CHAPTER 3  MINERAL DEPOSITS

INTRODUCTION

The Nelson-Rossland map area (082F/SW) contains a wide variety of mineral deposits and numerous past producers. Many of the historical mining camps in southern British Columbia are located in this area, and their discovery led directly to the settlement and development of the interior of the province. The names, Rossland, Trail, Salmo, Ymir and Nelson are forever tied to the early mining history of British Columbia, and these towns are still the centre of active and continued mineral exploration.

This chapter concentrates on deposits in the Rossland Group, but also reviews briefly other deposit types within the map area. The deposits are classified using the nomenclature of the British Columbia mineral deposit profiles (Lefebure and Ray, 1995; Lefebure and Höy, 1996). Deposits in the historical Rossland gold-copper camp are described in Chapter 4.

The Nelson-Rossland map area straddles the tectonic boundary between rocks of North America and the eastern edge of arc terranes. This area has a complex tectonic and magmatic history that is reflected in both the diversity and numbers of mineral deposits and occurrences. The eastern part of the map area is within the Kootenay arc, a north-trending arcuate structural zone in the eastern part of the Omineca belt that is characterized by intense polyphase deformation and locally high-grade regional metamorphism. The arc developed mainly in Late Proterozoic and Paleozoic rocks of the Kootenay terrane and in miogeoclinal North American rocks. It contains a number of lead-zinc carbonate-hosted deposits, most of which are concentrated in the southern part of the arc southeast and south of Salmo (Figure 1-1). The Sheep Creek gold camp, within mainly Eocambrian quartzites of the Hamill Group, has produced more than 23 055 kg of gold from gold-quartz veins.

Mesozoic volcanic arc rocks of Quesnellia, west of the Kootenay arc, contain important silver-lead-zinc mineral camps, such as the Ymir camp within mainly metasedimentary rocks, and gold-copper ± molybdenum deposits in mafic volcanic rocks and metasediments of the Rossland Group. These deposits are the focus of this study and are described in detail below.

Plutonic rocks of mainly Middle Jurassic or Early to Middle Cretaceous age are abundant within this part of the Omineca belt. They record post-accretionary magmatism and hence have geochemical and petrological signatures that reflect continental crustal contributions. Deposits within and along the margins of these plutonic rocks include a variety of porphyry types, copper-gold, tungsten and molybdenum skarns, and numerous precious metal and polymetallic veins.

The concentration of metallic mineral deposits in the southern part of the Omineca belt coincides with a marked change in the structural grain from easterly, south of Salmo, to more northerly farther north. This prominent deflection follows the loci of earlier structures that developed along or parallel to changes in the inferred western cratonic margin of North America, or to underlying basement anisotropies. In Middle Cambrian time, the southwesterly deflection parallels a change from platformal rocks of the Nelway Formation in the south to deeper water facies of the Lardeau Group to the north (Höy, 1982a,b). In Late Proterozoic time, fluvial quartzites of the Hamill Group and Quartzite Range and Reno formations were shed northward in alluvial fans (Devlin and Bond, 1987), inferring a tectonic high south of the Nelson-Rossland map area. Farther east in the Purcell anticlinorium, Windermere-age block faulting (Lis and Price, 1976) and fundamental changes in the character and thickness of Middle Proterozoic Purcell Supergroup rocks (Höy, 1993; 2000) are evidence of northeast-trending structures that parallel the southwest deflection of the southern Kootenay arc (Höy, 1982a,b). The coincidence of basement and early tectonic features with post-accretionary structures implies that tectonic transport during Laramide contractual deformation may have been parallel to these early structures.

It is suggested that the distribution of many deposits in southeastern British Columbia is controlled, at least in part, by these deep crustal structures. These structures influenced the orientation of extensional faults in Middle and Late Proterozoic time, and the eventual rifted continental margin in Eocambrian time. They appear to have controlled the distribution of granitic magmas, outflow of hydrothermal fluids, and a variety of mineral deposits.

CARBONATE-HOSTED DEPOSITS

Carbonate-hosted deposits in the Nelson-Rossland map area (Appendix 1), commonly referred to as ‘Kootenay arc lead-zinc deposits’, are essentially restricted to the Early Cambrian Badshot Formation, referred to as the Reeves member of the Laib Group in the Salmo area. The larger deposits ranged in size from 6 to 10 million tonnes and contained 1-2% lead, 3-4% zinc and trace silver. The Reeves MacDonald mine produced, until its closure in 1977, 5.8 million tonnes of ore containing 0.98% lead, 3.5% zinc and 3.4 g/t silver. None of these deposits are presently in production, but considerable recent work has focused on the Red Bird deposit, a southern oxidized extension of the Reeves MacDonald, and on gold-bismuth zones at the Jersey deposit.

‘Kootenay arc’ deposits generally consist of lenses, irregular bands, disseminated grains or massive zones of pyrite, sphalerite and galena in dolomite or chert zones within highly deformed limestone (Fyles and Hewlett, 1959; Fyles,
They are irregular in outline and commonly elongate parallel to the structural grain. Contacts with country rocks may be sharp or gradational.

Deposits of the Salmo camp are within fine-grained dolomite of the Reeves limestone. The dolomite is texturally different from more typical barren, well-banded limestone. The dolomite is poorly banded, flecked with black, irregularly streaked or crackled. Breccia zones with dolomite fragments surrounded by sulphides are present in many of the deposits (Photo 3-1a). Sulphides are typically folded along with their country rocks (Photo 3-1b). Massive dolomite typically contains only sparse mineralization.

The origin of these deposits is enigmatic. Fyles and Hewlett (1959) described the deposits as replacements controlled by the dominant phase 2 folds, and locally by faults. They described the close spatial association of mineralization to structures and the brecciated nature of some of the ore. Sangster (1970) and Addie (1970), emphasizing their stratabound nature and laminated sulphides, described the deposits as syngentic with sulphides accumulating in small basins in a deep-water platformal succession. Höy (1982a) suggested that ‘Kootenay arc’ lead-zinc deposits have a diagenetic-syngenic origin, with some sulphides accumulating in shallow water carbonate facies but others in collapsed breccia zones in lithified Badshot carbonate, a model which is similar to that ascribed to massive sulphide deposits in the MacMillan Pass area in Yukon Territories (Turner and Rhodes, 1990) and to some Irish-type Zn-Pb deposits (Hitzman, 1995).

However, Pb-Pb isotopic analyses of galenas from a number of the Kootenay arc lead-zinc deposits in the Salmo area suggest that these deposits have a replacement origin. The data plot as a well-defined, linear trend that closely follows an Upper Crustal model growth curve from middle Paleozoic through to Jurassic (Appendix 8). Pb-Pb data are “markedly radiogenic”, as is common to many carbonate-replacement deposits (Godwin et al., 1982), making interpretation difficult. Godwin and Gabites (in Appendix 8) suggest that the data may indicate a mixing trend from a Cretaceous point on the North American shale model curve to the Jurassic-Cretaceous on the Upper Crustal curve, with the data compatible with a Jurassic age. As these deposits are intensely folded during Middle Jurassic deformation, their age, based on this tenuous Pb isotopic data and their deformational history would be restricted to Early Jurassic, supportive of the model presented by Fyles and Hewlett (1959).

In summary, the intense deformation characteristic of Kootenay arc deposits has modified most of the original features of these deposits making any models of their origin tenuous. In this paper they are classified as carbonate-hosted deposits, a general term that can be applied to a variety of lead-zinc deposits, including Irish types, mantos or Mississippi-Valley types.

**VOLCANOGENIC MASSIVE SULPHIDE DEPOSITS**

A few mineral occurrences in the Nelson-Rossland map area are tentatively classified as volcanogenic massive sulphide deposits (Appendix 1). They are in mixed sediment-volcanic successions in the basal part of the Elise Formation or the upper part of the underlying Ymir Group or Archibald Formation. The Silver 1 deposit, within the Elise, is located on the east side of Cottonwood Creek, 5 kilometres southeast of Nelson (Figure 1-1, 2-1); the Hungary Man, 16 kilometres southwest of Nelson, is in rocks that have been tentatively assigned to the Ymir Group. A new discovery, Silver Lynx, in Ymir Group rocks approximately 10 kilometres west of Nelson may also be a polymetallic massive sulphide deposit.

The Silver 1 and Silver Hawk occurrences, and other showings in the immediate area, consist of galena, sphalerite, pyrite and minor chalcopyrite zones that parallel the prominent north-trending schistosity, and probable primary layering, in Elise Formation chloritic and biotitic schists. The mineralized zone has been exposed for a strike length of about 65 metres with a width of 1 to 3 metres. Assays are variable; values of 0.5 to 5.65% lead, 4 to 13.45% zinc and 13 to 497 g/t silver have been reported. A grab sample across 3 metres, from a trench 9 metres south of the main

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**Photo 3-1a.** Brecciated sulphides (mainly pyrite) in Lower Cambrian Reeves limestone, Reeves MacDonald deposit.

**Photo 3-1b.** Folded sulphides (mainly pyrite) in Reeves limestone, Reeves MacDonald deposit.
shaft, assayed 58 g/t silver, 1.85% lead and 7.36% zinc (Taylor, 1978).

Mineralization at the Hungary Man was discovered in 1900, and two shafts and a crosscut were subsequently developed. The showing consists of massive to semi-massive sulphides in a schistose volcanic-sedimentary sequence, mapped as part of the Ymir Group (Figure 2-2), but possibly within the basal part of the Elise Formation. Sulphide lenses up to 7 metres in thickness and 30 metres in length are within a mineralized north-south trending zone, up to 300 metres in length, that parallels the structural grain and inferred layering. Sulphides include pyrrhotite, pyrite and minor chalcopyrite in quartz gange. Mineralization appears to be concentrated along a volcanic-diorite contact in mineralized shear and breccia zones. Hence, although classified as volcanogenic massive sulphide Besshi-type in BC MINFILE (and Appendix 1), it is possible that it is an ‘intrusion-related gold-sulphide vein’.

Similar style mineralization occurs on the adjacent Connor and Anne-Marie claims. A channel sample from an exposure along Connor Creek assayed 4.42 g/t gold and 2.4 g/t silver over 1 metre (Akhurst, 1989).

The Silver Lynx property was discovered in September, 2000, by Bruce Doyle and subsequently optioned to Cassidy Gold Corp. Work to date, and proposed in the summer of 2001, includes a geochemical survey, geological mapping, prospecting, sampling and a geophysical survey. The geochemical survey has outlined a lead-zinc-silver anomaly greater than 800 metres in length and up to 300 metres in width. Mineralization is reported to be “near the contact between felsic volcanic rocks and black argillaceous sediments”; a selected grab sample from a roadcut of semi-massive sphalerite, galena, chalcopyrite and pyrrhotite assayed 24.59 % Zn, 22.35 % Pb, 0.21 % Cu and 556.4 g/t silver (Cassidy Gold Corp., report).

The possible recognition of volcanogenic massive sulphide deposits in the Rossland Group has some important exploration implications. These occurrences are in eastern, more basal exposures of the Elise Formation, in subaqueous mixed volcanic-sedimentary successions. The potential for classical volcanogenic massive sulphides may be considerably less in more western exposures of the Elise Formation, as large parts of these exposures are subaerial or shallow water, on the flanks of stratovolcanoes (Höy and Dunne, 1997). However, the potential for precious-metal rich Esky-type deposits (Alldrick, 1995) in the Rossland Group must be considered, particularly if felsic components of the Elise Formation are recognized. These deposits are within shallow-water, volcanic arc successions commonly associated with felsic volcanics in bimodal suites.

Felsic volcanic centres within the Elise have not been well documented, although foliated rocks of rhyolitic and dacitic composition are known. Some of these rhyolites are flow-banded Tertiary-age dikes such as occur throughout the Rossland camp area, in the Champion Lakes area, and on the Gus-Swift claims southeast of Salmo. Other occurrences are highly sheared sericite schists that are similar in appearance to sheared felsic volcanic rocks. A sericite schist at the Great Western property, p. 84) between 185.3±3 and 165.5±4 Ma in age, (Höy and Dunne, 1997) is a sheared intrusive rock at least 10 million years younger than the Elise Formation. However, there are some reported felsic volcanic rocks in the Elise, such as at the Silver King deposit, which may be evidence of local bimodal volcanism, and hence may enhance considerably the potential for additional discoveries of volcanogenic massive sulphide deposits.

PORPHYRY COPPER-GOLD: ALKALIC

INTRODUCTION

Porphyry copper-gold deposits related to alkaline rocks in the Canadian Cordillera occur within the pre-accretionary Triassic-Jurassic arc terranes (McMillan and Panteleyev, 1995; Lang et al., 1995a; McMillan et al., 1995). Some of these deposits in British Columbia include Galore Creek, Mount Polley, Afton and Copper Mountain.

General characteristics and settings of these porphyries are well described by McMillan et al. (op. cit) and Lang et al. (op. cit) and summarized by Panteleyev (1995). Alkaline porphyry copper-gold deposits have been further subdivided into those in silica-undersaturated or silica-saturated systems (Lang et al., 1992a, b). Silica-undersaturated systems are more strongly alkalic, dominated by syenite porphyries and containing high concentrations of magnetite. Diorites, monzodiorites and monzonites are the most common igneous phases in silica-saturated systems. Molybdenum content is generally low in both, copper/gold ratios are similar.

Alteration assemblages in alkaline systems are typically zoned vertically and laterally (Lang et al., 1995). Albitic alteration is commonly associated with mineralization in silica-saturated systems; potassium-calc-silicate in silica undersaturated. Sulphide-rich propylitic assemblages may surround these assemblages. In contrast with calc-alkaline deposits, sericitic, argillic and aluminosilicate alteration assemblages are generally absent or of minor importance in alkaline systems.

Within the Nelson-Rossland map area, porphyry copper-gold deposits include Katie, Shaft and possibly occurrences adjacent to the Eagle Creek plutonic complex, all associated with mafic stocks within Early Jurassic Elise volcanic rocks. The Gold Mountain zone of Kena may be a gold porphyry, related to the more felsic Silver King pluton. Associated porphyry rocks are dominantly alkalic, ranging from dominantly silica-undersaturated (Eagle Creek complex) to silica-saturated. They are typical of alkaline porphyry gold-copper class of deposits, with magnetite mineralization associated with potassic feldspar alteration and widespread regional propylitic alteration.

KATIE (082F/SW290)

Names: Katie, Jim
Location: Lat. 49°08’53” N; Long. 117°20’09” W
Elev. 1420 metres
Figure 3-1. Location and regional geology of the Katie property (after Höy and Andrew, 1990a).
INTRODUCTION

The Katie deposit is located 7 kilometres southwest of the town of Salmo (Figure 2-1). Access to the property is via the Hellroaring Creek logging road which leaves Highway 3, 2 kilometres south of Salmo. Topography on the property ranges from gentle to moderately steep slopes at elevations from 1250 to 1700 metres; outcrop is generally sparse. The following report is summarized from Cathro et al. (1993).

Katie is a porphyry gold-copper deposit in dominantly mafic and shoshonitic volcanic rocks of the Elise Formation that are intruded by subvolcanic mafic dikes and sills. Mineralization comprises disseminated and stockwork pyrite, chalcopyrite and magnetite, and late, sheared gold and silver-bearing veins.

Anomalous copper values were first indicated in Hellroaring Creek stream sediments by the 1977 National Geochemical Reconnaissance Survey (GSC Open file 514). A geochemical survey by Amoco Canada Petroleum Company Limited in 1980 identified anomalous copper values in soils (MacIsaac, 1980). Most work in the 1980s focused on adjacent shear-hosted gold-silver targets on the Gus, Swift, Elise and Lisa claims (Andrew and Höy, 1990).

The Katie claims were staked by Ken Murray in 1985 and subsequent soil geochemistry outlined a coincident gold-copper anomaly (Murray, 1987). Balloil Lassiter Petroleum Limited optioned the property in 1988 and completed geological and geophysical surveys and drilled four holes totaling 305 metres. The best intersection assayed 0.24% copper and 0.20 g/t gold (McIntyre and Bradish, 1990).

Yellowjack Resources Limited acquired the property in 1990 and formed a joint venture with Hemlo Gold Mines and Brenda Mines Ltd. to explore the property. Noranda Exploration Company, the operator, conducted geological and geophysical surveys and drilled four holes totaling 8260 metres (McIntyre and Bradish, 1990; McIntyre, 1991; Kemp, 1992). In 1992, Yellowjack took over as operator and drilled an additional 18 holes totaling 4477 metres.

PROPERTY GEOLOGY

The Katie property is underlain by mainly mafic to intermediate volcanic rocks of the Elise Formation in the northwestern limb of the Hellroaring Creek syncline (Figure 3-1). Drill information indicates that numerous subvolcanic sills, the 'Katie intrusions', cut these volcanic rocks. They are spatially associated with both alteration and mineralization.

Tight folds and, locally, shearing and a penetrative foliation deform Elise rocks in the area. Shear zones are more intense south of the Katie prospect, closer to the core of the Hellroaring Creek syncline, and are associated with intense carbonate-sericite-silica alteration (Andrew and Höy, 1990). This shearing appears to predate both Cretaceous (Wallack Creek) and Middle Jurassic (Nelson-age) intrusions. Late northwest-trending normal faults, possibly related to Eocene extension, offset earlier structures and the Cretaceous intrusions.

The Wallack Creek stock is a leucocratic, equigranular intrusion ranging in composition from granodiorite to granite. Although it truncates shearing in the limbs of the Hall Creek syncline, its margin is locally sheared and foliated. Limited trace and major element analyses of the stock indicate that it is metaluminous to slightly peraluminous with a CIPW normative composition of quartz, orthoclase and albite (Einersen, 1994).

MINERALIZATION AND ALTERATION

Drilling on the Katie prospect has defined three areas of low-grade porphyry copper-gold mineralization, the "Main", "West" and "17" zones (Figure 3-2). Reserves in
the Main zone are calculated at 55 million tonnes containing 0.17% copper (K. Murray, personal communication, 1998).

Cathro et al. (1993) recognized at least two stages of mineralization: an alkalic porphyry copper-gold stage and a later, shear-hosted gold-silver-copper-antimony-arsenic stage.

**Alkaline Porphyry Stage**

Porphyry-stage mineralization consists mainly of pyrite, lesser chalcopyrite and bornite, and traces of pyrrhotite, sphalerite, tetrahedrite and chalcocite. Total sulphide content ranges from 1 to 10% and averages about 2%. Sulphides occur disseminated in both volcanics and intrusive rocks and in narrow veinlets with quartz, calcite, K-feldspar, chlorite and epidote. Limonite, malachite and azurite are common on fractures, with partial oxidation extending to depths of over 100 metres.

Copper content generally ranges from 400 ppm to about 1%, and gold, up to 0.5 grams/tonne. Correlation between copper and gold analyses suggests that gold occurs mainly in chalcopyrite. Other elements, such as silver, lead, zinc, arsenic and antimony, have relatively low concentrations.

Up to several percent magnetite is present in most rock types, with the exception of the strongly potassic altered zones. Magnetite occurs as veins, irregular aggregates, breccia fillings, and in narrow zones of coarse secondary magnetite above mineralized intervals (Figure 3-3). A slightly oxidized surface sample of this secondary magnetite contained 14 200 ppm copper and 2 800 ppm gold (Cathro et al., 1993). Accessory minerals, commonly associated with magnetite, include rutile, sphene, ilmenite and leucoxene.

Propylitic alteration in the Katie deposit area is characterized by saussurization of feldspars to a greenish grey mixture of chlorite, epidote, sericite and calcite. Pyroxene grains have been altered to chlorite, sericite and actinolite. Albite is locally developed adjacent to sulphides. As well, calcite, epidote and chloride-pyrite stringers cut mineralization.

Potassic alteration is characterized by a grey, green, pink or brownish mottled, vaguely granular rock composed
Figure 3-3. Cross-sections through the Katie Main zone, Katie property. The location of the section is shown on Figure 3-2 (from Cathro et al., 1993).
Figure 3-4. Regional geology map showing location of mineral deposits and occurrences in the region of the Silver King shear zone, southwest of Nelson (after Höy and Andrew, 1989; Figure 1-1, in pocket).
of K-feldpar, plagioclase and lesser quartz, biotite and chlorite. K-feldpar replaces the groundmass, rims plagioclase grains, and occurs in narrow veins, quartz vein selvages, or irregular flooded zones associated with quartz, pyrite and chalcopyrite. Coarse secondary biotite is also present.

A late, retrograde hydrous alteration overprints prograde alteration types. Sericite replaces plagioclase and secondary K-feldspar and chlorite replace secondary biotite and amphibole (Gtsinger, 1992). Abundant late calcite, epidote and chlorite-pyrite stringers cut the potassic alteration and may also be part of this late retrograde stage.

**Shear-related Au-Ag-Cu-Sb-As Stage**

Although not common, mylonitic shear zones carry significant gold values (1 to 3 ppm), silver (10 to 60 ppm), up to 1% copper, and anomalous levels of arsenic and antimony. The sheared rocks are pervasively altered to an assemblage of quartz, sericite and carbonate and contain weakly to strongly contorted quartz-dolomite-sulphide veins. The veins contain minor but locally abundant concentrations of pyrite, chalcopyrite, tetrahedrite and arsenopyrite and traces of molybdenite and specular hematite.

The attitude of the mylonite shears is not known, but one set appears to strike northwest. The shears appear to be younger than the porphyry stage mineralization. They may be related to the early shearing recognized on the limbs of the Hellroaring Creek syncline, and parallel to the inferred northwest trend of layering in the deposit area.

**SUMMARY AND DISCUSSION**

Katie is an alkaline copper-gold porphyry deposit in mafic to shoshonitic volcanic rocks of the Elise Formation and a series of mafic, comagmatic (?) dikes and sills. A potassic alteration zone is surrounded by a wide area of pervasive propylitic alteration. Mineralization is closely associated with zones of biotite and K-feldspar alteration, in an area that measures at least 1800 metres by 500 metres. Coarse-grained secondary magnetite-cemented breccias are commonly associated with mineralization, locally concentrated above sulphide zones.

Shear zones, with local enrichment of gold and silver, and containing as well copper, arsenic and antimony, cut porphyry-style mineralization. The age of this shearing and related mineralization is not known. It is probably related to northeast-trending shearing that is recognized immediately to the south and appears to be pre-Middle Jurassic in age; however, there are more brittle northwest-trending faults farther to the northwest that are interpreted to be related to Eocene extension.

**SHAFT (082F/SW331)**

Names: Shaft, Cat, Magpie, Eldorado, Dolly
Location: Lat. 49°26'11" N; Long. 117°16'28" W
Elev. 1400 metres

**INTRODUCTION**

The Shaft occurrence is a gold-copper deposit associated with highly sheared mafic intrusive rocks approximately 7 kilometres south of Nelson (Figure 2-1; 3-4). It was located in 1987 near old trenches and adits that are believed to have been developed between 1900 and 1904. In the fall of 1987, South Pacific Gold Corporation optioned the property and undertook geological mapping, trenching, magnetic and induced polarization surveys (Seywerd, 1988), soil and rock geochemistry and 760 metres of diamond drilling. More recently, Sultan Minerals Inc. optioned the property, and the adjoining Kena, and resampled and assayed trenches and drill core.

**REGIONAL GEOLOGY**

The Shaft property is on the eastern limb of the Hall Creek syncline, a tight south plunging fold with Hall Formation in its core and Elise and Archibald formations on its limbs. Intrusive rocks in the vicinity of the Shaft deposit include the Silver King intrusion a few hundred metres to the west, a number of small Nelson-age (ca. 165 Ma) intrusions just to the north and a highly sheared and elongated diorite intrusion that, in part, hosts mineralization (Figure 3-5). Both the Silver King and the diorite are deformed by northwest trending shearing concentrated on the limbs of the Hall Creek syncline.

Much of the Shaft property is underlain by augite porphyry flows and lapilli, crystal and fine-grained tuffs of the upper part of the Elise Formation. These mafic to intermediate-composition volcanic rocks are intruded by an elongate, fine to medium-grained mafic intrusive complex that is commonly locally brecciated. Due to the local intense shearing and foliation, it is often difficult to distinguish it from mafic tuffs. The complex is tabular, up to 50 metres in width and 5 kilometres in strike length. Although it appears to be a sill, it is probable that it crosses the Elise hostrocks and has been transposed into parallelism.

The intrusive complex is a porphyritic intrusion that ranges in composition from quartz diorite to monzodiorite with minor diorite (Andrew and Höy, 1989). It is similar to other small mafic intrusions in the Elise Formation, such as the Katie, that are interpreted to be subvolcanic intrusions (Dunne and Höy, 1992). It comprises an intergrowth of 30 to 45% anhedral to subhedral calcic plagioclase (An 55-60), 5 to 10% orthoclase, rare microcline and 2 to 3% quartz. The feldspars are strained and have been variably altered to sericite. Biotite (10 to 25%) and ?K-feldspar are widely distributed. Biotite occurs as sheaves of tabular crystals, commonly intergrown with chlorite, that have grown parallel to schistosity; some masses retain a prismatic shape, perhaps pseudomorphic after hornblende or augite. Epidote and magnetite are common accessory minerals, and apatite, sphene, hematite and malachite are present in trace amount. Fine-grained chalcopyrite, pyrite and magnetite are disseminated throughout. Carbonate, mainly calcite, occurs as irregular veinlets, generally intergrown with quartz and, locally, biotite and feldspar.
lower ELISE FORMATION
augite ± plagioclase basal flows, flow breccias, subvolcanic intrusions.

Je1

lower ELISE FORMATION
andesite tuff, minor basaltic tuff: Je8l, lapilli tuff with plagioclase ± augite-bearing volcanic clasts; Je*x, plagioclase ± augite crystal tuff.

Je8

pyroclastic units
basaltic tuff: Je7f, mafic, fine tuff.

Je7

epiclastic units
tuffaceous siltstone, sandstone: Je10a, argillaceous siltstone.

Je10

tuffaceous conglomerate: Je11c, predominantly intermediate to felsic volcanic and intrusive clasts; Je11b, mixed mafic felsic clasts; Je11a, predominantly mafic volcanic clasts.

Je11

lower ELISE FORMATION: mafic to intermediate flows, tuffs, epiclastic deposits and subvolcanic intrusions.

Je

ELISE FORMATION: mafic to intermediate flows, tuffs, epiclastic deposits and subvolcanic intrusions.

upper ELISE FORMATION

MIDDLE JURASSIC
NELSON intrusions: Jn1, granodiorite, quartz monzonite; Jn2, diorite porphyry; Jn3, breccia.

mJn

INTRUSIVE UNITS

LOWER OR MIDDLE JURASSIC (?)
SILVER KING intrusions: plagioclase porphyry; locally intensely sheared.

Jsk

fine to coarse, granular diorite.

Jdi

LOWER JURASSIC
ROSSLAND GROUP

Legend

Figure 3-5. Geological map of the Gold Creek - Cottonwood Creek area south of Nelson, showing the location of the properties (see also regional map, Figure 1-1).
MINERALIZATION AND ALTERATION

Two principal copper-gold showings, the Shaft and the Cat approximately 500 metres apart, were identified on the Shaft claims in 1987 (Figures 3-6 and 3-7).

Mineralization on the Shaft occurs mainly in the monzodiorite intrusion, but also in the Elise tuffs and in the margins of the Silver King porphyry. It comprises up to one percent magnetite, and a high proportion of sulphides, including up to 15% pyrite, 3% chalcopyrite and rare pyrrhotite. Chalcopyrite occurs mainly as disseminations, small discrete patches, thin discontinuous laminae and fracture fillings, whereas pyrite and magnetite are mainly disseminated throughout the intrusive complex. Sulphides occur both within the breccia fragments and in the matrix. Malachite forms on fracture surfaces adjacent to chalcopyrite in surface exposures.

At the Cat zone (Figure 3-6), sulphides are concentrated within the matrix of a crackle breccia. The mineralization forms a lens, approximately 9 by 5.5 metres in dimension. Assays from this showing averaged 1.37 g/t gold and 0.7% copper (South Pacific Gold Corp., report, 1988).

The monzodiorite and Elise tuffs are both variably altered to a chlorite-epidote-carbonate-sericite assemblage. Although this assemblage resembles that typically found in greenschist facies regional metamorphism elsewhere in the Nelson area, the extent of alteration at the Shaft showing is far more intense. This suggests that probable early potassic

![Figure 3-6. Geology of the Cat zone.](Image)
### TABLE 3-1
ANALYSES OF SELECTED HAND SAMPLES AND 1-METRE SURFACE CHIP SAMPLES FROM THE CAT AND SHAFT SHOWINGS

<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Sample Type</th>
<th>Au ppb</th>
<th>Ag ppm</th>
<th>Cu ppm</th>
<th>Pb ppm</th>
<th>Zn ppm</th>
<th>Co ppm</th>
<th>Ni ppm</th>
<th>As ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cat showing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36475</td>
<td>R79-1</td>
<td>chip</td>
<td>160</td>
<td>&lt;0.3</td>
<td>820</td>
<td>6</td>
<td>95</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>36476</td>
<td>R79-2</td>
<td>chip</td>
<td>32</td>
<td>&lt;0.3</td>
<td>760</td>
<td>8</td>
<td>107</td>
<td>42</td>
<td>66</td>
</tr>
<tr>
<td>36477</td>
<td>R79-3</td>
<td>chip</td>
<td>&lt;20</td>
<td>&lt;0.3</td>
<td>320</td>
<td>9</td>
<td>95</td>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>36478</td>
<td>R79-4</td>
<td>chip</td>
<td>203</td>
<td>&lt;0.3</td>
<td>146</td>
<td>11</td>
<td>108</td>
<td>22</td>
<td>4</td>
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Figure 3-7. Geology of the Shaft area.
alteration was overprinted by propylitic alteration, with a later assemblage of sericite-carbonate-quartz.

Surface grab samples at the Shaft zone assayed an average of 6.2 g/t gold and 1% copper (Jenks, 1988). The best intersection in drill core is 5.4 metres containing 6.9 grams gold and 1% copper. Resampling and assayng of trenches in 1999 yielded 5.64 g/t Au and 0.95% Cu over a “true” mineralized width of 12 metres, including 2 metres containing 14.14 g/t Au and 1.73% Cu (Sultan Minerals Inc., report, 2000).

Analyses of selected hand samples and 1-metre surface chip samples are shown in Table 3-1; gold correlates positively with copper and with cobalt. High gold and copper concentrations also correspond with zones of intense chlorite-sericite-carbonate alteration. Lead, zinc and arsenic show a positive correlation, although concentrations are noticeably lower (Table 3-1).

**DISCUSSION**

Mineralization at the Shaft and Cat prospects is in Lower Jurassic Elise Formation tuffs and a mafic, possibly syngentic, monzodiorite intrusion. Potassic and intense propylitic alteration are spatially associated with the intrusion and the Au-Cu mineralization. Regional metasomatism to greenschist grade and intense shearing have overprinted host rocks and mineralization.

The nature of the mineralization and alteration and its association with an intrusive body suggest that Shaft may be part of a highly sheared alkali porphyry Cu-Au prospect, similar to the Katie deposit.

**KENA GOLD (082F/SW237)**

Names: Kena Gold, Kena 7, Cottonwood
Location: Lat. 49°25'33" N; Long. 117°15'57" W
Elev. 1500 metres

Kena Gold is located approximately 7 kilometres south of Nelson (Figure 3-5). Kena Gold and a number of other occurrences or zones in the area, including Shaft, Cat, South Gold, Gold Mountain and Kena Copper, have now been combined as the Kena property, owned by Sultan Minerals Inc.

The regional geology of the Kena property area is described above (see Shaft). The area is underlain by mainly mafic flows and tuffs of the upper Elise Formation which are intruded by the Middle Jurassic Silver King pluton. The Elise Formation is commonly brecciated and sheared, and in the vicinity of mineralization, silicified and potassic altered.

Mineralization at Kena Gold consists mainly of broad zones of disseminated pyrite and chalcopyrite within a silicified and brecciated diorite intrusion, and the host Elise metavolcanics. One drill hole, LK86-20, averaged 1.1 g/t Au over its entire 136.85 m length, with a 31.43 metre zone containing 2.3 g/t Au (Sultan Minerals Inc. Report).

**GOLD MOUNTAIN ZONE**

Name: Gold Mountain
UTM: 5475907N; 479363W
Elev. 1483 metres

The Gold Mountain zone, located several hundred metres southwest of the Cat showing, was discovered by Sultan Minerals Inc. in 2000. This brief description, summarized mainly from a report by Sultan Minerals (July, 2001), describes the results of their recent exploration of the zone. It is outlined by a gold soil geochemical anomaly that measures 2000 metres by 600 metres. In contrast with other zones on the Kena property, this zone is within and along the margins of the Silver King porphyry. It consists of disseminated and fracture-filled pyrite with elevated gold contents. One drill hole at the south end of the zone averaged 0.4 g/t Au over its entire 235.5 metre length, including 24 metres containing 1.1 g/t Au and 9 metres of 2.3 g/t Au. Analyses of hand samples have returned values up to 5.48 g/t Au, and chip samples of trenches averaged 1.43 g/t Au, with a 3-metre chip sample containing 11.38 g/t Au.

Preliminary work on the Gold Mountain zone by Sultan Minerals suggests that the deposit may by a porphyry gold deposit, related to the Silver King pluton.

**GREAT WESTERN (082F/SW333)**

Names: Great Western, White Witch, Thistle, Aberdeen
Location: Lat. 49°26'17" N; Long. 117°18'47" W
Elev. 1432 metres

**INTRODUCTION**

The Great Western Group is located 6 kilometres south of Nelson near the confluence of the west and main forks of Giveout Creek. Mineralization comprises a number of gold-copper zones in highly sheared mafic volcanic rocks of the Elise Formation and felsic intrusive (?) rocks.

Access to the property is via the Giveout Creek road for 3.5 kilometres, which leaves Highway 6, 6.2 kilometres south of Nelson, and then the Silver King mine road for 2 kilometres (Figure 3-4).

The property was initially discovered in the early 1900s and a number of small pits and trenches were dug. Systematic exploration began in 1979 when Asarco Exploration Company of Canada Ltd. registered the Aberdeen claims. Asarco conducted soil sampling, geophysics and diamond drilling in nine holes in the period 1972-1982. In 1985, Lindex Explorations Ltd. entered into an option agreement with Asarco Ltd. (Aberdeen claims) and R.J. Borden (Great Western claims).

Lectus Developments Ltd. began surveying, sampling and trenching on the claims in 1986, and in 1987 drilled 21 holes. Pacific Sentinel Gold Corp. did extensive work over a large area in 1989-1990, termed the Great Western Star Project that included considerable trenching, sampling, geophysics, geochemistry and 5,880 metres of diamond drilling. Most of this work, however, was concentrated on other occurrences or areas, most notably on the Toughnut claims (see below).

**REGIONAL GEOLOGY**

The Great Western Group lies on the eastern margin of the Silver King shear zone, a zone more than a kilometre wide that extends northwest from the closure of the Hall
Formation in the core of the Hall Creek syncline (Figure 3-4). Rocks are locally intensely sheared and therefore it is often difficult to distinguish original rock types. Much of the upper Elise is missing in this area, perhaps removed by this shearing.

The Elise succession is intruded by the Silver King porphyry, dated at ca. 174-178 Ma (Höy and Dunne, 1997). The porphyry is deformed and metamorphosed, with intense shearing concentrated along its margins.

Augite porphyry flows, mafic tuff and intermediate lithic tuffs underlie the southwestern part of the Great Western claims. The succession is interpreted to be inverted as it occurs on the western limb of the overturned Hall Creek syncline. Supportive evidence for a generally overturned succession includes possible inverted graded beds in drill core (P.B. Read, personal communication, 1989) and rare bedding-cleavage intersections recognized in thin limestone layers.

The mafic volcanic rocks comprise predominantly green phyllites and schists. Lapilli tuff units, containing stretched mafic clasts in a schistose matrix, are observed locally. Foliated and sheared mafic flows and flow breccias occur in the footwall of the most northerly mineralized zone (Figure 3-8). Elsewhere, foliated green phyllyite without recognizable clasts is interpreted to be derived from mafic fine tuff. Within these mafic volcanic rocks are a number of zones of intense carbonate-sericite-quartz alteration that are conformable to foliation and contain the gold-copper mineralization. A number of these zones are cored by felsic intrusive lenses.

One of these lenses, now largely altered to a carbonate-sericite-quartz assemblage, is exposed in the most northerly mineralized zone (Figure 3-8). U-Pb dating of zircon fractions restricts its age to between 185.3±3 and 165.5±4 Ma. The lens is generally less than a metre thick and at least 200 metres in length. It contains broken quartz grains, altered plagioclase phenocrysts and minor secondary biotite in a fine-grained schist matrix. Accessory minerals include biotite, apatite and tourmaline; fine-grained euhedral pyrite is concentrated mainly as stringers parallel to the foliation.

MINERALIZATION AND ALTERATION

Three principal zones of gold-copper mineralization occur in the immediate area. These are the Giveout Creek North and South zones, discovered in 1987, and the Black Witch zone located to the north.

Mineralization occurs in zones of intense carbonate-quartz-sericite alteration in both mafic units and in the associated “felsic” lenses. The alteration zones are 5 to 10 metres in width and several hundred metres in length. They contain 2 to 3% sulphides, dominantly pyrite with minor chalcopyrite, as foliation parallel discontinuous stringers but also pervasive disseminations throughout. Although most mineralization is deformed along with the host rocks, some occurs as late, post-kinematic, crosscutting quartz veins.

Analyses of randomly selected grab and chip samples of the Great Western Group are shown in Table 3-2. Gold content does not appear to correlate positively with other metals but copper, silver and lead have strong positive correlations as do cobalt, zinc and nickel (Höy and Andrew, 1989c). The best intercept in drill core at the Great Western Group was 7 metres containing 9.7 g/t gold; the highest reported assay was 58 g/t gold over 0.9 metres (George Cross Newsletter, Nov. 17, 1987).

SUMMARY AND DISCUSSION

The age and origin of gold-copper mineralization at the Great Western occurrence is not known. Zones have been referred to as ‘conformable gold deposits’ (Höy and Andrew, 1989c). They appear to be spatially associated with
felsic to intermediate intrusions, are aligned parallel to the prominent foliation, have conspicuous alteration envelopes, and are sheared and foliated along with their country rocks. They may be porphyry gold prospects, with mineralization associated with small, high level? intrusions, that owe their conformable nature to overprinting by the intense deformation. The chemistry, mineralogy, age and pre to syntectonic form suggest that the intrusion may be related to the Silver King porphyry. Recognition of probable gold porphyry mineralization here and at the Gold Mountain zone on the Kena property enhances considerably the potential for this style of mineralization in the Silver King intrusions.

**REGIONAL GEOLOGY**

The Toughnut area is underlain by Elise volcanic rocks, comprising dominantly augite phric mafic tuffs, flows?, and a quartz feldspar porphyry (Addie, 1986; Figure 3-9). It is within the Silver King shear, a wide zone of shearing in the limbs and the core of the Hall Creek syncline.

Mafic volcanic rocks of the Elise have a pervasive carbonate alteration, with 1 to 2% disseminated pyrite and minor disseminated magnetite. Fine-grained, pale grey to dark green schists are interpreted to be quartz and feldspar crystal tuffs of intermediate composition (Dawson et al., 1989). They are typically intensely altered with abundant silicification, sericite and iron carbonate. Pyrite, and locally chalcopyrite and malachite, are disseminated throughout the alteration.

The quartz-feldspar porphyry is medium to coarse grained with sericitized plagioclase crystals, ‘eyes’ of quartz, and chloritized hornblende in a bleached, sericitized matrix. It is interpreted to be a high level, possibly subvolcanic, sill (see, for example, Dawson et al., op. cit.). Alternatively, it may be a sheared marginal phase of one of the Silver King intrusions.

A number of fine-grained biotite lamprophyre dikes and sills, with only minor disseminated pyrite and magnetite, cut other units in the Toughnut area.

**MINERALIZATION AND ALTERATION**

The Toughnut showing was first described as a vein “four to eight feet” wide that “contains ore of a high grade character” (GSC Annual Report 1890-1891). Addie (1986) described mineralized shears that contain gold, silver, tetrahedrite, galena, chalcopyrite, pyrite, sphalerite and pyrolusite in a quartz-carbonate gangue. Analyses of three hand picked samples from old working are presented in Table 3-3.
quartz crystal tuffs, and in numerous veinlets in these and other more mafic tuffs. A number of quartz veins, including those that were worked near the turn of the century, contain galena, chalcopyrite, sphalerite and rare tetrahedrite, and are enriched in gold and silver (see Table 3-3). These veins typically parallel the regional foliation, striking approximately 120 degrees and dipping steeply southwest; one vein, on which early workings were developed, can be traced discontinuously for at least 120 metres. Other sulphide-bearing quartz veins clearly cut across the regional north-trending foliation.

Chalcopyrite also occurs rarely with only pyrite in small veinlets or veins; one 5 cm wide vein contained 10 g/t gold and 0.1% copper (Dawson et al., op. cit.). Chalcopyrite, galena and sphalerite are also locally disseminated in zones of chloritic, sericitic or iron carbonate altered Elise volcanic rocks. Sericite zones are locally associated with altered and sheared quartz-feldspar porphyry intrusive lenses. Silification is locally common, as is enrichment of gold and silver. Chlorite and iron carbonate alteration is more common in the more mafic assemblages.

Drilling intersected some gold enriched zones up to several tens of metres thick in Elise volcanic rocks. These are commonly in brittle K-feldspar altered zones, with disseminated pyrite and elevated arsenic values. Diamond drill hole GWS-90-18, at a depth of 106 metres, intersected 26
metres assaying 1.49 g/t gold and 25-50 ppm arsenic (Ronning, 1990).

DISCUSSION

The origin of these and numerous other occurrences in the Silver King shear zone are debatable (see also, Silver King, below). A number of veins farther northwest, close to the margin or within the Eagle Creek plutonic complex (e.g., Star, 082F/SW083) are interpreted to be related to, and perhaps remobilised from, sheared gold-copper porphyry deposits. Others within the shear zone may be related to intense alteration within or along the margins of Silver King intrusions.

Quartz-carbonate-sulphide veins in the Tougntut area, both parallel to and crosscutting the Silver King shear, may also be remobilised from larger low grade deposits of disseminated mineralization. The tenor of these veins, carrying base metal sulphides and chalcopyrite, and with elevated gold content, is similar to some porphyry mineralization. Furthermore, the widespread alteration in hostrocks, disseminated sulphide content, potassic alteration, and spatial relationship with intrusive rocks, support porphyry style mineralization. The elongation of mineralized zones parallel to the Silver King shear, as indicated in both soil geochemistry and geophysical surveys, may be due to structural extension.

**ALMA N AND STAR (082F/SW083)**

Names: Star, Alma N, Great Western Star, Gold Eagle, Ron, Ja, Pb, Bee

Location: Lat. 49°26’55” N; Long. 117°21’45” W

Elev. 1493 metres

INTRODUCTION

Alma N and Star are gold-copper prospects near the margin of the Eagle Creek plutonic complex seven kilometres southwest of Nelson (Figure 3-4). They are accessible by the Giveout Creek road that leaves Highway 3a, 6 kilometres south of Nelson. The original Alma N showing is located about 400 metres southeast of the Star occurrence. These are dominantly veins, although associated dispersed mineralization, commonly within the intrusion, and pervasive K-feldspar alteration, suggest similarities with copper-gold porphyry deposits. They are in the Silver King shear zone, within either the Eagle Creek complex or Elise volcanic rocks.

Alma N and Star were discovered in 1897. Cockfield (1936) reported minor underground work and a small ore shipment to the Trail smelter that returned 21.6 g/t gold, 75 g/t silver and 1.2% copper. In 1912, some ore was shipped to the Granite-Poorman mill. In 1984, U.S. Borax explored these prospects under the terms of an option agreement with Reymont Gold Mines Limited. Work included soil geochemical surveys, I.P., reverse circulation drilling and diamond drilling.

Pacific Sentinel Gold Corp. optioned a large area, including the Alma N and Star prospects, from Reymont Gold Mines and Lectus Development, and in 1989 began an exploration program that included geological mapping, line cutting, soil geochemistry, magnetometer and I.P. surveys, trenching and rock geochemistry (Dawson et al., 1989). Work by Pacific Sentinel in 1990 concentrated on diamond drilling, with 5,880 metres drilled in 26 holes, mainly in the Alma N and Star showing areas, but also at the Tougntut occurrence located farther south. The target of this exploration program was a “bulk mineable copper-gold deposit with similarities to a porphyry system. Volcanogenic massive sulphide are a secondary target” (Ronning, 1990).

REGIONAL GEOLOGY

The Alma N and Star showings are near the contact of the Eagle Creek plutonic complex with Elise volcanic rocks. Intense shearing and alteration related to the Silver King shear zone are pervasive throughout the area. The Eagle Creek plutonic complex, or “pseudodiorite” (Mulligan, 1952) is generally a medium to coarse-grained mafic intrusion, in part gneissic, with syenitic to ultramafic phases (Mulligan, 1951, 1952; Little, 1982a,b). In the vicinity of the Moochie occurrence, it is a metadiorite (Lindsay, 1991). Its age is not known; however, it has been interpreted to be co-genetic with the Elise Formation (Dunne and Höy, 1992; Höy and Dunne, 1997). It is cut by the Middle Jurassic Nelson intrusion and by the Silver King shear zone.

Contacts of the Eagle Creek plutonic complex with the Rossland Group rocks are generally sharp, locally marked by coarse-grained clinoxyroxenite that comprises mainly augite with lesser green amphibolite and secondary chlorite. Within the Silver King shear, the complex is altered so that plagioclase is commonly saussuritized, sericitized and/or partially replaced by chlorite; muscovite, chlorite and calcite overprint and surround plagioclase and microcline and segregated albite and epidote show fine-grained cataclastic textures.

Elise volcanic rocks in the vicinity of the showings are now mainly chlorite schists, also due to intense shearing and alteration in the Silver King shear zone. These rocks are interpreted to be within the upper Elise; however, the lower-upper Elise contact is not well established here so it is possible that they are mafic tuffs of the lower Elise.

MINERALIZATION AND ALTERATION

**Alma N**

The Alma N is at the contact of schistose Elise rocks and the Eagle Creek complex. The contact is “an indistinct zone several tens of metres across typified by large xenoliths of partially digested volcanic rock within potassic altered leucocratic monzonite” (Dawson et al., 1989). Pyrite is disseminated throughout the contact zone, increasing from 1-2% in the country rock to 3-5% in the intrusion. Gold content correlates positively with increasing pyrite content and potassic alteration. In the Silver King shear zone, higher gold content is associated with strong quartz-sericite alteration and pyrite content up to 10 percent.

Cockfield (1936, p. 70) described decomposed dioritic rock at the contacts, specks of pyrite, manganese on joint planes, and a number of faults. The Elise Formation is described as a schist “impregnated with pyrite and stained with malachite”. Cockfield (op. cit.) also reported “gold values”
in quartz and silicified country rock along this contact. A “dioritic” rock, with little pyrite or quartz, carried a rich “streak of ore”. Numerous grab samples of unaltered to oxidized Elise and intrusive rock, reported by Cockfield, contained gold values that ranged up to 31 grams/tonne.

Considerable drilling by Pacific Sentinel Gold Corp. concentrated on the contact mineralization of the Alma N zone. Mineralized drill intersections are listed in Table 3-4. These mineralized zones are within an altered “monzodiorite”, with disseminated and fine fracture-controlled pyrite, magnetite and minor chalcopyrite (Ronning, 1990). Alteration includes bleaching, locally pervasive K-feldspar, and late calcite veinlets.

**Star**

The Star deposit is in sheared rocks within the Eagle Creek monzodiorite complex. Cockfield (1936) described it as a north-trending, nearly vertical shear that contains an irregular quartz vein locally up to 35 centimetres in width. The vein “includes a considerable amount of country rock and the whole is mineralized with pyrite, chalcopyrite and malachite. The sulphides are not confined to the vein but are found in the sheared rock on either side” (p. 70).

Drilling by U.S. Borax, summarized in Dawson et al. (1989) and tabulated below, intersected wide zones of low grade mineralization in generally medium to coarse-grained monzonite that are cut by considerably higher grade veins. Drill hole S-48 intersected several centimetre-wide regular quartz vein locally up to 35 centimetres in width. Drill hole S-51, collared 200 metres to the north, intersected a wide zone of intense potassic alteration with abundant secondary biotite and orthoclase and locally up to 50% sericite. Mineralization here comprises widespread, finely disseminated pyrite, chalcopyrite and minor bornite (Dawson, op. cit.). This mineralization apparently trends northwest, parallel to the Silver King shear zone. Trenching along the extension of the zone uncovered monzonite with disseminated chalcopyrite and malachite and northwest trending fractures with higher (one percent) chalcopyrite concentrations.

**DISCUSSION**

Early exploration work in the Star and Alma N area focused on the small high grade gold veins. However, more recent work has recognized the potential for larger, high tonnage, low grade copper-molybdenum mineralization.

Widely dispersed chalcopyrite and pyrite occur near the margins of the Eagle Creek plutonic complex, associated with widespread K-feldspar and biotite alteration. Locally, this style of mineralization extends out into altered and sheared Elise Formation mafic volcanics, although there the grades are lower. Mineralization appears to be largely prekinematic, locally sheared out or concentrated parallel to the northwest trend of the Silver King shear.

The style of mineralization, its concentration in the margins of the Eagle Creek plutonic complex, and association with pervasive potassic alteration, suggest that it is a porphyry gold-copper prospect. Concentration within and parallel to the Silver King shear may be due to later remobilization. Higher grade veins, such as Star and Alma N, may also record late remobilization.

**PORPHYRY Mo**

Porphyry molybdenite deposits within the Nelson-Rossland map area are concentrated on Red Mountain west of the Rossland gold-copper vein camp and on the Stewart claims west of Ymir. The Red Mountain deposits are described in Chapter 4; the Stewart deposits, below. A number of other porphyry Mo occurrences are listed in Appendix 1 and plotted on Figure 1-1. For summaries, refer to BC MINFILE.

**STEWART 2 (082F/SW229), BOBBI (250) and Fresno (251)**

**INTRODUCTION**

The Stewart molybdenite occurrences are associated with a multistage intrusive complex in the Elise and Hall formations due west of Salmo (Figure 3-10). Base and precious metal occurrences on the Stewart property include the Free Silver (082F/SW277) and May Blossom (082F/SW070), discovered in 1896. Arrow Tungsten (082F/SW311) is a tungsten-copper-zinc-molybdenum skarn occurrence in the Hall Formation just north of the Breccia 2 molybdenite complex (Figure 1-1).

Work on the Fresno group by Copper Horn Mining from 1969 to 1970 included geological mapping, and magnetometer and geochemical surveys (Manning, 1967). Quintana Minerals Corp. held a large part of the property in 1969-1970, then called the Salmo Group, and carried out extensive surface exploration for base and precious metals. In the late 1970s, Eric and Jack Denny acquired the Stewart property, which included Fresno, Main Molly, West Anomaly, Arrow Tungsten, Free Silver and May Blossom. In 1979 it was optioned to Shell Canada which did geochemical and geophysical surveys, geological mapping and diamond drilling (Turner, 1980). After cessation of mineral exploration by Shell Canada, Selco optioned the Stewart claims, and carried out extensive exploration in the early 1980s, including mapping, considerable rock geochemistry, soil conditions and geophysical surveys. A number of other porphyry Mo occurrences are listed in Appendix 1 and plotted on Figure 1-1. For summaries, refer to BC MINFILE.
sampling, airborne geophysical surveys and diamond drilling (Grant, 1983; Hickling, 1983; Carpenter, 1984). More recent work, including additional mapping concentrated in the Stewart Mo - Arrow Tungsten area, Gold Hill on the southwestern Stewart claims, and the Craigtown Creek gold anomaly area, is summarized by Kaufman (1995). The Stewart claims are presently held by Eric and Jack Denny.

This brief summary concentrates on the geology of the molybdenite occurrences at and adjacent to the Stewart Group. Descriptions of other occurrences on the claim group, listed in Appendix 1, are found in BC MINFILE. This review is taken largely from the referenced assessment reports, some unpublished data supplied by Eric Denny (BC Property File) and from BC MINFILE.

REGIONAL GEOLOGY

The Stewart property area is underlain by Hall Formation metasediments in the core of the Hall Creek syncline, and Elise Formation metavolcanics on the east limb of this syncline (Figure 3-10). The Elise-Hall contact generally trends northward, but is offset to the east in the vicinity in the claim area, probably due to a late southeast-trending right-lateral fault. This fault is cut by a composite porphyritic quartz monzonite stock that is probably a phase of the Nelson batholith. Molybdenite-bearing breccia zones occur within the stock, the Arrow Tungsten occurrence is along its northern margin, and the May Blossom and Free Silver vein occurrences are close to its southern margin.

Coryell intrusive rocks, of Eocene age, cut the Hall Formation in the vicinity of the West Anomaly and just south of the Nelson stock. A prominent suite of late north-trending rhyolite dikes cut the eastern lobe of the Nelson stock, the Coryell stock, and both Elise and Hall Formation rocks (Figure 3-10).

MOLYBDENITE MINERALIZATION

Three main areas of molybdenite mineralization are known: showings on the Stewart 2 claim, Fresno farther east, and Bobbi just northeast of the Stewart 2 claim. As well, molybdenite occurs in a zone of quartz stockwork in a small Middle Jurassic(? ) quartz monzonite intrusion, of probable Nelson age, on the West Grid (Hickling 1983).

Molybdenite mineralization on the Stewart 2 claim is concentrated mainly in two breccia complexes along the western edge of the quartz monzonite porphyry. One of these breccias is a pipe-like body that contains disseminated molybdenite; molybdenite also occurs on fractures and in narrow quartz veins. The breccia is associated with intense pyrite-sericite alteration. Molybdenite also occurs in quartz stockwork zones with pyrite and pyrrhotite, K-feldspar alteration and more distal propylitic alteration. Reported reserves are 204,000 tonnes grading 0.37% MoS₂.

The Fresno showing is located on Quartz Creek, about 1.5 kilometres west of Main Showing (Figure 3-10). Molybdenite mineralization, with pyrite, occurs as selvages on fracture surfaces within sheared felsic intrusions.

The Bobbi occurrence is located 2 kilometres northwest of Ymir. Molybdenite, scheelite and minor chalcopyrite are found with sericite in quartz veins and in fractures in a quartz monzonite plug. Fluorite is a common accessory mineral in the intrusion, and very minor disseminated chalcopyrite, sphalerite and galena occur in adjacent sedimentary rocks.

SKARN DEPOSITS

A variety of skarn deposits are recognized within the Nelson-Rossland map-area. Copper, lead-zinc, iron and gold skarns are associated with Middle Jurassic intrusions, whereas tungsten skarns occur mainly in Early Cambrian marbles along the margins of Cretaceous intrusions. A wollastonite skarn north of Rossland is in the Permian Mount Roberts Formation, adjacent to the Tertiary Coryell batholith. Many of these skarns are past producers, most notably the gold skarns at Second Relief and Bunker Hill, the tungsten skarns such as the Emerald Tungsten and Dodger northeast of Salmo, and the molybdenite skarns, including Coxey and Giant on Red Mountain in the Rossland camp (Appendix 1). Exploration continues to be active on a number of these deposits, with considerable recent work in the vicinity of Bunker Hill and on the Rossland Wollastonite, as well as the Mammoth molybdenite skarn drilled in late October, 1998.

The geology of the various skarn types in British Columbia has been dealt with extensively by G.E. Ray and the following overview descriptions are taken largely from his work (Ray and Webster, 1997). Deposit descriptions are summarized from BC MINFILE, assessment reports and field visits during the course of our regional mapping. A number of vein deposits have extensive skarn envelopes that contain dispersed mineralization and have been described as skarns.

GOLD SKARNS

Gold skarns, skarns in which gold is the primary or dominant economic mineral, occur within either Rossland Group rocks or Late Paleozoic rocks adjacent to Middle Jurassic intrusions. Gold skarns are typically within calcareous rocks and can be broadly separated into pyroxene-rich, garnet-rich or epidote-rich varieties (Ray and Dawson, 1998). Mineral and metal zonings are typical of gold skarns. At the Nickel Plate deposit near Hedley, proximal garnet-dominated assemblages containing higher copper-gold ratios give way distally to diopsidic skarns that contain the gold deposits (Ray and Dawson, 1994) and at the QR deposit near Likely, the richest gold mineralization occurs within 50 metres of the distal epidote skarn (Ray and Dawson, 1998; Fox and Cameron, 1995).

All gold skarns within the Nelson-Rossland map-area have been found along the margins of Middle Jurassic intrusions, including the Nelson and Bonnington batholiths and the Rossland monzonite (Appendix 1). Most are within the Elise Formation and many occur adjacent to vein deposits. Copper mineralization is common in many, and lead-zinc-silver mineralization is characteristic of the associated veins. Second Relief, a polymetallic vein with locally, well-developed skarn envelopes, is here described as a gold skarn. However, it has many similarities with the intru-
Figure 3-10. Geology of the Stewart claim group, west of Ymir (modified from Carpenter, 1984 and cited Selco reports).
sion-related gold-sulphide veins described below and in Chapter 4.

SECOND RELIEF (082F/SW187), INEZ AND RAND (082F/SW216)

INTRODUCTION

Second Relief, Inez and Rand are past-producing vein/skarn deposits located along Erie Creek, approximately 20 kilometres south-southwest of Nelson. They are accessible by a road that follows Erie Creek north from Highway 3a west of Salmo.

Vein mineralization at the Second Relief was discovered in the late 1890s and intermittent production continued from 1900 to 1948, with 3 118 kg of Au, 858 kg of Ag, 20 210 kg of Pb and 1 057 kg of Zn recovered from 205 316 tonnes of ore (Appendix 3).

Interest in the Second Relief area continued after production ceased, with Calmark Explorations Ltd. conducting both surface and underground mapping in 1969 (Read, 1969), and Homestead Resources Inc., mapping, soil geochemistry, minor geophysics and some diamond drilling in 1984 (Sookochoff, 1984). In 1988, Hawkeye Developments Ltd amalgamated most of the claims in the area and began an extensive survey with road rehabilitation, sampling and some surface excavating. The program continued in 1989 with the establishment of a large grid, soil sampling, geological mapping, trenching, and magnetometer, VLF-EM and seismic surveys (Ostensoe, 1989). Reverse circulation and diamond drilling tested a number of the veins. Additional work, including underground rehabilitation and sampling, were recommended on two of the veins, the No. 2 and Ida D.

REGIONAL GEOLOGY

The Second Relief area is underlain by a panel of folded and faulted Archibald and Elise Formation rocks surrounded on the north, east and south by the Bonnington batholith. The Elise Formation is in the core of a north-trending syncline, with upper Archibald Formation exposed immediately to the east (Höy and Andrew, 1989b). However, underground work in the late 1930s suggested that the structure is considerably more complex with local reversals of bedding common.

The Archibald Formation comprises dark, thin-bedded argillites and argillaceous siltstones with, locally, concentrations of disseminated pyrite. Adjacent to intrusive rocks, the Archibald is altered to a dark, fine-grained biotite hornfels. The overlying Elise Formation is the main host for the mineralized veins. It consists of dominantly lapilli tuffs with plagioclase and/or augite-phryic clasts. Feldspar crystal tuffs and mafic, fine tuffs are less common.

A variety of dikes occur throughout the area; some diorite and diorite porphyry dikes are clearly early and cut by the veins whereas other “granitic” dikes are post mineralization (Cockfield, 1936). A prominent diorite porphyry dike, with phenocrysts of oligoclase and quartz in a fine-grained dark grey to green matrix, trends northeast closely following the footwall of the Second Relief vein. Small north projections of the dike are cut by the vein, indicating that the vein is post dike. U-Pb data of zircons collected from a probable southwest extension of this dike yielded a 168.9±8 Ma age (Höy and Dunne, 1997). This dike and the mineralization are both cut by “granite porphyry dikes” that trend more northerly (Cockfield, 1936).

The Mount Verde fault (previously referred to as the Red Mountain fault; Höy and Dunne, op. cit.) is a vertical to steeply west dipping fault that is inferred to separate the Archibald from the Elise. Small, generally north-trending faults, offset the Second Relief vein.

MINERALIZATION

The Second Relief mine area includes at least eight subparallel veins that strike northeast and dip steeply northwest in altered volcanics and argillaceous quartzites of the Elise and Archibald Formations. These include the Second Relief or No.1 vein, No.’s 2 to 5, the Ida D and the Inez and Rand veins (Figure 3-11). The veins are sheared, generally quartz-poor, and irregularly mineralized with pyrite and/or pyrrhotite with variable magnetite, chalcopyrite and sphalerite, and trace molybdenite. Gold and silver contents are variable, but concentrated in the quartz, pyrite, epidote, garnet and magnetite bearing veins; visible gold has been reported locally. In general, more massive pyrrhotite and chalcopyrite veins contain less gold. Local skarn envelopes and gangue assemblages include abundant epidote with some diopside, garnet, feldspars, quartz and carbonate.

Second Relief

The Second Relief is the main vein in the camp area, accounting for most of the production. It follows the hanging wall contact of a diorite porphyry dike. The vein strikes 050° and dips steeply northwest. It has a strike length of 300 metres and has been mined to a depth of 400 metres. To the northeast where the vein and dike pass from volcanics to slates, their trend changes from discordant to parallel the trend of the slates and metal values in the vein decrease substantially.

The No. 2 vein parallels the Second Relief vein in the footwall of the porphyry dike. Its width is up to 2.4 metres and its length, greater than 300 metres. Gold assays between 0.137 to 34.2 g/t across one metre or more are reported (Ostensoe, 1989). The No. 2 vein is similar to the Second Relief vein, hosted by fragmental volcanic rocks and mineralized with pyrite, pyrrhotite, magnetite, sphalerite, chalcopyrite and, locally, visible fine-grained gold. Quartz content is variable, and a silicified envelope surrounds the vein.

The No. 3 vein is a narrow stringer, approximately 45 metres southeast of the Second Relief vein. It has no obvious mineralization.

The No. 4 vein, approximately 90 metres southeast of Second Relief, has been exposed by open cuts over a length of 15 metres. “Greenstone” (Elise volcanic rocks) occurs in its hanging wall and diorite in its footwall. It is a quartz vein up to a metre wide that contains pyrrhotite and chalcopyrite. A 0.5 metre wide sample assayed 12.3 g/t gold (Ostensoe; 1989).

The No. 5 vein, 10 metres farther southeast, comprises massive pyrrhotite and chalcopyrite with only minor pyrite
Legend

Mesozoic
Middle Jurassic

- Nelson intrusion
- Feldspar porphyry

Early Jurassic
Archibald formation
- Argillite, argillaceous siltstone, quartzite
- Elise Formation
- Lapilli tuff, minor ash tuff

Veins
Geological contact (approximate)
Abandoned Mineshaft
Adit
River, creek
Road
Layering - inclined
Layering - vertical
Jointing

Figure 3-11. Geology in the vicinity of the Second Relief vein-skarn deposit (from Ostensoe, 1989).
and quartz. It is generally less than a metre in width, although underground it is locally up to 1.5 metres wide. O’Grady (1933, p. 236) reported assays of approximately 7.7, 12.5 and 11.5 g/t gold across widths of 30, 100 and 107 centimetres. More recent assays returned values of 0.07 and 26.53 g/t gold (Ostensoe, 1989).

The Ida D vein occurs in the central portion of the property, about 150 metres west of the Second Relief vein. It has produced approximately 34 280 grams of gold (Appendix 3). Samples of the vein taken at the portal in 1988 assayed 0.10 to 35.65 g/t gold (Ostensoe; 1989). As well, samples of pyritic alteration zones in the central portion of the property were reported to assay 6.2 g/t gold over widths of more than 7 metres (Vancouver Stockwatch, Sept. 12, 1989).

**Rand and Inez**

The Rand and Inez veins occur west of the Second Relief vein system, on the west side of Erie Creek (Figure 3-11). Production from these veins is not known as it is included in production figures for Second Relief. The veins were first described by Cockfield (1936, p. 12): “A vein has been traced continuously for about 800 feet by a series of open-cuts. It strikes north 70 degrees east, dips 75 degrees northwest, and ranges from 1 to 3 feet wide…..The quartz is well mineralized with pyrite”.

A considerable amount of the work in the late 1980s was directed towards exposing and exploring these veins. The veins trend northeast and dip steeply north; they appear to converge towards the northeast, and near the portal are approximately 15 metres apart. The Rand vein has been traced on surface and underground for a total distance of 420 metres; the Inez, approximately 750 metres. Mineralization is generally erratic, comprising lenses of massive sulphides that typically range in strike length from 0.4 to 9 metres. Mineralization consists of pyrite, pyrrhotite and chalcopyrite with flakes and minute particles of gold.

The Inez vein is in Elise fragmental volcanic rocks that contain bands of silicified, hornfelsed sedimentary rocks. A banded, pale buff-coloured, one metre thick rhyolite dike occurs in the footwall at the portal. At least seven zones with possible significant mineralization have been reported with values up to 21.6 g/t gold in one zone 0.37 metres in width and 17 metres in length (Table 3-5).

Results from sampling the Inez and Rand veins during this study are shown in Table 3-6. These are selected grab samples across the width of the veins at three locations on the Inez (344-3, 344-4 and 344-6) and two on the Rand (349-1 and 349-3). Other individual samples include 344-5b and 349-2. Gold content in virtually all samples is significant, with values to 29 ppm in the Inez and 33 ppm in the Rand. Copper content is variable, but generally low, and both lead and zinc contents are generally low. Although molybdenite is locally visible, Mo is not abundant with maximum values of a few tens parts per million.

**DISCUSSION**

These veins were first described as fissure veins by Cockfield (1936). They are clearly structurally controlled, as they are locally sheared and have a common and pronounced northeast structural trend. This trend parallels a number of early plagioclase porphyry dikes, dated at ca. 169 Ma. The close spatial association with these dikes, their common structural control, and the high temperature skarn assemblages in some veins, suggest a genetic link. One of these dikes forms the footwall of the Second Relief vein but, in detail, mineralization locally cuts and, therefore, post-dates the dike. A number of drill holes at the Inez vein encountered massive, locally coarse-grained feldspar porphyry at variable depths, but generally greater than 60 to 70 metres, within sections of epidotized Elise fragmental rocks, suggesting the presence of an underlying intrusion.

The veins have many similarities with the massive sulphide veins of the Rossland camp, including a similar mineralogy, alteration, metal content, and structural control. Both vein camps are also related to similar age intrusions that may be earlier, more mafic phases of the Middle Jurassic Nelson granitic suite.

**GOLD-QUARTZ VEINS**

**INTRODUCTION**

Gold-quartz veins, commonly referred to as Mother Lode veins or mesothermal lode gold deposits, typically occur along major structures, including continental collisional sutures or crustal breaks in stable cratons. Within British Columbia, the largest Au-quartz vein camp is Bralorne; other important camps are the Atlin and Cassiar districts. In the Nelson-Rossland map-area, most Au-quartz veins are within quartzites of the Reno and Quartzite Range formations in the Sheep Creek camp southeast of Salmo. Others occur along major fault structures to the west of the Rossland gold camp (Chapter 4), and in sheared Elise Formation rocks and the Eagle Creek plutonic complex south of Nelson (Appendix 1).

Due to their economic importance, mesothermal gold veins have been the focus of many studies; summaries of their characteristics and settings have been presented by Hodgson (1993), Kerrich and Wyman (1990), Roberts (1987) and Ash and Alldrick (1996). They typically contain native gold in a quartz and carbonate gangue, with variable but generally minor amounts of sulphide minerals such as pyrite, arsenopyrite, galena, sphalerite and chalcopyrite. Alteration is usually restricted, with silicification, pyritization

<table>
<thead>
<tr>
<th>Zone</th>
<th>Length (m)</th>
<th>Average Width (m)</th>
<th>Gold (g/T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15</td>
<td>0.63</td>
<td>8.8</td>
</tr>
<tr>
<td>B</td>
<td>17</td>
<td>0.73</td>
<td>21.6</td>
</tr>
<tr>
<td>C-II</td>
<td>15.5</td>
<td>2</td>
<td>2.9</td>
</tr>
<tr>
<td>C-II</td>
<td>15.5</td>
<td>0.7</td>
<td>8.8</td>
</tr>
<tr>
<td>D</td>
<td>26</td>
<td>2.37</td>
<td>5.8</td>
</tr>
<tr>
<td>E</td>
<td>35.5</td>
<td>0.9</td>
<td>8.4</td>
</tr>
<tr>
<td>F</td>
<td>17</td>
<td>1.93</td>
<td>4.4</td>
</tr>
</tbody>
</table>
and sericitization occurring a few metres adjacent to the veins, and carbonate alteration, to several tens of metres. Most veins have sharp contacts with wallrocks. They commonly occur in high-angle faults, typically as en-echelon veins; some are associated with broad areas of fracturing with gold and sulphides occurring in quartz veinlets or stockworks. Although intrusive rocks are not associated with all Au-quartz veins, many occur along the margins or within syn to post-collisional, felsic to intermediate plutons.

### TABLE 3-6A
ANALYSES OF HAND SAMPLES FROM THE INEZ AND RAND VEINS, SECOND RELIEF

<table>
<thead>
<tr>
<th>Sample No</th>
<th>Au (ppb)</th>
<th>Ag (ppm)</th>
<th>Cu (ppm)</th>
<th>Pb (ppm)</th>
<th>Zn (ppm)</th>
<th>Co (ppm)</th>
<th>Ni (ppm)</th>
<th>Mo (ppm)</th>
<th>Cr (ppm)</th>
<th>As (ppm)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>344-3d</td>
<td>7613</td>
<td>2</td>
<td>400</td>
<td>12</td>
<td>340</td>
<td>30</td>
<td>2</td>
<td>&lt;10</td>
<td>15</td>
<td>39</td>
<td>silicified vein</td>
</tr>
<tr>
<td>344-3e</td>
<td>2821</td>
<td>1</td>
<td>324</td>
<td>26</td>
<td>24</td>
<td>38</td>
<td>2</td>
<td>&lt;10</td>
<td>19</td>
<td>37</td>
<td>disseminated sulphides</td>
</tr>
<tr>
<td>344-3f</td>
<td>535</td>
<td>0.5</td>
<td>410</td>
<td>46</td>
<td>240</td>
<td>34</td>
<td>3</td>
<td>&lt;10</td>
<td>20</td>
<td>40</td>
<td>disseminated sulphides</td>
</tr>
<tr>
<td>344-3g</td>
<td>2949</td>
<td>2</td>
<td>685</td>
<td>14</td>
<td>190</td>
<td>38</td>
<td>5</td>
<td>&lt;10</td>
<td>22</td>
<td>0.28%</td>
<td>quartz vein with sulphides</td>
</tr>
<tr>
<td>344-3h</td>
<td>2071</td>
<td>2</td>
<td>740</td>
<td>192</td>
<td>210</td>
<td>24</td>
<td>2</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>15</td>
<td>sulphide veining</td>
</tr>
<tr>
<td>344-3i</td>
<td>3187</td>
<td>3</td>
<td>0.27</td>
<td>32</td>
<td>2.37%</td>
<td>31</td>
<td>2</td>
<td>22</td>
<td>&lt;10</td>
<td>8</td>
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</tr>
<tr>
<td>344-4a</td>
<td>9399</td>
<td>2</td>
<td>512</td>
<td>62</td>
<td>84</td>
<td>47</td>
<td>&lt;2</td>
<td>11</td>
<td>&lt;10</td>
<td>34</td>
<td>silicified, disseminated sulphides</td>
</tr>
<tr>
<td>344-4b</td>
<td>394</td>
<td>1</td>
<td>196</td>
<td>32</td>
<td>350</td>
<td>40</td>
<td>2</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>19</td>
<td>silicified, disseminated sulphides</td>
</tr>
<tr>
<td>344-4c</td>
<td>4003</td>
<td>2</td>
<td>740</td>
<td>16</td>
<td>104</td>
<td>18</td>
<td>33</td>
<td>10</td>
<td>15</td>
<td>0.32%</td>
<td>quartz-pyrrhotite veining</td>
</tr>
<tr>
<td>344-4d</td>
<td>1932</td>
<td>2</td>
<td>490</td>
<td>14</td>
<td>250</td>
<td>24</td>
<td>&lt;2</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>47</td>
<td>sericite, sulphides</td>
</tr>
<tr>
<td>344-5g</td>
<td>3187</td>
<td>3</td>
<td>0.27</td>
<td>32</td>
<td>2.37%</td>
<td>31</td>
<td>2</td>
<td>22</td>
<td>&lt;10</td>
<td>8</td>
<td>sulphide veining</td>
</tr>
<tr>
<td>344-6a</td>
<td>284</td>
<td>&lt;.5</td>
<td>191</td>
<td>16</td>
<td>60</td>
<td>39</td>
<td>13</td>
<td>&lt;10</td>
<td>66</td>
<td>14</td>
<td>skarn</td>
</tr>
<tr>
<td>344-6b</td>
<td>49</td>
<td>&lt;.5</td>
<td>1</td>
<td>&lt;4</td>
<td>&lt;2</td>
<td>&lt;2</td>
<td>&lt;2</td>
<td>&lt;10</td>
<td>10</td>
<td>35</td>
<td>skarn</td>
</tr>
<tr>
<td>344-6c</td>
<td>75</td>
<td>&lt;.5</td>
<td>79</td>
<td>18</td>
<td>85</td>
<td>37</td>
<td>2</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>21</td>
<td>minor skarn, epidote</td>
</tr>
</tbody>
</table>

Notes: Au by fire assay, ICP; Ag, Cu, Pb, Zn, Co, Ni, Mo, As, by Atomic absorption; Cr by XRF

### TABLE 3-6B
ANALYSES OF HAND SAMPLES FROM THE RAND VEIN, SECOND RELIEF

<table>
<thead>
<tr>
<th>Sample No</th>
<th>Au (ppb)</th>
<th>Ag (ppm)</th>
<th>Cu (ppm)</th>
<th>Pb (ppm)</th>
<th>Zn (ppm)</th>
<th>Co (ppm)</th>
<th>Ni (ppm)</th>
<th>Mo (ppm)</th>
<th>Cr (ppm)</th>
<th>As (ppm)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>349-1b</td>
<td>1565</td>
<td>1</td>
<td>0.10%</td>
<td>8</td>
<td>885</td>
<td>42</td>
<td>2</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>25</td>
<td>thin pyrite veinlet</td>
</tr>
<tr>
<td>349-1c</td>
<td>24</td>
<td>0.5</td>
<td>124</td>
<td>12</td>
<td>70</td>
<td>24</td>
<td>2</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>6</td>
<td>disseminated sulphides in diorite</td>
</tr>
<tr>
<td>349-1d</td>
<td>7872</td>
<td>1</td>
<td>875</td>
<td>14</td>
<td>54</td>
<td>33</td>
<td>25</td>
<td>11</td>
<td>&lt;10</td>
<td>30</td>
<td>silicified, veinlets</td>
</tr>
<tr>
<td>349-1e</td>
<td>6292</td>
<td>2</td>
<td>0.14%</td>
<td>12</td>
<td>60</td>
<td>22</td>
<td>2</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>245</td>
<td>quartz-pyrite veins</td>
</tr>
<tr>
<td>349-1f</td>
<td>6481</td>
<td>1</td>
<td>0.11%</td>
<td>12</td>
<td>83</td>
<td>33</td>
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Notes: Au by fire assay, ICP; Ag, Cu, Pb, Zn, Co, Ni, Mo, As, by Atomic absorption; Cr by XRF

Sheep Creek Camp

**Introduction**

The Sheep Creek camp, located 12 kilometers southeast of Salmo (Figure 1-1), includes more than a dozen past-producing gold-quartz vein deposits in dominantly EoCambrian quartzites of the Reno and Quartzite Range formations. Production from this camp, between 1899 and 1988, totaled 23 101 859 grams of gold (761,456 ounces) and 9 102 786 grams of silver (280,495 ounces) from 1.53 million tonnes of ore; remaining reserves in these deposits are estimated to be approximately 3 940 kilograms of gold (Schroeter and Lane, 1991). The largest individual produc-
ers in the camp were the Queen, Reno and Kootenay Belle deposits (Appendix 1).

The first mine in the camp, the Yellowstone, was discovered in 1896 and began production in 1899. Shortly after, the Queen (1900), Motherlode (1906), and Kootenay Belle (1905) mines began production (Photo 3-2). This early production was concentrated mainly in upper levels of veins that had been enriched by oxidation and leaching. The second period of mining began in 1928 when a new vein on the property, the Reno, was brought into production and other older mines reopened (Mathews, 1953). Production in the camp reached its peak in 1937 and continued at high levels until 1942. A 100-ton cyanide mill was built on the Kootenay Belle mine in 1934 and operated until the mine closed in 1942. Gold Belt Mining Company Limited was formed in 1932, and after acquisition by North American Mines, Inc., a 150-ton mill was installed in 1943.

In 1934 a number of properties, including Queen, Yellowstone, Alexandra, Vancouver and Midnight were amalgamated under the newly formed Sheep Creek Mines Ltd. This company produced from the Queen vein until 1938, and intermittently from other properties until 1970.

Exploration and development work has continued on a number of properties of the Sheep Creek camp. In 1982 some rehabilitation work and drilling were done by Carl Creek Resources, and in 1984 approximately 2 000 tonnes of low grade ore were shipped to the Trail smelter. Work in 1986 by Gunsteel Resources Inc. and Nugget Mines Ltd. was concentrated on the Nugget Mine and included underground rehabilitation, installation of surface facilities and minor drilling (Allen, 1987). Two tunnels explored the Nugget and Calhoun veins. Another company in the Sheep Creek camp, Goldrich Resources Inc., concentrated exploration on their Goldbelt property (Ellerington, 1987). This work included underground rehabilitation and mapping, geophysical and geochemical surveys and diamond drilling on a number of the veins. Some exploration has continued into the 1990s, including a self potential survey at the Reno mine (Endersby, 1992).

**REGIONAL GEOLOGY**

Veins of the Sheep Creek camp are mainly within quartzitic rocks of the Reno and Quartzite Range Formations. These comprise massive, thick-bedded quartzites, argillaceous quartzites and minor argillite deposited as a north to northwest prograding fluvial-deltaic complex along the ancestral western margin of North America in latest Pre-Cambrian to Early Cambrian time. They are overlain by the Laib Group, consisting of impure marbles, calcareous schists, phyllites of the Truman or Mohican Formation, and the immediately overlying Lower Cambrian Reeves or Badshot marble. Overlying rocks of the Upper Laib or Lardeau Group are within the Kootenay terrane.

The structure of the area is well described by Mathews (1953). It is dominated by the Sheep Creek anticline, a major overturned isoclinal fold that has been traced from south of the United States border to north of the Sheep Creek camp. In the vicinity of the camp, it consists of a larger eastern anticline and a western subsidiary anticline (Mathews, 1953). These are cored by rocks of the Reno and Quartzite Range formations, with the Laib Group exposed in an intervening syncline. The folds trend north, have steep east-dipping axial surfaces, and plunge at low angles to the south and, locally, to the north. Most of the veins are on the west limb of the main eastern anticline and in the core and limbs of the western anticline.

Four well-defined sets of faults are recognized by Mathews (1953) in the camp. All the productive gold veins occur within a group of northeast-trending, generally southeast-dipping faults. These have up to 60 to 70 metres right-hand strike-slip motions and several tens of metres of normal displacement. Many are listric. These faults, referred to as the vein fractures, are refracted as they cross from argillaceous units into more competent quartzites, resulting in tensional regimes in quartzitic units. A north-trending quartz porphyry sill swarm cuts these northeast-trending faults.

A few northwest-trending faults, with left-lateral strike-slip motion may be the same age as the vein faults; these, however, contain no mineralization.

Two fault sets clearly post-date mineralization. North-trending, east-dipping faults, with normal displace-
ments up to 300 metres, and “flat-lying” faults with displace-
ments of a few metres have been recognized in underground workings and on surface (Mathews, 1953).

A number of early Cretaceous stocks are exposed in the vicinity of the Sheep Creek camp, but none appear to be spati-
ally related to the veins. As well, north-trending quartz porphyry sills and dikes, referred to as a sill swarm, occur throughout the mine area. The total width of the swarm ranges up to 50 metres, with individual sills varying from a few to 10 metres in thickness. The age of these sills, relative to faulting and mineralization, is not well known. Accord-
ing to Mathews (op. cit.), they cut the northeast-trending vein faults and vein quartz, but appear to be earlier than the sulphide and gold mineralization. Evidence for post-dike mineralization includes rare pyrite veinlets cutting the quartz porphyry, grains of sphalerite along the vein-growth contact and low gold values in the porphyry.

MINERALIZATION

Gold mineralization in the Sheep Creek camp occurs as Au-quartz veins within northeast-trending fault zones. These veins may be branching or occur as en-echelon arrays and can have been explored to depths up to 600 metres. A general description of veins is taken from Mathews (1953, p. 50):

“Nearly all the production of gold has been from those parts of the veins where one or both walls consist of quartzite of either the Nugget or the Nevada members of the Quartzite Range Formation. Vein fractures cutting argillite are generally devoid of quartz or are occupied by only a thin band of barren vein matter. The extent of the productive part of any vein along the vein is, therefore, limited by the distribution of the favorable quartzite in its walls.”

The upper limit of orebodies is most commonly the ground surface, or in the Western anticline the crest of the quartzite beds, but in places in the southern part of the camp, even within a single type of rock, veins become narrower upward to the point that they cannot be mined economically. In general…. vein widths are average or greater than average on the lowest levels of most mines. However, high grade ore occurs less abundantly in the lower levels, and the propor-
tion of the vein that could be mined profitably diminishes.”

Recognition of vein quartz is often difficult within the host quartzites, particularly as vein contacts may be gradational into the host rock. In general, vein quartz is coarser grained, milky white in colour and may be banded parallel to the walls.

Gold occurs as isolated grains, generally from a few microns to 30 microns in size. Most gold occurs associated with sulphides, commonly along quartz-pyrite contacts or, less commonly, along contacts of other sulphides. Approximately 30% occurs in quartz, and very minor amounts in sulphide grains.

OTHER AU-QUARTZ VEIN DEPOSITS

A number of deposits within and along the margins of the Eagle Creek complex west of Nelson have been classified as Au-quartz veins (Appendix 1, Figure 1-1). Although most were small producers, the Kenville (Gran-
ite-Poorman) deposit has produced 2 024 216 grams of gold and 861 085 grams of silver. Other gold-quartz veins occur west of the main Rossland gold camp within fault zones in ultramafics and Elise Formation rocks.

KENVILLE (Granite-Poorman) (082F/SW086)

The Kenville deposit, staked in 1888, was one of the first vein deposits discovered in the Nelson area. It produced intermittently for more than 50 years until its closure in 1954. In 1995, Anglo Swiss Industries Ltd. and Teck Corpo-
ration, with Teck as operator, conducted prospecting, an in-
duced polarization survey and 1140 metres of diamond dril-
lng (Thomson, 1995). The veins form a north-
west-trending system of quartz veins within mafic to ultra-
mafic intrusive rocks of the Eagle Creek plutonic complex parallel to the northwest trend of the Silver King shear to the southeast. The veins comprise milky to glassy quartz with pyrite, chalcopyrite and minor amounts of galena, scheelite, sphalerite and some visible gold (BC MINFILE data). Dis-
seminated sulphides occur in adjacent hostrocks; plagioclases in these rocks are commonly replaced by albite and potassic feldspars, and ferromagnesium minerals by biotite and epidote.

ROSSLAND AREA

Au-quartz veins in the Rossland area are within mainly mafic metavolcanic rocks of the Elise Formation near the northern, faulted contact with an east-trending serpentinite (Fyles, 1984). In contrast with the veins of the Rossland camp, inferred to be genetically related to intrusion of the Rossland monzonite, these Au-quartz veins are assumed to be related to east-directed thrust faults that carried Mount Roberts Formation, unconformably overlying Rossland Group and ultramafic rocks over Rossland Group rocks.

Production from this camp totaled 1 094 000 grams of gold and 496 000 grams of silver; the largest individual pro-
ducers were the I.X.L (811 746 grams Au) and Midnight (245 311 grams). They are described in more detail in Chap-
ter 4.

POLYMETALLIC VEINS: Ag-Pb-Zn±Au

INTRODUCTION

Polymetallic Ag-Pb-Zn±Au veins are the most com-
mon deposit type in the Canadian Cordillera and constitute one of the largest silver resources in the world. They are
common throughout the Nelson-Rossland map-area, and many are past producers. These past producers include many of the veins of the Ymir camp, those within Elise Formation rocks southwest of Nelson, and a number in the South belt of the Rossland camp. These latter veins are described in Chapter 4.

Polymetallic veins have traditionally been considered to be related to intrusion of granitic stocks or batholiths. Supporting evidence includes the close spatial association of these veins and intrusions; many of the veins in the Nelson-Rossland map area are within or along the margins of the Nelson batholith or other small, related stocks. Beaudoin et al. (1992a; 1992b) have stressed the close genetic ties of these veins with major structures that appear to have formed late in the evolution of an orogen. As evidence, they cite the apparent age difference between intrusions and mineralization.

Polymetallic Ag-Pb-Zn±Au veins typically contain galena and sphalerite, with minor pyrite, chalcopyrite and sulphosalts in a carbonate and quartz gangue (Lefebure and Church, 1996). They are generally narrow and steeply dipping, within fractures or fault zones. Wall rock alteration is commonly of limited extent, comprising sericitization, silicification and pyritization.

Appendix 1 lists the known polymetallic veins within the Nelson-Rossland map area. Examples described below typify the main camps; the Ymir camp, dating back to 1899, is the largest of these vein camps.

**YMIR CAMP**

The Ymir camp includes numerous silver-gold-lead-zinc veins in the Ymir Group and Nelson batholith east and north of the town of Ymir (Photo 3-3). Most descriptions of these veins date back to the time of their discovery and development (Drysdale, 1915; Cockfield, 1936); recent work is detailed in a number of company assessment reports. The veins are in an irregular north to northeast-trending belt within the Ymir Group and the southern ‘tail’ of the Nelson batholith. This belt parallels the regional foliation trend in the Ymir Group as well as the Ymir-Nelson contact. It also coincides with the tectonic boundary between Quesnellia and North American rocks, a boundary that is exposed as the Waneta fault to the southwest of Nelson and the Ymir-Nelson contact. It also coincides with the tectonic boundary between Quesnellia and North American rocks, a boundary that is exposed as the Waneta fault to the southwest but is obscured in the Ymir camp by the Nelson batholith ‘tail’.

The camp was discovered in the late 1800s with production beginning at the Ymir, Dundee and Protection deposits in 1899 (Appendix 3). Production reached a peak in the 1930s and was, during these years, the largest silver-producing camp in the British Commonwealth. Production from these deposits ceased in the early 1950s, with total production of 43 006 kilograms of silver and 8 294 kilograms of gold.

The Ymir Group consists of several hundred metres of argillaceous quartzites overlain by a thick succession of grit, siltstone and argillite with discontinuous bands of thin-bedded impure limestone. It has a prominent north-trending foliation, and appears to be internally folded.
A regional precious metal zonation, based on published production data (Appendix 3) is apparent. In general, more northern veins have higher gold/silver ratios than those in the very southern part of the camp. These variations appear to be independent of host lithologies, alteration assemblages or type or degree of shearing. The only noted mineralogical change that accompanies these changes is a higher concentration of arsenopyrite in the more northern deposits. Due to limited recovery of zinc or copper, it is difficult to determine if there is consistent variation in base metal ratios.

Wall rock alteration is generally limited to silicification and sericitization. Disseminated pyrite, extending several metres into the country rock is also common. Some veins are highly fractured and brecciated, and others contain graphitic fault gouge.

The age of these veins is not known. Their close spatial association with the tail of the Nelson batholith suggests a genetic link. Their formation in dextral shear zones that may be related to the northern extension of the Waneta fault implies an age synchronous with latest motion on the fault. However, many veins appear to crosscut the prominent north-trending foliation in the Ymir Group and some, such as the Wilcox deposit, cut the mylonitic fabric within Nelson batholith rocks. These mylonites are typical of high temperature shear zones, suggesting formation during or shortly after intrusion (Vogel and Simony, 1992). Brittle fractures and veins within the shears imply formation after cooling through the ductile-brittle transition, possibly as late as Cretaceous time as K-Ar biotite dates in the ‘tail’ have Cretaceous ages (Archibald et al., 1983). However, Pb isotope analyses, discussed in detail in Appendix 8, group these veins with polymetallic and gold-quartz veins of the Nelson and Rossland camps. This data suggests that the deposits may be related to I-type granitic rocks of Jurassic age.

SILVER KING (082F/SW176)

Names: Silver King, Dandy, Ollie, King, F.S., D50, D45, Iroquois, Kohinoor, Kootenay, Bonanza

Location: Lat. 49°25’18” N; Long. 117°18’00” W; Elev. 1800 metres

INTRODUCTION

The Silver King mine is located 4.5 kilometres south of Nelson on the northeast side of Toad Mountain (Figures 1-1, 3-4). It comprises a number of sheared polymetallic veins in the Elise Formation. It is accessible through the Giveout Creek and Silver King roads, south of Nelson. Exposures are generally scarce in the area, and growth of brush and timber are heavy (Photo 3-4).

The Silver King deposit, discovered in 1886, spurred exploration and initiation of mining in the Nelson area. Production began on a large scale in 1896 and continued through to 1910 by Hall Mining and Smelting Co. Ltd. and Kootenay Development Syndicate; further intermittent production continued, mainly by Consolidated Mining and Smelting Ltd, until about 1949. Total production from the Silver King veins is greater than 200 000 tonnes with recovery of 138 214 kg of silver, 6 789 million kg of copper and 8 896 grams of gold (Appendix 3).

In 1965, New Cronin Babine Mines Ltd. undertook an extensive re-evaluation of the property, reopened underground workings, and from 1965 to 1967 drilled 3710 metres in 54 holes. This work identified a new vein, the King vein, and increased the total proven reserves to 75 026 tonnes containing 295 g/t Ag, 2.1% Cu and 0.9% Pb.

Sproatt Silver Mines conducted a geochemical and geophysical survey in 1973, and outlined two coincident anomalies, one over the Iroquois vein and a second on a new target located 200 metres farther south (White and Cruz, 1973).

In 1981, Hecate Gold Corporation did some sampling and mapping, and in 1983, Mine Quest Exploration Associates Ltd., for Host Ventures Ltd., conducted an exploration program that included 566 metres of diamond drilling, considerable trenching, sampling and mapping (Aylward, 1983).

Proposed work (1998) by Amulet Resources Ltd., current operators, includes an I.P. survey and drilling of three or four holes.

The property geology in this report is based largely on the published results of these exploration programs.

REGIONAL GEOLOGY

Silver King is within the Elise Formation in the Silver King shear zone (Figure 3-4). The Silver King intrusion, a leuco-diorite porphyry characterized by 30 to 60% plagioclase phenocrysts, is located approximately one kilometer to the northeast; similar, highly sheared intrusive rocks are exposed just to the southeast in the Silver King shear zone and the core of the Hall Creek syncline. Two samples of the Silver King intrusion have yielded U-Pb zircon ages of 177±3.0 Ma and 172±6.0 Ma (Höy and Dunne, 1997).

The Elise Formation in the Silver King deposit area comprises highly sheared, mafic volcanic rocks. These have been assigned to the Lower Elise (Höy and Andrew, 1989a;b); however, due to the structural complexity in the area...
area, it is possible that they are a mafic component of the Upper Elise.

The Silver King shear is a zone of intense shearing, nearly a kilometre in width, that trends northwest from the core of the Hall Creek syncline, through the Elise volcanics and into the Eagle Creek plutonic complex. To the southeast it deforms the Silver King intrusion, then appears to die out farther south at higher structural levels in the limbs of the Hall Creek syncline (Figure 1-1). The age of the shearing and associated folding is bracketed between the ca. 175 Ma Silver King intrusion and essentially post-kinematic ca. 165 Ma Nelson batholith.

PROPERTY GEOLOGY

The Elise Formation in the deposit area comprises dominantly augite phryic volcanic rocks and chlorite schist. Previous workers (e.g., H.L. Hill, 1965, unpublished report) have interpreted the more massive units as mafic intrusions within schistose tuffs, whereas Wiswall (1981; in Aylard, 1983), based largely on the gradational nature of the contacts, suggested that these are more competent mafic flows and clastic rocks preserved as cores within sheared tuffaceous volcanics.

The clastic volcanic rocks are either coarse mafic pyroclastic breccias or flow breccias. They typically contain the veins and anomalous metal values, possibly due to their more competent nature. "Pods of felsic material", generally concordant with foliation, include "quartzite" and "rhyolitic" material, interpreted to be both metasediments and felsic volcanics (Wiswall, 1981). It is possible that the "rhyolite" is similar to the felsic intrusive lenses on the Great Western property that are at least 10 million years younger than the Elise Formation (Appendix 4). Alternatively, the "rhyolite" may be older, Elise-age felsic volcanics.

The Silver King porphyry intrudes the chlorite schists, with "apothyses of Silver King porphyry in chlorite schist, xenoliths of the schist, and sharp, cross-cutting contacts" (Wiswall, 1981). It is not an important host for Silver King mineralization.

MINERALIZATION AND ALTERATION

The veins of the Silver King camp include the Main Silver King vein, the Iroquois vein, the King vein and the Kohinoor vein. All trend northwest, within and approximately parallel with the Silver King shear. The veins comprise mainly quartz with calcite, iron carbonate and minor hematite; sulphide minerals include pyrite, chalcopyrite, galena, minor sphalerite and locally, trace stromeyerite, tetrahedrite and bornite. Large prominent lamellae of a black, submetallic mineral may be manganite (Mulligan, 1952). Regional alteration within the shear includes pervasive development of calcite and replacement of mafic minerals by chlorite; iron carbonate, sericite and locally K-feldspar alteration occur more proximal to the veins.

The Iroquois structure has been traced or is inferred to have a strike length of nearly three hundred metres. It comprises irregular stringers and massive quartz with abundant disseminated pyrite, concentrations of chalcopyrite and galena, and minor bornite. Sulphides are commonly concentrated in east-west cross fractures within the shear zone. The immediate hangingwall and footwall are bleached, probably due to sericite and silica alteration. Assays of a number of grab samples, listed in Table 3-7, show silver content up to 456 grams/tonne. Drilling intersected bleached zones with disseminated pyrite, two to five metres in width, with intensely silicified intervals containing abundant stringer pyrite and variable sphalerite; however, silver content is low in these zones, up to 48 grams/tonne (Aylward, 1983).

The Main Silver King vein structure is located 300 metres north of the Iroquois vein. It has a strike length of at least 700 metres and appears to be on strike with the King vein, 300 metres farther east. The vein has a gange of quartz and iron carbonate, with variable concentrations of pyrite, chalcopyrite, galena and sphalerite; in general, lead and zinc content increase to the west. Although mineralization is erratic within the Main vein, widths up to 15 metres are noted by Lorimer (1967). Locally higher sulphide concentrations occur in cross-fractures, similar to those in the Iroquois vein. In the open pit area, an east-west structure, the footwall vein, appears to intersect the Main vein and is the location of most past production as well as present reserves.

Drilling of the King vein in 1965-1967 outlined a reserve of 37 000 tonnes containing 346 g/t Ag and 2.8% Cu (Lorimer, 1967). Further drilling in 1983 also intersected the vein (Table 3-7) and trenching located the vein, for the first time, at surface. It occurs as a highly weathered and fractured structure within augite phryic, manganese-altered Elise volcanic rocks; recognized sulphides include pyrite, galena, minor bornite and minor sphalerite. Sulphides are commonly concentrated in east-west cross fractures within the shear zone.

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<th>Cu %</th>
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Note: analyses by Chemex Labs Ltd., Vancouver, B.C. data from Aylward, 1983; sample 98SK-1; selected hand sample, this study
chalcopirite and galena (Aylward, 1983). Minor disseminated sulphides, including chalcopirite, also occur in the footwall of the vein.

The Kohinoor vein, located about 150 metres south of the King vein, was discovered by the 1965-1967 drill program, and subsequently drilled and trenched in 1983. Mineralization is discontinuous and erratic. Trench SKTR 4 exposed a 0.5 metre-wide silicified zone with minor pyrite, chalcopirite, galena and sphalerite in sheared mafic volcanics. An assay of a 0.5 metre chip sample is listed in Table 3-7.

SUMMARY AND DISCUSSION

The Silver King deposit consists of a number of Ag-Pb-Zn-Cu veins in Elise volcanics in the Silver King shear. The distribution and concentration of sulphides in the Silver King veins are controlled by the shear, cross-fractures, and the occurrence of more competent units of the Elise. There appears to be no correlation between vein sulphides and the Silver King or Nelson intrusions.

The origin and age of these veins is not known. It is possible that they are synkinematic veins, related to development of the Silver King shear. Alternately, they are earlier than the shear zone, possibly distal polymetallic veins related to the Eagle Creek plutonic complex. Copper-gold mineralization of the Elise. There appears to be no correlation between vein sulphides and the Silver King or Nelson intrusions.

In 1989, diamond drilling by YellowJack Resources Ltd. intersected gold-bearing quartz veins and silicified zones beneath the No. 5 level of the Clubine-Comstock occurrence (Cooke, 1990; Figure 3-13). The Maggie Zone to the northwest, an area of anomalous silver, lead, zinc and copper, was discovered in 1990 by YellowJack Resources Ltd. during the course of geophysical and soil geochemical work over the whole of the Clubine property. Trenching on this zone uncovered significant lead-zinc and silver-bearing quartz-carbonate veins.

REGIONAL SETTING

The Clubine property lies on the east limb of the Hall Creek syncline just north of Salmo (Figure 3-12). The Hall Creek syncline is a tight, south-plunging fold that can be traced from north of Hall Creek in the Nelson area, to Salmo. Near Salmo, it is cut by the Erie Creek fault, a Tertiary east-side-down normal fault, but is exposed south of Salmo as an overturned, east-dipping syncline called the Hallroaring Creek syncline. Both Hall and Hallroaring Creek synclines are the earliest structures recognized in the Salmo area.

A slaty cleavage in clastic rocks and a penetrative foliation in volcanic rocks parallel the axial planes of the Hall Creek and Hallroaring Creek synclines. A number of faults or shear zones in the volcanic rocks parallel the margins of the synclines (Andrew and Höy, 1991).

East and northeast-dipping normal faults, such as the Erie Creek fault, are the youngest structures in the Clubine area. They may be related to Middle Eocene extension recognized throughout southeastern British Columbia.

The Early Cretaceous Hidden Creek granite stock intrudes the eastern part of the Clubine area and a granite stock, of unknown age, intrudes south of Keystone Mountain. The Hidden Creek stock comprises 10 to 15% plagioclase (An60-86), 15 to 20% microperthite, 50 to 60% orthoclase, 25 to 30% quartz, up to 2% biotite and 1 to 2% opaques. Numerous small dikes, one-half to two metres wide, trend north to northwest across the property (Figure 3-13). They are of various compositions including lamprophyre, hornblende diorite, quartz porphyry and massive rhyolite and are probably mainly Middle Eocene in age.

PROPERTY GEOLOGY

The eastern part of the Clubine property is underlain by mafic volcanic rocks of the Elise Formation; the western part, by the Hall Formation. The Elise Formation consists of augite porphyry flows and lapilli, crystal and fine tuffs. Unaltered primary mafic minerals are rare in the augite por-
phyry flows but relict blue-green amphibole (15-20%) and green biotite (10-15%) can sometimes be distinguished. The mafic minerals are variably altered to chlorite and epidote. Apatite is a common accessory mineral in the flows. Lapilli tuffs contain subrounded to subangular volcanic fragments (up to 5 cm in diameter) that vary from coarse augite porphyry to crystal and fine tuff. The crystal tuffs contain 20 to 25% plagioclase (An55-59) and minor (5 to 10%) albite. Most mafic minerals are variably altered to chlorite and epidote. The volcanic succession is intruded by a lensoid monzogabbro sill near the contact with the Hall Formation north of Key Creek. A number of these monzogabbro/gabbro sills or small stocks occur throughout the exposures of the Elise Formation and are interpreted to be high-level syn-Elise intrusions (Dunne and Höy, 1992).

MINERALIZATION AND ALTERATION

A number of quartz and quartz-carbonate precious and base-metal vein occurrences are in the upper 500 metres of the Hall Formation and lower part of the Elise, in the Keystone Mountain area. They generally trend north to north-west and dip steeply northeast and include variable amounts of galena, pyrite, chalcopyrite with minor sphalerite, tetrahedrite and pyrrhotite.

The Clubine property has two principle showings; the Clubine-Comstock workings (082FSW200) and the Maggie Zone.

The Clubine-Comstock, hosted mainly by the Elise Formation, has lenses of quartz and quartz-carbonate up to 0.5 metres wide with variable amounts of pyrite, chalcopyrite, galena and minor sphalerite and pyrrhotite. The lenses or veins of the main workings are commonly brecciated and parallel to the footwall of a biotite lamprophyre dike. Gold (34.6 g/t over 21.6 m in level No. 2 and 14.7 g/t over 8.6 m in level No. 5) occurs in the vein quartz and also within broad silicified and pyritic zones (Cooke, 1990). The No. 1 level workings, in the Hall Formation 60 metres west of the main workings, have veins with lesser gold content but higher lead and zinc values.

Figure 3-12. Geology of the Erie Lake area, showing the location of mineral deposits (after Höy and Andrew, 1989; 1990; Little, 1960; 1965; Mulligan, 1952 and Fitzpatrick, 1985).
The Maggie Zone consists of 12 to 15 cm widths of brecciated quartz and quartz-carbonate veins. In thin section, vein material appears as translucent quartz and rarely carbonate crystals crosscut by a dense network of wispy microfractures defined by tiny (<2 microns) fluid inclusions. The wispy quartz texture is commonly observed in veins formed at deep crustal levels (>4 km) (Reynolds, 1991). The selvages of the veins are commonly marked by 2 to 3 cm of massive ‘steely’ galena and/or 8 to 10 cm of coarse-grained, euhedral, slightly oxidized galena (90%), pale sphalerite (<3%), and trace pyrite. This zone has high silver and lead but low gold and zinc values (Table 3-8). A distinctive yellow-green alteration envelope of mica(?) and iron carbonate(?), 5 to 10 centimetres wide, surrounds some of the veins in the Maggie zone.

Analyses of selected vein samples from the Clubine property, not including the Clubine-Comstock workings, are given in Table 3-8. This data indicate a strong positive correlation between gold, silver and lead (Dunne et al., 1992). Zinc and molybdenum also have a positive correlation, although the actual concentrations of these elements are relatively low.

**SUMMARY AND DISCUSSION**

The concentration of veins near the contact of the Elise and Hall formations may result from shearing near the sedimentary/volcanic contact.

The age of these veins is not known. They may be associated with either the Middle Jurassic Nelson intrusions or the Early Cretaceous Hidden Creek stock, an interpretation supported by Pb isotope data (Appendix 8). However, it is possible that the veins are Tertiary as they trend north, parallel to Tertiary structures, and some are spatially associated with Tertiary dikes.

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**Figure 3-13. Geology of the Clubine prospect (from Dunne et al., 1992).**
The variation in composition from gold-bearing at the Clubine-Comstock to silver-lead bearing at the Maggie zone may reflect the different host rocks for these two systems: Elise volcanic rocks versus Hall argillite, respectively. However, dominantly gold-bearing quartz veins have been reported elsewhere in the Hall Formation at the Keystone, Canadian King and Arlington deposits. It is possible that the Maggie veins were deposited in the same vein system as the Clubine-Comstock but at a deeper structural level.

OTHER DEPOSITS

VELVET (082F/SW162)

Names: Velvet (L.2521), Portland (L.2523), Velvet-Portland

Location: Lat. 49°00′45″ N, Long. 117°54′50″ W
Elev. 1200 metres

INTRODUCTION

The Velvet Mine is a gold-silver-copper vein system within ultramafic pendants in Middle Eocene Coryell intrusive rocks southwest of Rossland (Figures 1-1, 4-2, in pocket). The host ultramafic rocks contain large xenoliths(?) of mafic volcanic rocks and are intruded by Coryell and later dikes. The age and origin of these veins is not known; they may be related to deformation in Early to Middle Jurassic time or to Middle Eocene tectonic-magmatic events.

Access to the area is by a well-maintained gravel road that extends approximately 13 km southwest from Rossland. Property access is via two 4-wheel-drive roads that branch north from the main road (Figure 3-15).

Between 1901 and 1964, the Velvet Mine produced 88 833 tonnes of ore yielding 620 785 grams gold, 664 359 grams silver, 1 154 104 kg copper and minor amounts of lead and zinc (Appendix 3). Potential reserves on the property are 450 000 tonnes containing 12 g/t gold, 31 g/t silver and 6.5% copper (International Prospectors and Developers, Nov/Dec 1983).

EXPLORATION HISTORY

The Velvet and Portland Crown-granted claims were located in 1896 at approximately 1200 metres elevation on the northwest slope of Sophie Mountain in the valley of Big Sheep Creek south of Rossland (Photo 3-5). These adjacent claims were developed separately until 1904 when Velvet-Portland Mines Ltd. formed and acquired both properties. The Velvet mine was operated intermittently by this and several other companies until 1967, with closures between the years 1916-20, 1928-32, and 1942-52. In 1978,
### TABLE 3-8
ANALYSES OF SELECTED SAMPLES OF THE CLUBINE PROPERTY
(from Dunne et al., 1992)

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<th>Cu(^4)</th>
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Sample No. | Sample Width | Ag\(^2\) | Pb\(^2\) | Zn\(^2\) |
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1. Lab No. 42076 to 42089: analyses by Ministry of Energy, Mines and Petroleum Resources Laboratory
2. Lab No. 38777 to 38793: analyses by Acme Analytical Laboratories Ltd.
3. Analyses by fire assay/Induction Coupled Plasma
4. Analyses by atomic absorption spectrophotometry
5. Analyses by X-ray fluorescence
6. Analyses by Induction Coupled Plasma
Velvet Exploration Co. Ltd. acquired the property and in 1980, 1000 metres of drilling was carried out. In 1982, approximately 930 tonnes of rock from the ore pile on the 8th level and the dump on the 1st level, containing 5.5 g/t gold, was shipped to the H.B. mill in Salmo (George Cross Newsletter, May 25, 1982).

The Velvet workings are on 8 levels, each approximately 30 metres apart; a vertical shaft serviced all levels. In 1903 the mine was flooded to the 400 level and in 1937, to the 600 level (Peters, 1937). Long adits were opened from surface at the 400 and 600 levels to drain the mine. A 180-metre adit on the 800 level is connected to the 600 level by a raise (BC Property File). The size and shape of ore shoots and extent of mine workings are shown in Drysdale (1915) and Peters (1937).

The only other deposit in the vicinity of the Velvet Mine is the Douglas (082F/SW161), which was in production from 1948 to 1950. This is a silver-lead-zinc vein in coarse clastic rocks of the Upper Cretaceous Sophie Mountain Formation, which are intruded by several Middle Eocene Coryell dikes. Most recent work in the area is on the Santa Rosa property one kilometre east of the Velvet Mine (Keyser and Smith, 1988).

**REGIONAL GEOLOGY**

The Velvet Mine area is underlain by ultramafic cumulate rocks intruded on the west by the Middle Eocene Coryell batholith. Large blocks of mafic volcanic rocks, up to 70 metres wide, occur within the ultramafic rocks. Generally north-trending Middle Eocene, and possibly Middle Jurassic, granite, pulaskite, augite-biotite porphyry and biotite-potassium feldspar porphyry dikes, up to 6 metres wide, occur within the ultramafic rocks. Generally north-trending Middle Eocene, and possibly Middle Jurassic, granite, pulaskite, augite-biotite porphyry and biotite-potassium feldspar porphyry dikes, up to 6 metres wide, are common. Bedrock exposures are limited; outcrops are found mainly at road cuts, trenches and ridge crests.

West of Rossland, these ultramafic bodies are interpreted to be in thrust contact with both the Pennsylvanian-Permian Mt. Roberts Formation and Early Jurassic Rossland Group (Figure 4-1). They are dunitic to wehrlitic ultramafic cumulates of probable oceanic affinity, perhaps part of the Slide Mountain Terrane (Ash, 2001).

The Coryell intrusions are exposed mainly as a batholith, which extends from the USA border north to the Castlegar area and from Christina Lake east to Granite Mountain just west of Rossland. Numerous U-Pb zircon ages from the Coryell intrusions (e.g., 51.7±0.5 Ma; Bevier, 1987) and field relationships on Old Glory Mountain that indicate that the Coryell is genetically related to the Marron Formation (Little, 1982a; Monger, 1968) support a Middle Eocene age. The Coryell batholith varies from coarse-grained, inequigranular and locally porphyritic syenite to medium-grained porphyritic syenite, granite, quartz monzonite and monzonite. Small stocks and dikes of the Coryell occur throughout the Rossland-Salmo-Nelson area. These are generally more mafic than the batholith, consisting of augite-biotite monzonite and hornblende monzonite (Little, 1982a,b).

The Coryell intrusions generally have a pinkish-red colour but adjacent to areas of hydrothermal alteration or metasomatism, appear green due to chloritization of mafic minerals.

**PROPERTY GEOLOGY**

The Velvet Mine is within dunite and wehrlite ultramafic cumulates intruded by Coryell rocks. The ultramafic rocks are exposed as four pendants, the largest approximately 600 by 150 metres in area (Figure 3-15). Ultramafic outcrops are a medium-brown colour on weathered surfaces; a penetrative foliation or shearing is generally present. In thin section, ultramafics comprise antigorite + serpentine after olivine, magnetite, spinel, chrysotile and other opaques in a serpentine mat (Little, 1982a).

Xenoliths of mafic volcanic rocks occur within the ultramafics in the Velvet mine area. The shaft on the Portland claim is reported to be in a large xenolith of pyritized, silicified greenstone (Drysdale, 1915). Mafic flows, pyroclastic breccia, tuff and minor siltstone crop out south of Santa Rosa Creek (Figure 3-16). These exposures have undergone widespread propylitic alteration (Keyser and Smith, 1988).

Samples of Coryell batholith exposures comprise, in general, microperthite and/or orthoclase, minor plagioclase, pyroxene, biotite and/or hornblende, less than 10% quartz and accessory apatite, sphene, zircon, magnetite and allanite (Little, 1982a). Samples from the Velvet Mine area are similar, with megacrysts of biotite (~10%), pyroxene (~5%), plagioclase (~10-15%), orthoclase (1-2%) and microperthite (1%) in a finer-grained matrix of quartz (3%), plagioclase (10%) and orthoclase (~60%). Apatite and sphene commonly occur as accessory minerals.

Whole-rock analyses from two ‘fresh’ (pink-coloured) samples of Coryell intrusive rocks from the Velvet Mine area were compared with four samples of ‘average’ Coryell rocks (Table 3-9). Samples from the Coryell batholith generally plot as metaluminous (Al2O3 < Na2O+K2O) in the high clinopyroxene and orthoene field of Debon and Le Fort (1983). Velvet Mine area samples fall into the quartz monzonite and monzodiorite fields, which is within the syenite to monzodiorite compositional range of the Coryell batholith.

**MINERALIZATION AND ALTERATION**

Shear zones cutting the ultramafic rocks in the Velvet mine area contain veins of quartz and calcite with specularite, chalcopyrite and pyrite; galena and sphalerite occur in lesser amounts (Photo 3-6). Locally, chalcopyrite is massive, particularly along the margins of the ore shoots. Minor scheelite may be sparsely disseminated in the ore (Stevenson, 1943, p. 154). Drysdale (1915, p. 78) reported a lens of molybdenite half a metre thick at the Velvet mine. The veins generally strike north parallel to the main dike system and dip steeply west. Drysdale (1915, p. 157) described the vein wallrock as “impregnated for some feet”, indicating a significant alteration envelope. Little (1960, p. 182) suggested that the wallrock had been replaced in part by quartz, calcite and sulphide minerals. He described the Velvet mine as shear zone-related, containing veins or stockwork of veinlets with disseminated sulphides.
Figure 3-15. Geology of the Velvet mine area, southwest of Rossland.
Assays from a number of hand samples of the Velvet veins are shown in Table 3-10. One sample contains 34 ppm gold and 0.2% copper. There appears to be little correlation between copper and gold content. Cu/Au ratios vary from 1 to 710000 and Cu/Ag, from 0.064 to 0.00061. High nickel content in some samples reflects the ultramafic host.

The main Velvet vein occurs in the Kelley stope, the richest area of the mine (Peters, 1937). The Main vein trends north-south and dips 70° west. Four productive veins, including the South and Stable veins, occur 20, 40, 60 and 105 metres east of, and parallel to, the Main vein. Ore zones occur at the intersection of north-trending veins with crosscutting dikes or faults. Sulphides in the veins have been largely altered to limonite and malachite in the upper three levels of the mine (Drysdale, 1915, p. 157; Little, 1960, p. 182). Later crosscutting east-trending veins are barren.

Within approximately 100 metres of the serpentinized ultramafics, Coryell intrusive rocks are propylitized to a green colour, with chloritization of biotite (20%), breakdown of feldspars to epidote (20%), sericite and clay minerals (25%) and addition of quartz (up to 20%). Drysdale (1915) described the Coryell wallrock adjacent to veins in the Velvet mine as “a mottled grey irruptive rock, with coarse siliceous and chloritic phases, which is much epidotized in places”. The wide distribution of altered Coryell rocks in the Velvet mine area is outlined in Figure 3-15; it may be a useful exploration parameter for mineral exploration in Coryell batholith rocks.

### SUMMARY AND DISCUSSION

The origin of copper-gold-silver veins at the Velvet Mine is not well understood. They may have formed as mesothermal veins along structures related to Middle? Jurassic thrust faults marginal to ophiolitic crustal and/or mantle lithologies. Alternatively, there has been some suggestion that the mine may be a skarn, although there is little published evidence of calc-silicate mineral assemblages or limy protoliths. Skarn occurrences possibly associated with Coryell intrusions include the May Blossom, Jumbo, Stewart 2, Kimbarb and Rossland Wollastonite (BC MINFILE 082F/SW070, 111, 229, 326 and 341).

It is possible that the veins are related to extension during emplacement of the Middle Eocene Coryell intrusions. Their dominant north-south orientation is parallel to Coryell dikes. Furthermore, the pervasive alteration of the Coryell

**TABLE 3-9**

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<th>SiO₂</th>
<th>TiO₂</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>MnO</th>
<th>MgO</th>
<th>CaO</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>P₂O₅</th>
<th>Total</th>
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<td>2.08</td>
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<td>3.00</td>
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<table>
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<th>Ba</th>
<th>Sr</th>
<th>Zr</th>
<th>Y</th>
<th>Nb</th>
<th>Ta</th>
<th>V</th>
<th>La</th>
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<td>21</td>
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Samples 325-10,16 and -22 are from the Velvet mine area. Locations and descriptions are given in Appendix 8.

Assays from a number of hand samples of the Velvet veins are shown in Table 3-10. One sample contains 34 ppm gold and 0.2% copper. There appears to be little correlation between copper and gold content. Cu/Au ratios vary from 1 to 710000 and Cu/Ag, from 0.064 to 0.00061. High nickel content in some samples reflects the ultramafic host.

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The origin of copper-gold-silver veins at the Velvet Mine is not well understood. They may have formed as mesothermal veins along structures related to Middle? Jurassic thrust faults marginal to ophiolitic crustal and/or mantle lithologies. Alternatively, there has been some suggestion that the mine may be a skarn, although there is little published evidence of calc-silicate mineral assemblages or limy protoliths. Skarn occurrences possibly associated with Coryell intrusions include the May Blossom, Jumbo, Stewart 2, Kimbarb and Rossland Wollastonite (BC MINFILE 082F/SW070, 111, 229, 326 and 341).

It is possible that the veins are related to extension during emplacement of the Middle Eocene Coryell intrusions. Their dominant north-south orientation is parallel to Coryell dikes. Furthermore, the pervasive alteration of the Coryell
rocks adjacent to ultramafic rocks that host the veins suggests a syn to post-Coryell age. However, it is possible that this alteration is simply a contact altered phase of the Coryell, unrelated to mineralization.

**RED POINT (082F/W366)**

Names: Red Point, Gold Dust
Location: Lat. 49°05’00” N, Long. 117°43’34” W
Elev. 1100 metres

**INTRODUCTION**

Red Point is located approximately 5 kilometres southwest of Trail on the northern ridge of Lookout Mountain. It was initially staked in 1893 and by 1897 a large amount of underground development had been done on the property. The property was drilled by Tomex Resources in 1988 and by Gamah International Ltd. in 1997. Gamah Resources, the operator for Loumic Resources Ltd. who had optioned the property from the owner, M. Gerg, drilled a total of six holes for a total of 1 014 metres. This work resulted in a “the discovery and delineation of a bulk tonnage gold deposit” (Ermanovics and Downing, 1997).

**REGIONAL GEOLOGY**

Red Point is within a sequence of mainly basaltic to andesitic lapilli tuff of the Elise Formation. These include augite-phyrhic lapilli tuff, lapilli tuff with plagioclase ± augite-bearing clasts and crystal tuff. Ermanovics and Downing (1998, p. 3) report that drill intersections of Lower Elise in this area are dominantly “felsic/siliceous and agglomeratic”.

The Elise succession on the northern ridge of Lookout Mountain defines a north-northwest trending and plunging syncline. Bedding on the ridge north of Lookout Mountain swing from north-trending, west-dipping to east-west trending in the core of the syncline near the summit of Lookout Mountain.

Elise Formation in the Red Point area is surrounded by intrusive rocks (Figure 4-2, in pocket). The area is within an embayment of the Rossland monzonite; the monzonite is exposed less than a kilometre to the west and less than 2 kilometres to the east. The Trail pluton truncates the Rossland monzonite immediately to the north of Red Point and Sheppard and Coryell intrusions, both of Eocene age, are exposed just south of the summit of Lookout Mountain. A number of generally north-trending, late dikes cut Elise metavolcanics. These commonly have flow textures suggestive of a volcanic origin; however, they are Eocene in age, as they are post-tectonic, cutting Elise stratigraphy and regional foliation at high angles.

**MINERALIZATION**

Mineralization on the property is variable, including disseminated sulphides, sulphide clasts in Elise volcanoclastics, some spectacular sulphide-matrix breccias, and veins and fracture filling (Ermanovics and Downing, 1997). Disseminated sulphides consist mainly of pyrite, pyrrhotite and minor chalcopyrite, most commonly in fragmental Elise volcanic rocks. Sulphide clasts, up to 6 cm in diameter, consist mainly of massive pyrrhotite and pyrite. Vein and fracture-controlled pyrrhotite, pyrite and chalcopyrite may contain minor carbonate, quartz and chlorite gangue.

Drill holes intersected anomalous gold and copper values, with gold in the range of 2-12 ppm over two metre lengths, in sections with “agglomerate/breccia and breccia” that contained up to 6% pyrrhotite, pyrite and minor chalcopyrite (Ermanovics and Downing, op. cit.). Average copper values were less than 750 ppm, with the highest value of 1991 ppm obtained in one 2-metre interval.

The origin of this low-grade, but potentially large-tonnage gold-copper deposit, is not known. Ermanovics and Downing (op. cit.) note that mineralization is best developed in volcanoclastic rocks, regardless of their composition, implying a porosity/permeability control. Furthermore, they note that the sulphide clasts indicate “pyroclastic or epiclastic” sulphide deposition with local hydrothermal enrichment.

Red Point has some similarities with the Harper Creek deposit in the Eagle Bay assemblage north of Kamloops. There, disseminated sulphides, minor layered sulphides and fracture-controlled sulphides in mafic volcanoclastics were interpreted as a “volcanogenic disseminated sulphide deposit” (Höy, 1997). Red Point also has similarities with a copper-gold porphyry deposit. Considerable more work on this deposit is required to understand and classify it.

---

**TABLE 3-10**

<table>
<thead>
<tr>
<th>Sample No</th>
<th>Au (ppb)</th>
<th>Ag (ppm)</th>
<th>Cu (ppm)</th>
<th>Pb (ppm)</th>
<th>Zn (ppm)</th>
<th>Co (ppm)</th>
<th>Ni (ppm)</th>
<th>Mo (ppm)</th>
<th>Cr (ppm)</th>
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<td>41536</td>
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<td>5</td>
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<td>39</td>
<td>205</td>
<td>15</td>
<td>0.10%</td>
<td>&lt;10</td>
<td>massive mag. + cp</td>
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<tr>
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<td>41537</td>
<td>34510</td>
<td>27</td>
<td>2182</td>
<td>36</td>
<td>65</td>
<td>223</td>
<td>228</td>
<td>&lt;10</td>
<td>&lt;10 g.c. bi-feldspar syenite(?)</td>
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<tr>
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<td>1116</td>
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<td>880</td>
<td>618</td>
<td>55</td>
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<td>10</td>
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<td>3.07%</td>
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<td>173</td>
<td>78</td>
<td>18</td>
<td>&lt;2</td>
<td>6 cc vein, spec + cp</td>
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</table>

Notes: Au by fire assay, ICP; Ag, Cu, Pb, Zn, Co, Ni, Mo, As, by Atomic absorption; Cr by XRF