PETROLOGY OF THE EVENING STAR CLAIM, ROSSLAND, B.C. (82F/4)

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INTRODUCTION

The Rossland mining camp of southeastern British Columbia has been one of the most important gold producers in the province's history. Most of the camp's production was during the period 1895 to 1928, 98 per cent of this from four large, connected mines (Le Roi, Centre Star, Josie, and War Eagle). During this period and for a few years after, minor production was recorded on about 30 other claims.

The Evening Star claim, about 1.5 kilometres northwest of the town of Rossland, has been one focus of renewed exploration in the Rossland camp. A drilling program carried out by Antelope Resources Inc. from 1988 to 1990 has revealed significant gold potential on this claim (approximately 20 000 tonnes averaging 17 grams per tonne gold; Wehrle, 1991). A petrographic study of samples from surface and drill core was undertaken to determine the mineralogy and paragenesis of the deposit, and to compare it to the rest of the Rossland camp.

GEOLOGY OF THE ROSSLAND AREA

The geology of the Rossland area has been well studied due to the importance of its mineral deposits (Figure 2-2-1). Drysdale (1915) described the geology of the camp and the

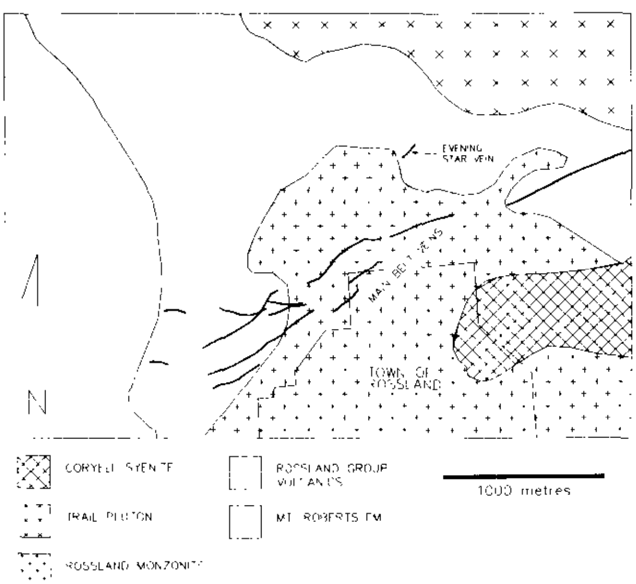

Figure 2-2-1. Schematic geological map of the north part of the Rossland mining camp, showing the location of the Evening Star vein and the main belt veins (after Höy *et al.*, 1992, and Little, 1982).

mineral deposits when the underground mines were active. More recently the geological setting of the camp has been described by Fyles (1984) and Höy *et al.* (1992) and the regional geology by Little (1982). The Rossland area is underlain by late Paleozoic sediments of the Mount Roberts Formation and the Jurassic Rossland Group, comprising volcanics and volcanic sediments. These rocks have been intruded by three distinct igneous suites – the Early Jurassic Rossland monzonite, the Middle Jurassic Trail pluton, and Eocene dikes and stocks, probably related to the large Coryell batholith to the west.

Gold mineralization at Rossland is roughly centred on the Rossland monzonite and is mainly hosted by Rossland Group metavolcanics and metasediments, which are possibly comagmatic with the monzonite (Höy *et al.*, 1992). The camp has traditionally been divided into three belts based on the structural trends of the mineralized fractures. The main belt contains all the large producers and runs east-northeast across the north side of the monzonite. The north belt, containing the Evening Star claim, appears to be a northeast splay of the main belt. The south belt parallels the southern margin of the monzonite. The Crown Point deposit within this belt was recently described by Wilson *et al.* (1990).

Thorpe (1967) proposed a mineralogical zonation of the Rossland camp based on ore petrology and copper, silver and gold ratios of the ores. He divided it into central, intermediate and outer zones centred on the Le Roi - Centre Star main vein. The central zone ores are mostly massive pyrrhotite and chalcopyrite. The intermediate zone is characterized by arsenopyrite and pyrite, and the outer zone by galena, tetrahedrite and sphalerite. Thorpe placed the Evening Star deposit in the intermediate zone based on two samples taken from the old workings.

EVENING STAR CLAIM

The Evening Star deposit (Figure 2-2-2), located on the north belt, saw minor production from 1896 to 1907 and from 1932 to 1939. Total output was 56.7 kilograms of gold, 21.5 kilograms of silver and 1276 kilograms of copper from 2859 tonnes of ore (Fyles, 1984). Production was mainly from shallow surface workings following a strong mineralized trend across the claim, representing the surface expression of a steeply dipping tabular orebody near the contact of the Rossland monzonite. The ore is crosscut by several north-striking porphyritic syenite dikes which are probably Eocene.

The ore is hosted by strongly altered Rossland Group volcanics. The main alteration types include silicification, local formation of andraditic garnet, diopside and epidote (skarn), and patchy amphibole-chlorite-calcite alteration. Early sulphide mineralization appears to have been spatially associated with the skarn alteration. The genetic association

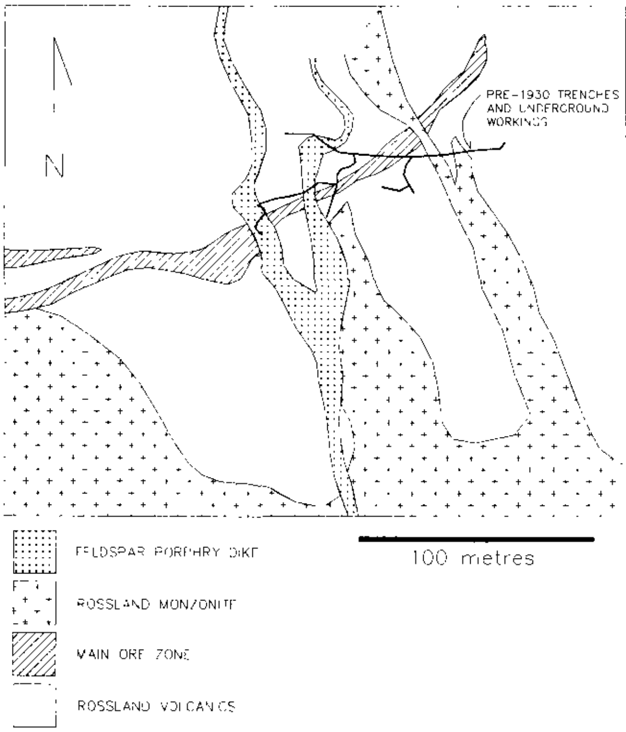

Figure 2-2-2. Map of the Evening Star deposit. Mineralization dips steeply to the north (from Wehrle, 1991).

between the ore and the contact metasomatism associated with the Rossland monzonite has only been recognized recently in this camp (Wilson *et al.*, 1990), and its overall significance is not yet well understood.

Petrology

METAMORPHIC HOSTROCKS

The Evening Star deposit is hosted by contact metamorphosed and hydrothermally altered Jurassic volcanic sediments. There is a general gradation in mineral assemblages outward from the contact of the monzonite across the tabular orebody.

Pockets of garnetiferous skarn, the highest metamorphic grade observed, occur locally in the ore zone within 10 metres of the igneous contact. These exhibit a coarse-grained skarn assemblage of andraditic garnet, diopside and plagioclase, which in turn is overprinted by hornblende along growth zones in garnet (Plate 2-2-1), and by quartz, calcite and zeolites. Minor arsenopyrite and pyrite are disseminated in this rock, and chalcopyrite and pyrrhotite are mainly confined to late quartz-carbonate veins.

Farther out from the monzonite contact (20 to 40 m) pockets of lower grade skarn are found within the hydrothermally altered country rock. The skarn consists of diopside and plagioclase, overprinted by actinolite and later epidote and clinozoisite. Minor minerals present include sphene, apatite, sericite and tourmaline. These assemblages

Plate 2-2-1. Hornblende alteration (dark) of garnet (light) along growth zones. Both minerals are cut by pyrrhotite-bearing calcite veins. Transmitted light, width of photo 2 mm.

are cut by carbonate and quartz-carbonate veins. In the ore zone arsenopyrite, pyrrhotite, chalcopyrite and other opaque minerals are disseminated in highly variable amounts.

Still farther out from the monzonite (40+ m) the volcanics are dominantly fine grained and strongly silicified. These are cut by veins of diopside, wollastonite and/or actinolitic amphibole, 0.5 to 5 millimetre wide, which are partly replaced by calcite. Some actinolite veins contain arsenopyrite along their margins, suggesting it might have been formed at the same time as the actinolite alteration. Pyrrhotite is present in the veins as a replacement of arsenopyrite and actinolite (Plate 2-2-2).

These assemblages are crudely arranged outward from the Rossland monzonite, in a similar fashion to skarn zones in the Hedley district as described by Ray *et al.* (1987). This marked spatial association with the monzonite provides evidence in favour of it being the source of heat and possibly mineralizing fluids for the Evening Star deposit.

ORE PETROLOGY

The ore assemblages consist of variable proportions of a few common minerals. There appear to be two main stages of sulphide mineralization. The first is characterized by pyrite, arsenopyrite and gold; the second by chalcopyrite and pyrrhotite. Locally magnetite is a late replacement of the sulphide phases, and hematite and marcasite are present as minor alteration products.

Arsenopyrite and pyrite occur mainly as fine to coarse-grained subhedral crystals and crystal aggregates in the silicate host and in zones of massive pyrrhotite. Early formation of arsenopyrite and pyrite relative to pyrrhotite and chalcopyrite is indicated by several textures. Blebs of optically continuous arsenopyrite often occur within massive pyrrhotite. Grains of pyrite and arsenopyrite are commonly traversed by irregular veinlets of pyrrhotite and chalcopyrite with irregular or cuspate walls (Plate 2-2-2). Textures between arsenopyrite and pyrite are equivocal, possibly indicating that they are contemporaneous.

Gold appears to be related to the earlier arsenopyrite-pyrite stage. There is a strong correlation of high gold values with high arsenic contents (Wehrle, 1991). It generally occurs as small (10-40 μm) subhedral grains in arsenopyrite, or disseminated with it in the silicate host. This strong association suggests that gold precipitated at the same time as arsenopyrite, either as free gold or in solid solution with it.

Locally, gold visible within arsenopyrite grains forms small subparallel elongate blebs which might be indicative

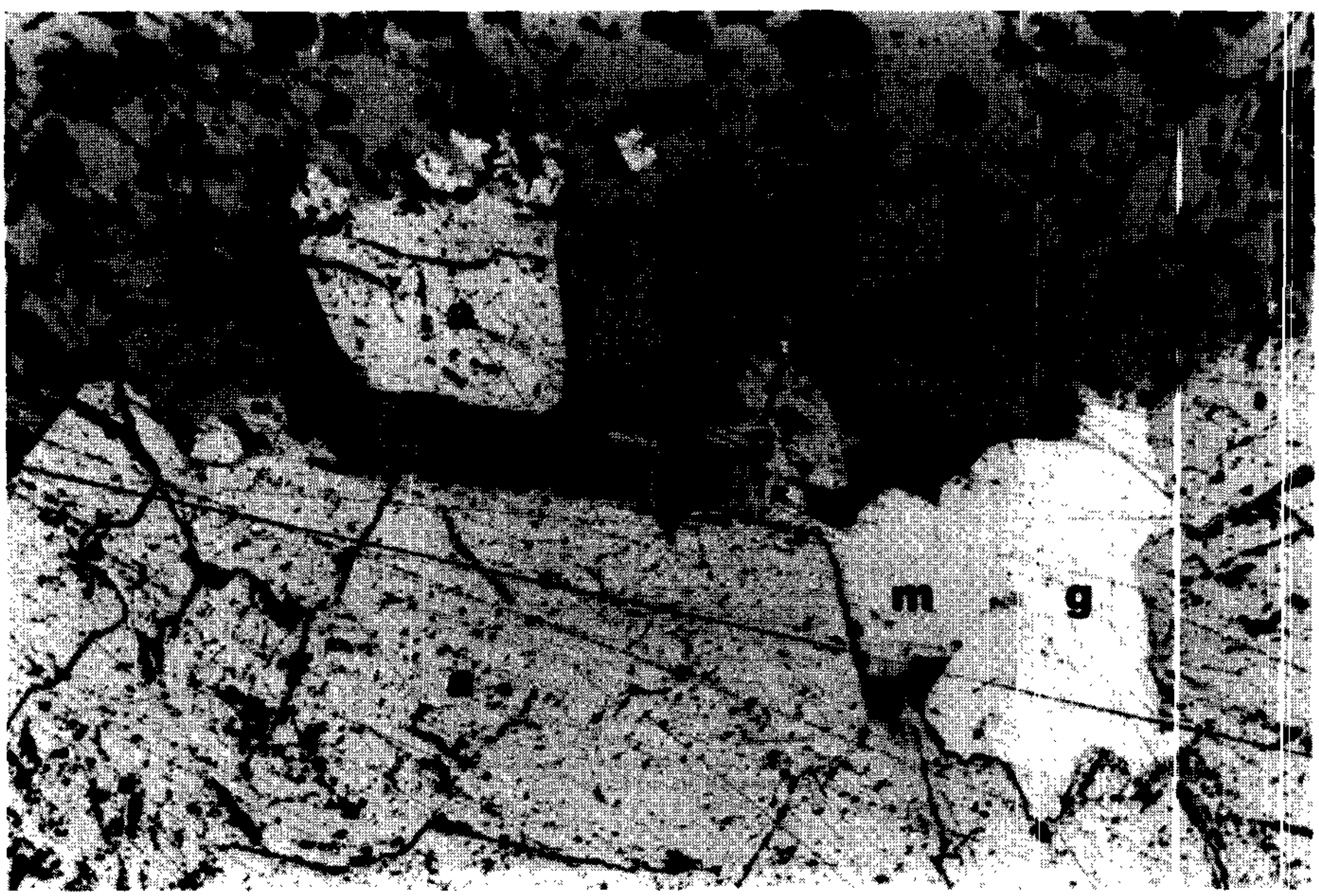

Plate 2-2-2. Pyrrhotite (top, dark grey) replacing gold-bearing arsenopyrite (bottom, light grey) along an irregular contact. The cavity in arsenopyrite near the interface contains gold (g) intergrown with maldonite (m). Arsenopyrite and gold (small arrow, right of centre) are contained in pyrrhotite. Reflected light, width of photo 400 microns.

of exsolution. In one instance native gold is intergrown with a mineral which preliminary microprobe work indicates is maldonite, Au_2Bi (Plate 2-2-2).

The second mineralizing episode is represented by deposition of pyrrhotite and chalcopyrite. These minerals occur in three associations: in quartz-carbonate veins; as coarse disseminations in the metamorphic host; and as large massive sulphide veins. Pyrrhotite and chalcopyrite generally appear to envelope or replace the earlier arsenopyrite-pyrite-gold assemblage. Textures between chalcopyrite and pyrrhotite are inconsistent, suggesting generally coeval formation.

Rarely, native gold occurs in chalcopyrite veins cutting arsenopyrite (Plate 2-2-3). Although this could represent a second influx of gold it may also be the result of local remobilization. Cook and Chryssoullis (1990) indicate that, in general, arsenopyrite can carry significantly more gold in solid solution than chalcopyrite (by several orders of magnitude). In this case, significant replacement of auriferous arsenopyrite could result in the solid solution gold being reprecipitated with the chalcopyrite as visible gold.

Several other late phases are locally present. In places magnetite forms a massive replacement of the sulphide minerals. Hematite is a minor replacement of all the other opaque minerals in surface grab samples, and marcasite is a local alteration product of pyrite.

Link Between Skarn And Sulphide Mineralization

The relationships between the sulphide minerals and the hostrock alteration are important in determining the origin of this deposit. The occurrence of arsenopyrite along the margins of actinolite-rich veins suggests it was deposited during the initial stages of vein opening, followed by further deposition of actinolite and calcite during continued vein widening. Pyrrhotite and calcite also occur in these veins as partial replacements of arsenopyrite and actinolite (Plate 2-2-4). Late quartz-carbonate veins which crosscut garnetiferous skarn contain chalcopyrite and pyrrhotite. Mineral relationships indicate that arsenopyrite and pyrite are probably contemporaneous with actinolite and epidote alteration and that pyrrhotite and chalcopyrite are later and might be synchronous which quartz-carbonate alteration and veining. The overall paragenetic interpretation of the alteration types and mineralization is presented in Figure 2-2-3.

CONCLUSIONS AND DISCUSSION

Gold-bearing sulphide mineralization occurred in two main stages in the Evening Star deposit. The first resulted in deposition of pyrite, arsenopyrite and gold. The second consisted of partial replacement of these phases by pyr-

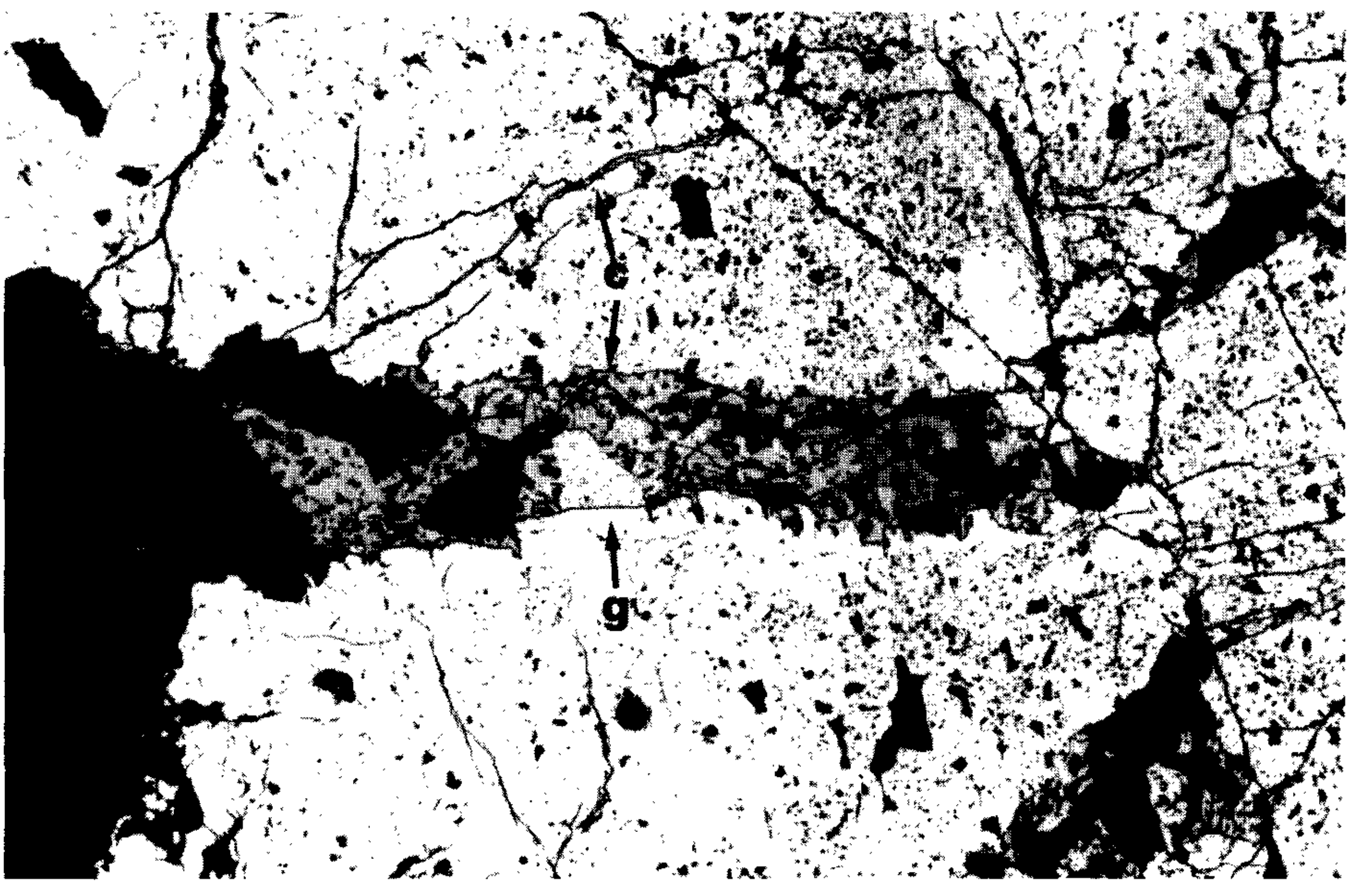

Plate 2-2-3. Chalcopyrite veins (c) cutting arsenopyrite. A large bleb of gold (g) is contained in the larger vein. Reflected light, width of photo approximately 2.5 mm.

Plate 2-2-4. Actinolite replaced by pyrrhotite (bright white) along cleavage. Reflected light, width of photo 2 mm.

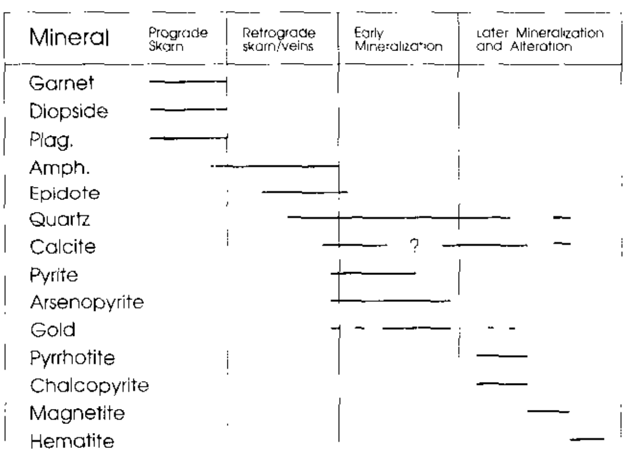

Figure 2-2-3. Paragenetic diagram for the Evening Star deposit.

rhotite and chalcopyrite, possibly with some reprecipitation of gold.

One conspicuous aspect of the Evening Star deposit is the strong association of gold with arsenopyrite. Although this association is well known from many gold camps, previous work at Rossland has mainly suggested a gold-chalcopyrite association. Thorpe (1967) concluded from work mainly in the central zone that much of the Rossland gold was in solid solution with chalcopyrite. However, recent microanalytical work from a variety of gold deposits (Cook and Chryssoulis, 1990) has shown that, in general, chalcopyrite and pyrrhotite are limited in their ability to carry gold in solid solution (maximum about 7 ppm) compared to arsenopyrite.

The gold-arsenopyrite mineralization is contemporaneous with the formation of retrograde skarn assemblages in the aureole of the Rossland monzonite, and consequently may be temporally and genetically related to it. This is consistent with recent work on the Rossland camp pointing to a genetic link between the gold ores and the monzonite, rather than with the later intrusions or large-scale regional structures (Höy *et al.*, 1992; Thorpe, 1967).

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