THE GEOLOGY OF THE CAROLIN MINE GOLD DEPOSIT IN SOUTHWESTERN BRITISH COLUMBIA AND THE GEOCHEMISTRY OF ITS REPLACEMENT SULPHIDE-ALBITE-QUARTZ-GOLD MINERALIZATION (92H/11)

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The Carolin gold deposit lies approximately 20 kilometres northeast of Hope in southwestern British Columbia. It occurs in the Coquihalla gold belt which, in addition to Carolin mine, contains four former producers as well as 19 minor gold occurrences (Ray, 1983). Most of these are gold-bearing quartz veins hosted in tension, quartz-filled fractures. However, mineralization at Carolin mine is of the mesothermal, epigenetic, replacement type; it is characterized by the introduction of sulphides, albite, quartz, and gold.

When production started in 1982, reserves at Carolin mine were estimated to be 1.5 million tonnes grading 4.8 grams gold per tonne, at a cutoff grade of 2.7 grams gold per tonne. Jurassic metasedimentary rocks of the Ladner Group host the mineralization, close to their unconformable contact with an older greenstone basement of spilitized oceanic ridge basalts (Spider Peak Formation), and their faulted contact with ultramafic rocks of the Coquihalla serpentine belt (Cairnes, 1924, 1929). This ultramafic belt lies within a major crustal fracture, the Hozameen fault, and exceeds 50 kilometres in discontinuous strike length; it is over 2 kilometres wide in the Carolin mine area. Ladner Group rocks are largely fine-grained, distal turbidites; however, gold mineralization is preferentially hosted in the coarser grained wackes, lithic wackes, and conglomerates that predominate in the basal part of the sequence (Ray, *et al.*, 1983).

During the first year of the mining operation, precise geological controls of the gold mineralization were uncertain. Surface mapping in the mine area indicated that both the Ladner Group and the stratigraphically underlying Spider Peak Formation were tectonically inverted, and subsequently deformed into large-scale, upright to asymmetric folds (Ray, *et al.*, 1983). Underground mapping later demonstrated that gold mineralization is both lithologically and structurally controlled (Shearer and Niels, 1983). It is preferentially concentrated in more competent and permeable sedimentary beds in the tectonically thickened hinge regions of a disrupted, asymmetric antiform. As a result, orebodies exhibit a saddle reef-like morphology and the deposit plunges gently northwest, subparallel to the antiformal axis (Ray and Niels, 1985a). Polished section studies indicate that pyrite dominates the upper parts of the deposit and pyrrhotite the deeper parts (Shearer, 1982). The precise age of mineralization is unknown, but the pyrite-pyrrhotite zoning suggests that the deposit is upright, and thus younger than the tectonic overturning that affected the host rocks. However, the presence of folded, post-ore quartz veins suggests that mineralization either predated or accompanied the episode of upright to asymmetric folding.

Mineralization at Carolin mine is characterized by sulphide disseminations and veinlets, deformed, multiphase quartz veins, and intense albitic alteration; however, not all areas containing these features are enriched in gold. Opaque minerals make up between 1 and 15 per cent of the ore; these are, in decreasing order of abundance, pyrrhotite, arsenopyrite, pyrite, magnetite, chalcopyrite, bornite, and gold; traces of sphalerite occur sporadically. Visible gold is rare; most forms small grains up to 0.02 millimetre in size that generally occur as inclusions in the pyrite and arsenopyrite crystals or as rims on the pyrite and chalcopyrite. Gold is also found independent of the sulphides as minute grains within some quartz, calcite, and feldspar crystals. Magnetite is the oldest opaque mineral in the ore; it is probably unrelated to the mineralization since it shows no spatial relationship to either gold or sulphides. The paragenesis of the opaque minerals is as follows: (1) contemporaneous deposition of arsenopyrite, pyrite, and gold, (2) pyrrhotite, (3) chalcopyrite and some gold.

There are at least three generations of albitization (Ray, *et al.*, 1983); the earliest was apparently coeval with the sulphide-gold mineralization and is fine-grained and disseminated throughout the ore. The subsequent two generations produced veins and masses containing coarse-grained, well-twinned albite crystals; locally, angular fragments of sulphide-rich ore are engulfed by the youngest albitic phase. The deposit is surrounded by an albitic envelope (Ray and Niels, 1985b); drill hole data indicate that it extends at least 60 metres beyond the mineralization. (In early 1986, analytical results are expected from a detailed surface lithogeochemical sampling program around the deposit; these should outline the full dimensions of this albitic envelope).

Geochemical analyses on samples collected from drill holes intersecting the deposit reveal complex and variable major and trace element zoning patterns; the most dramatic changes in element abundances occur within and immediately above the hangingwall sections of the ore zones (Ray and Niels, 1985b). Mineralization does not have associated anomalous mercury or bismuth values, and gold/silver ratios vary throughout the deposit from 1:1 to 1:22. Statistical analysis indicates that gold has a strong to moderate positive correlation with Na_2O, S, CO_2, Sb, Mo, Cu, As, and Ag, and a strong to moderate negative correlation with Al_2O_3, MgO, K_2O, H_2O, and BaO. No significant correlation between gold and SiO_2, Fe_2O_{3T}, CaO, TiO_2, MnO, or Pb was apparent. Unlike many epigenetic gold deposits, K_2O/Na_2O ratios decrease markedly as the auriferous horizons are approached. The gold mineralization is marked by distinct zones of barium and potassium depletion that are generally twice as thick as their associated gold-bearing horizons; this type of depletion could form valuable drill targets. Furthermore, the wide albitic envelope around the deposit suggests that lithogeochemical sampling for areas of sodium enrichment represents a viable exploration tool to locate similar gold deposits in the district.

On a district scale, the main controls of mineralization in the Coquihalla gold belt, including the Carolin mine deposit, are the presence of host rocks suitable for the development of tectonically induced permeability, and close proximity (<400 metres) to the Hozameen fault, the Coquihalla serpentine belt, and the Ladner Group basal unconformity (Ray, 1984).

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