with distinct mineral core in biotite from the Rossland sill (field of view = 185 microns).

sions. Previously referred to as 'diorite (Jdi)' (Andrew *et al.*, 1991), the sills are renamed on the basis of detailed petrography. They are typically tabular, lensoid or sill-like, several tens of metres thick and can often be traced for several kilometres. Others are subrounded, discordant plutons. They are fine to medium grained and often porphyritic with 30 to 40 per cent plagioclase phenocrysts in a dark green-grey matrix. They are petrographically distinct from the Eagle Creek Plutonic Complex, Rossland monzonite and Silver King intrusions. Monzogabbro stocks can occur anywhere within the Elise Formation but tend to be mainly in the upper part. Locations of monzogabbros studied in this report are plotted on Figure 1-1-1.

The best-documented example of an Early Jurassic monzogabbro is the Shaft intrusion, a tabular, locally brecciated complex up to 50 metres in width and 5 kilometres in strike length. It has pervasive propylitic alteration that hosts disseminated chalcopyrite, pyrite and magnetite (Andrew and Höy, 1989).

Petrography

Monzogabbros in the Nelson area have the widest diversity of mineral assemblages. Most are found intruding both upper and lower Elise Formation rocks up to 5 kilometres south and west of Nelson, in the plateau areas east of Toad Mountain and in the vicinity of Morning Mountain. They are characterized by 15 to 45 per cent labradorite (An_{50-67}), rarely saussuritized, a significant orthoclase component (5 to 25%), and minor quartz (2 to 10%). Primary mafic minerals are rarely seen (Plate 1-1-7), as they are commonly altered to hornblende, biotite, chlorite and epidote. Often, the unit has a fine-grained matrix of feldspar and chlorite with up to 1 per cent apatite and 1 per cent magnetite and pyrite. The Nelson area intrusions fall within the monzonite, (quartz) monzogabbro and quartz gabbro fields on Streckeisen's (1973) quartz-alkali feldspar-plagioclase diagram (Figure 1-1-2).

The Shaft intrusion exposed 3 kilometres south of Nelson is a fine to medium-grained, locally porphyritic monzogabbro. It is brecciated and locally sheared. It contains 30 to 45 per cent labradorite (An_{50-64}), 5 to 10 per cent orthoclase and 2 to 3 per cent quartz. It ranges in composition from quartz gabbro to quartz monzogabbro and monzogabbro. The feldspars are variably saussuritized and sericitized (10 to 25%). Biotite, chlorite and epidote have totally replaced any augite or hornblende phenocrysts. Apatite and

Plate 1-1-6. Symplectite texture of magnetite (?) – clinopyroxene mantled by biotite in the Rossland sill (field of view = 370 microns).

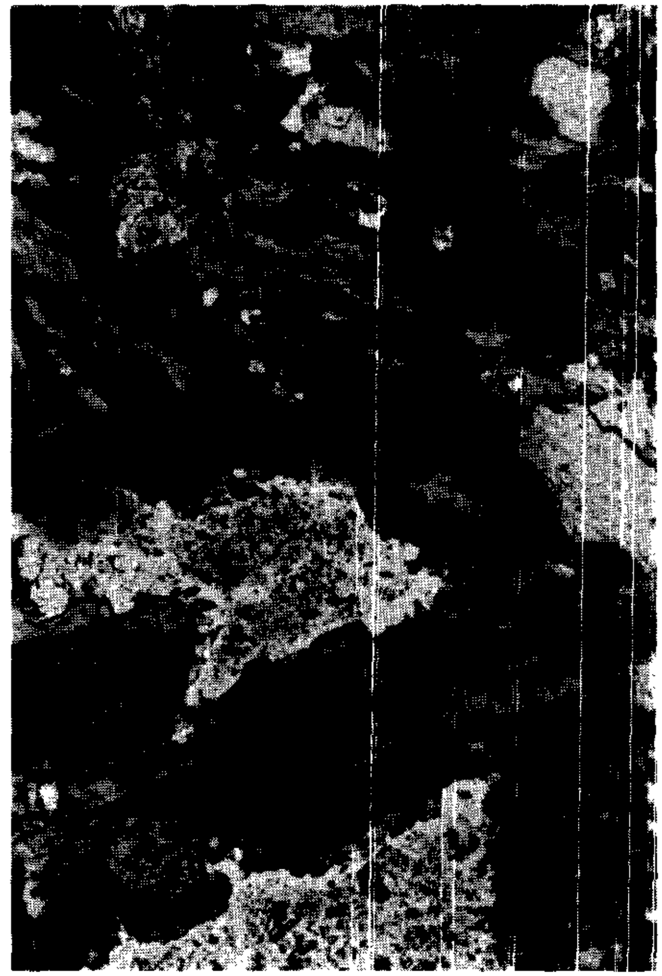

Plate 1-1-7. Hornblende, chlorite and epidote in 'gabbro from the Nelson area (field of view = 1.4 mm).

sphene are present as accessory minerals. Opaques include chalcopyrite, pyrite and magnetite. Hematite and malachite are common oxide minerals.

A number of monzogabbros in the Elise Formation north and east of Fruitvale are quartz-poor but have diverse feldspar compositions. They are characterized by 30 to 45 per cent labradorite (An_{48-72}), rarely concentrically zoned or saussuritized, and varying orthoclase content (0 to 35%); quartz is generally absent. Augite is usually preserved but variably altered to hornblende and chlorite. These monzogabbros may have a fine-grained matrix of feldspar, biotite and chlorite. Accessory apatite is rarely seen and 2 to 5 per cent opaque minerals, mainly pyrite, are present. The Fruitvale area monzogabbros plot within the monzonite, monzogabbro and gabbro fields (Streckeisen, 1973; Figure 1-1-2).

Monzogabbros in the Rossland area are quartz-poor and alkali-feldspar poor. Most are found in the Elise Formation south of Rossland on Tamarac Mountain or Deer Park Hill. They are characterized by 50 to 55 per cent euhedral labradorite and bytownite (An_{58-88}), typically saussuritized, minor orthoclase and no quartz. Augite is still preserved but variably altered to biotite and chlorite. Apatite is rare and up to 7 per cent opaque minerals, mainly pyrite occur in the matrix. These monzogabbros are mainly within the gabbro field on Figure 1-1-2.

SILVER KING INTRUSIONS

The Silver King intrusions are a suite of dominantly feldspar porphyries in the Nelson area. The main body is traced southeast from Giveout Creek, 1 to 5 kilometres south of Nelson (Figure 1-1-1). Several lenses of the Silver King porphyry outcrop on the west slopes of Mount Elise and border the main Silver King intrusion.

Outcrops of the Silver King intrusion are typically cream coloured and form resistant ridges. Contacts with Rossland Group rocks are either sharp and discordant or intensely sheared.

The Silver King intrusion is sheared along its margins. Commonly, smaller lenses are strongly foliated or sheared sericite phyllites that superficially resemble foliated felsic volcanic rocks. These contact relationships and the foliated to massive nature suggest that the Silver King intrusions are a pre to syntectonic suite.

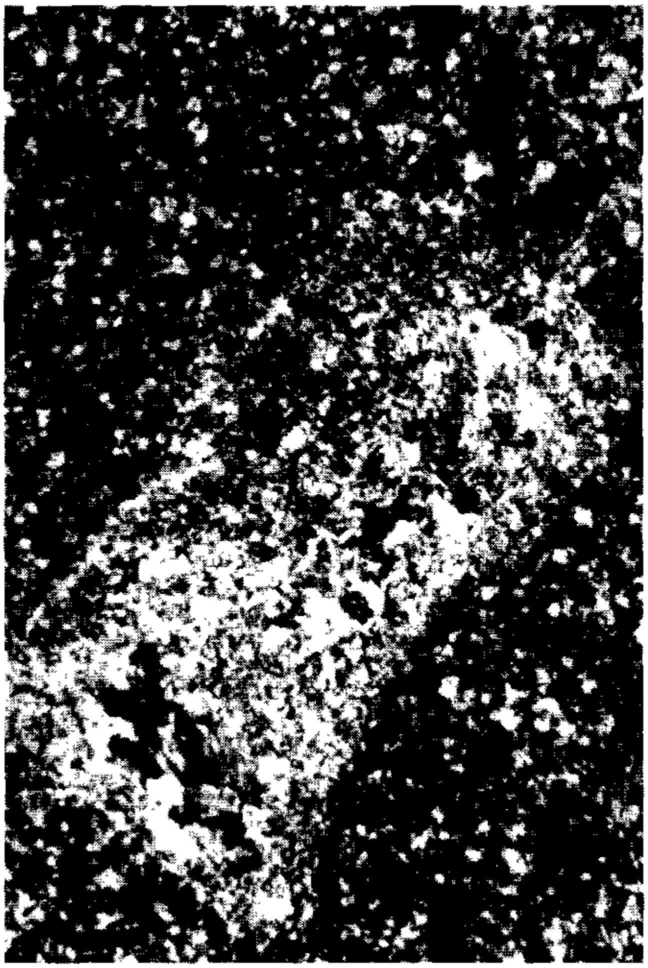

Plate 1-1-8. Intensely saussuritized plagioclase phenocrysts with inner zones replaced by clusters of sericite needles in a fine-grained matrix of feldspar and secondary quartz, Silver King intrusion (field of view = 1.48 mm).

Plate 1-1-9. Cataclastic fabric in the Silver King intrusion; platey minerals rotated into parallelism and rounded feldspar boudins in a protomylonite (field of view = 1.48 mm).

A stratabound conglomerate-breccia unit, the Silver King breccia (Mulligan, 1951, page 117), characterized by clasts of feldspar porphyry, outcrops in Gold Creek and the drainage basin south of Cottonwood Lake. It is described as an epiclastic unit of the Elise Formation by Höy and Andrew (1988), and is characterized by abundant to ubiquitous 10 to 15-centimetre clasts of plagioclase porphyry. These porphyry clasts were weathered from a high-level subvolcanic intrusion within the Elise Formation. Farther south, only the distal portions of the apron is exposed. The clasts are not, as previously described (Höy and Andrew, 1988), derived from weathering of Silver King intrusions; the intrusions are now known to be much younger than the Elise Formation.

Petrography

Silver King rocks are porphyritic, characterized by 10 to 30 per cent euhedral to subhedral plagioclase (An_{28-60}) phenocrysts, 5 to 10 millimetres in size (Table 1-1-1) in a fine-grained greenish grey groundmass. Quartz content ranges from 1 to 2 per cent; grains are commonly resorbed which may indicate a high-level of intrusion. Generally, primary mafic minerals are not preserved although acicular secondary hornblende needles are locally observed. Accessory sphene and ilmenite are common (Mulligan, 1951); apatite is rare.

The Silver King intrusion has been strongly altered and sheared. Plagioclase twinning is commonly obscured by intense saussuritization and the inner zones of the phenocrysts are replaced by clusters of sericite needles (Plate 1-1-8). Mafic minerals are almost totally replaced by chlorite and calcite. The groundmass comprises abundant secondary albite (?), epidote, carbonate and often 10 to 50 per cent interlocking aggregates of quartz grains and sericite 'mats'. A cataclastic fabric is typically seen in thin section. This varies from shearing and parallelism of platy minerals to rotation of feldspar boudins in a protomylonite (Plate 1-1-9).

A quartz-sericite-carbonate schist on the Great Western property, initially assumed to be part of the Elise Formation (Höy and Andrew, 1989c), is interpreted to be a small, strongly sheared Silver King intrusion. This occurrence is unusual as it contains 2 to 3 per cent scattered tourmaline crystals. The interpretation that this lens is part of the Silver King plutonic suite has important implications because it means that the Elise Formation is strictly intermediate to mafic in composition with no recognized felsic members.

The Silver King intrusions fall within the diorite/gabbro field on Streckeisen's (1973) quartz-alkali feldspar-plagioclase diagram (Figure 1-1-2). As the porphyry has virtually no mafic minerals and plagioclase is generally $An_{<50}$, it is classified as a leucodiorite porphyry.

Geochronology

Preliminary U-Pb analyses of zircons from Silver King intrusions give dates that range between 178 to 182 Ma (J. Gabites, personal communication, 1991). The intrusions are interpreted to have been emplaced contemporanous with the early phase of deformation in Rossland Group rocks (Höy *et al.*, 1992). Other synorogenic intrusions in the Kootenay Arc of southern British Columbia include the Cooper Creek stock (*ca.* 180 Ma; Klepacki, 1985), a small discordant pluton northwest of Kaslo, and the Aylwin Creek stock south of Silverton. The Aylwin Creek stock, in Rossland Group volcanic rocks in a roof pendant of the Nelson batholith, hosts copper-gold-silver mineralization on the Willa property. Preliminary U-Pb data indicate an intrusive age of approximately 184 Ma (W.J. McMillan, personal communication, 1991).

Mineralization

A genetic connection between some of the satellite phases of the Silver King intrusions and certain ore deposits has been suggested by Drysdale (1915, page 32). Deposit types associated with the Silver King intrusions include shear-related copper-gold and copper-zinc-silver, and vein lead-zinc-silver-gold.

The California prospect is a vein deposit in the Silver King intrusion near its northern contact with the Elise Formation and Nelson batholith. Quartz veins contain pyrite, galena, sphalerite and free gold. The Great Western occurrence (Höy and Andrew, 1989c), Kena occurrence and Silver King mine are examples of shear-related deposits.

The largest producer hosted by Silver King intrusions is the Silver King mine, after which the intrusions were named. It began production in 1896 and attracted wide attention to the Nelson area. The Silver King orebody is believed to have been a shear-related silver-lead-zinc-gold deposit although its origins are still debated more than 100 years after its discovery. Mineralization, within three main shear-controlled veins, is characterized by galena, chalcopyrite, pyrite and tetrahedrite with minor sphalerite, bornite and stromayerite (a gold-copper sulphide) near the east contact of the Silver King intrusions with highly sheared Elise Formation mafic volcanic flows. The gangue is quartz, carbonate and siderite in sericite schist, a strongly sericitized and sheared Silver King intrusion. Shearing is right lateral as indicated by C-S fabric kinematic indicators.

SUMMARY AND DISCUSSION

This paper presents preliminary data, based largely on field relations, descriptive petrology and preliminary U-Pb dating, on Early and Middle Jurassic plutons in the Rossland Group. More definitive statements, particularly regarding the relationship of magmatism to tectonism, must await analysis of chemical data and additional U-Pb dating.

At least four suites of Early to Middle Jurassic intrusions, associated with or within the Rossland Group, are exposed in the Trail map area. The Early Jurassic Eagle Creek Plutonic Complex west of Nelson, the Rossland monzonite and small monzogabbros throughout the Elise Formation are interpreted to be coeval with the Rossland Group, whereas the early Middle Jurassic Silver King intrusions are interpreted to be synorogenic, related to collision of the eastern margin of Quesnellia with North America (*see* Höy *et al.*, 1992).

The Rossland monzonite is dominantly a monzodiorite with at least one large xenolith of biotite clinopyroxenite. Preliminary U-Pb analysis of zircons suggests a date of approximately 190 Ma (Höy *et al.*, 1992). It is pretectonic, overprinted by regional metamorphic alteration assemblages and skarn alteration associated with Middle Jurassic plutons.

The Eagle Creek Plutonic Complex may be similar to the Rossland monzodiorite. It is associated with clinopyroxenite phases as well as hornblende syenite, monzonite and gabbro. It is pretectonic, with local development of a penetrative fabric due to shearing in the Silver King shear zone.

It is suggested that these intrusions are comagmatic with arc volcanics of the Rossland Group. They were both emplaced along major structures, and are both associated with mineralization – gold-copper veins in the Rossland area and dominantly alkali porphyry gold-copper prospects in the Eagle Creek Plutonic Complex. The ubiquitous presence of both apatite and magnetite in these intrusions is common in Upper Triassic – Early Jurassic arc complexes elsewhere in Quesnellia and Stikinia. These intrusive complexes have phases that are typically calcalkaline as well as phases that resemble feldspar-bearing rocks found associated with Alaskan-type complexes in the Cordillera (Nixon *et al.*, 1989; Nixon, 1990).

Small widely scattered monzogabbros are inferred to be high-level synvolcanic intrusions. They are restricted to the Elise Formation, have diffuse, commonly brecciated margins, and may be associated with minor copper-gold-magnetite mineralization.

The Silver King intrusions occur south of Nelson in strongly deformed eastern exposures of the Rossland Group. They are interpreted to be syncrogenic, related to convergence of Quesnellia with North America. Small intrusions and margins of large intrusions are penetratively foliated or intensely sheared. Other intrusions, petrologically similar to the Silver King intrusions and assumed to be comagmatic, are discordant, massive or only locally foliated. The preliminary age of these intrusions – *ca.* 178–182 Ma – coupled with a 180 Ma date on a post-tectonic intrusion, the Cooper Creek stock farther north in the Kootenay Arc (Klepacki, 1985), dates this early collisional event.

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