MINERAL CHEMISTRY OF SOME METAMORPHOSED SHUSWAP-AREA MINERAL DEPOSITS (82L,M)

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INTRODUCTION

This paper is an initial report on the mineral chemistry of four metamorphosed stratabound mineral deposits which are located within or adjacent to the Shuswap Complex. These are commonly referred to as Cottonbelt, CK, Goldstream and Big Ledge deposits. Rock specimens were selected from those collected by Trygve Höy of the British Columbia Geological Survey Branch. The particular specimens chosen were not selected specifically to be representative of each deposit as a whole but rather as examples of the assemblage sphalerite-pyrrhotite-pyrite, in order to test the proposed sphalerite geospeedometer (Bartholomew and Lasaga, 1992). However, since very few data on the chemistry of minerals within these deposits has previously been reported, this paper was written in order to begin to correct this deficiency. After reviewing the mineralogy of each of the selected specimens, one was chosen from each deposit for analysis. Only these four specimens are described here.

GEOLOGIC SETTING

The four deposits covered by this report are all located in southeastern British Columbia (Figure 2-3-1). All four are interpreted to be of syngenetic exhalative origin (Höy *et al.*, 1984; Höy, 1987). They are all stratabound and exhibit structures and textures indicative that mineralization predates regional deformation and metamorphism and, most likely, was syngenetic with the enclosing sediments. Three of the deposits, Cottonbelt, Big Ledge and CK, are lead-zinc deposits situated within the Shuswap Complex. Cottonbelt and Big Ledge are within the Monashee Complex which is bounded by the Columbia River fault on the east and the Monashee décollement on the west. The CK deposit is in the Shuswap Terrane to the west and north of the Monashee Complex. Goldstream is a copper-zinc deposit in the Selkirk Terrane on the east side of the Columbia River fault.

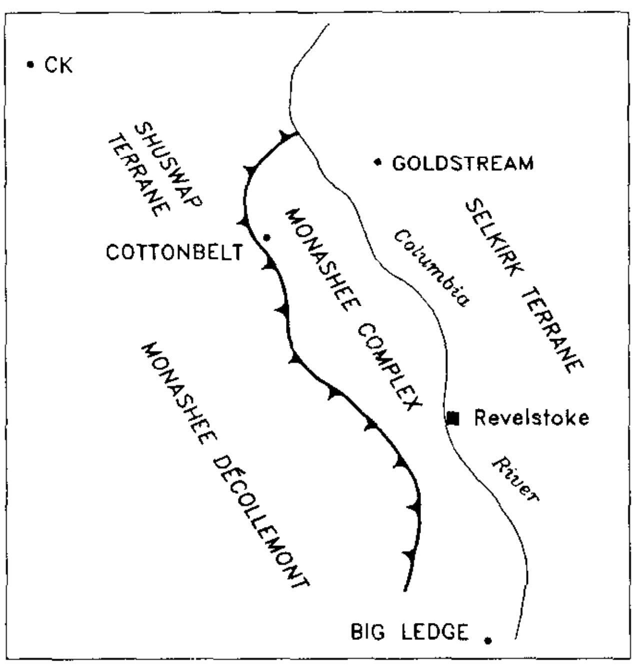

Figure 2-3-1. Sketch map showing the location of the four deposits.

Big Ledge and Cottonbelt are both hosted by strongly deformed and metamorphosed sedimentary and volcanic rocks which conformably overlie Precambrian basement gneisses which core the Monashee Complex (Höy, 1977, 1987). Their age is not known with certainty, however Pb-Pb dating of the Cottonbelt deposit suggests a Cambrian age (Höy and Godwin, 1987). Both of these deposits have experienced upper amphibolite grade metamorphism. Each lies within a metasedimentary sequence which includes quartzites, pelitic schists, calcareous gneisses and marbles. Big Ledge is a massive sulphide deposit, dominated by sphalerite, in calcareous, graphitic schists. Cottonbelt is a sulphide-magnetite deposit in a calcareous gneiss succession.

The CK showings are also hosted by calcareous gneisses (Höy, 1979, 1987). However, this deposit is hosted by younger allocthonous rocks of the Shuswap Terrane which structurally overlie the Monashee Complex. Here the calcareous hostrock succession is underlain by metavolcanic hornblende gneisses and amphibolites. The grade of metamorphism which the CK deposit has been subjected to is broadly amphibolite facies.

The Goldstream deposit and other copper-zinc deposits in the Goldstream area are interpreted to be volcanic exhalative in origin due to a close association with basic metavolcanic rocks (Höy *et al.*, 1984). At Goldstream, a massive sulphide layer is hosted by chloritic phyllite in a metasedimentary sequence which includes chloritic and sericitic phyllites, carbonaceous phyllites and limestones. The metamorphic grade is greenschist facies.

METHODS

Polished thin sections were examined optically and with a JEOL JXA-8600 electron microprobe. Under the microprobe, backscattered electron (BSE) imaging was used in combination with energy-dispersive x-ray spectrometry in order to corroborate optical mineral identification and to identify mineral grains too small to be identified optically. Wavelength-dispersive x-ray spectrometry was used for quantitative analysis.

MINERALOGY AND MINERAL CHEMISTRY

GOLDSTREAM

The specimen from the Goldstream deposit is designated GS-Ha. Its mineralogy includes actinolite, calcite, quartz, pyrrhotite, chalcopyrite, sphalerite, galena, biotite, muscovite and traces of silver and bismuth tellurides. The tellurides are only found intergrown with galena. Chemical analyses show that the amphibole is 80 to 90 mole per cent tremolite and slightly aluminous. The calcite contains minor amounts of manganese, magnesium and iron, the sphalerite contains 16 mole per cent iron and 1 mole per cent manganese, the biotite is phlogopitic containing 16 mole per cent annite, 15 mole per cent of the hydoxyl in the biotite is replaced by fluorine, and the galena contains 5 weight per cent selenium. The amphibole is zoned with grain cores slightly higher in aluminum and iron.

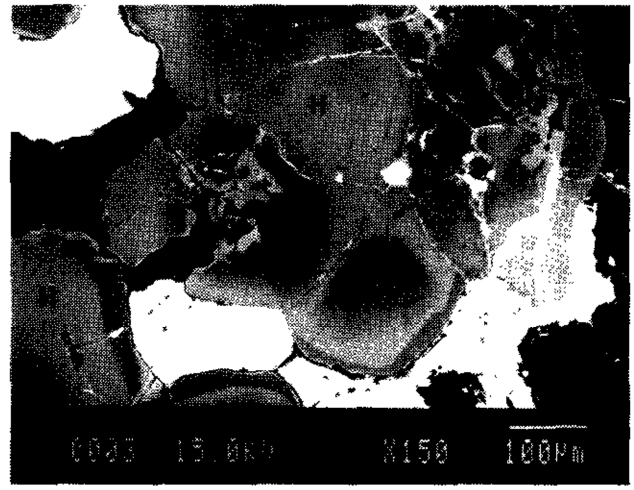

Plate 2-3-1. BSE photograph of hyalophane grains (H) from specimen BL-H555. The brighter regions of the hyalophane are relatively rich in barium.

CK

The specimen from the CK deposit which was examined is designated CK-H67. Its mineralogy includes sphalerite, pyrrhotite, galena, potassium feldspar, plagioclase, quartz, biotite and both sphene and rutile. Chemical analyses reveal that the sphalerite contains 18 to 21 mole per cent iron; the plagioclase is An_{49}; the potassium feldspar is a hyalophane containing 11 mole per cent albite and 9 mole per cent celsian. The biotite is titanian containing 35 mole per cent annite, 3 mole per cent replacement of potassium by barium and 25 per cent replacement of hydroxyl by fluorine.

BIG LEDGE

The specimen from the Big Ledge deposit is designated BL-H555. Its mineralogy includes pyrrhotite, sphalerite, pyrite, galena, diopside, tremolite, calcite, potassium feldspar, phlogopite, chlorite, sphene, apatite and graphite. Chemical analyses show that the sphalerite contains 16 mole per cent iron; the diopside, tremolite and phlogopite are highly magnesian, being 95 to 98 mole per cent of their magnesium end-members. Phlogopite has 3 per cent replacement of potassium by barium and 50 per cent replacement of hydroxyl by fluorine. Calcite is nearly pure, and the potassium feldspar is hyalophane containing 3 per cent albite and 5 to 17 mole per cent celsian.

The hyalophane grains are, in fact, distinctly zoned with respect to the barium content (Plate 2-3-1). This zoning has a recognizable sequence beginning with a discrete high-barium phase which is overgrown by a phase distinctly lower in barium. Further feldspar growth resulted in continuous gradational zoning increasing in barium content. This phase is locally overgrown by a phase distinctly lower in barium. A late, high-barium phase is also present locally with some fracture control on its distribution.

COTTONBELT

The specimen from the Cottonbelt deposit is designated CB-H12. Its mineralogy includes magnetite, sphalerite, pyrrhotite, galena, olivine, biotite, rhodochrosite, kutnohorite, apatite and graphite. Chemical analyses confirm the high abundance of manganese in gangue minerals reported by Höy (1987) and reveal a significant manganese content in the ore minerals as well. These analyses show that the sphalerite contains 24 to 27 mole per cent iron and 5 per cent manganese, the olivine is 50 per cent fayalite, 30 per cent tephroite and 25 per cent forsterite, and the biotite is 35 per cent annite with 8 per cent of the hydroxyl replaced by fluorine and 1.5 per cent of the hydroxyl replaced by chlorine.

The carbonates exhibit a distinct zoning sequence with textures indicative that the latest generations formed by infilling small open spaces (Plate 2-3-2). The most voluminous phase is a manganese-rich dolomitic carbonate (kutnohorite) which is approximately 50 mole per cent kutnohorite, 30 per cent dolomite and 20 per cent ankerite.

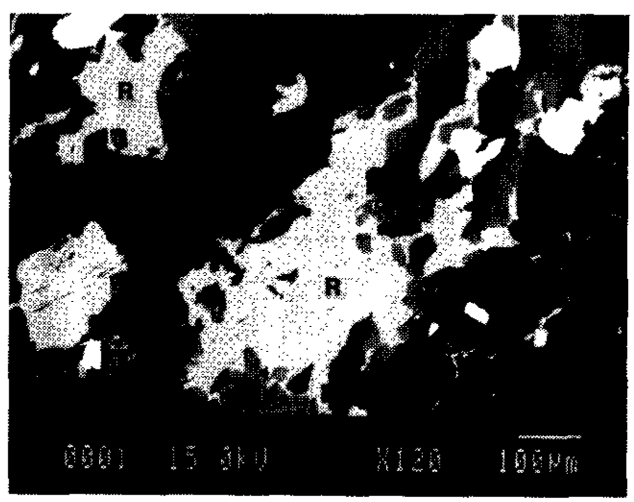

Plate 2-3-2. BSE photograph showing manganese carbonate zoning in specimen CB-H12. Indicated are early kutnohorite (EK), late kutnohorite (LK) and rhodochrosite (R).

Near the centre of areas filled with carbonate this intermediate kutnohorite generally has regular terminations and is overgrown with small amounts of a distinct high-manganese kutnohorite (90% kutnohorite) phase which also has crystal-face type terminations. The small remaining central volume is filled with a high-manganese rhodochrosite (80 to 90% rhodochrosite).

The magnetites have an exsolution texture, undoubtedly a response to solubility shifts during cooling from the maximum metamorphic temperature (650°-700°C, Höy, 1987). The exolved phase is an aluminous spinel containing 48 mole per cent gahnite, 32 per cent hercinite, 12 per cent spinel ($MgAl_2O_4$) and 8 per cent galaxite ($MnAl_2O_4$). Very small grains of this spinel speckle the interior of magnetite grains (Plate 2-3-3). However, within about 20 micrometres of grain edges the magnetite is free of spinel inclusions. The identification of aluminous spinel grains along these grain boundaries (intergrown with the surrounding phases) indicates that within this edge region the spinel components have migrated to the grain boundary rather than nucleating within the magnetite. The magnetite itself contains almost 3 weight per cent MnO.

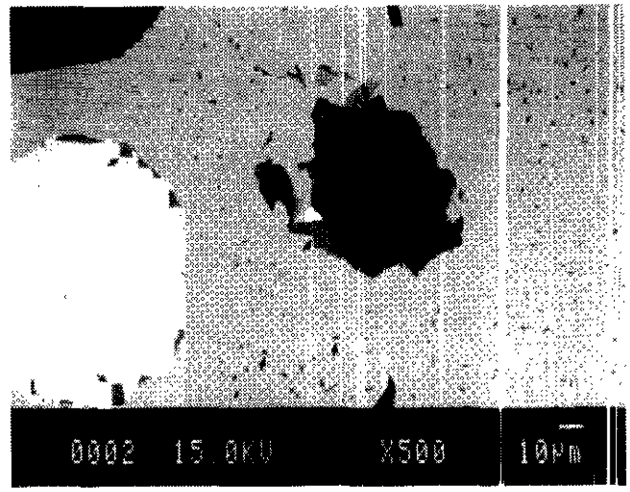

Plate 2-3-3. BSE photograph showing spinel exsolution textures in mangetite in specimen CB-H12.

DISCUSSION

Although it is beyond the scope of this report to extensively discuss any implications of the mineral chemistry described above, there are several features worthy of note: the selenium content of the Goldstream galena, the manganese content of the Cottonbelt specimen, the fluorine content of the biotites, the occurrence of hyalophane, the preservation of compositional zoning in the Big Ledge and Cottonbelt specimens, and the implications of the buffered sphalerite composition in the Big Ledge specimen.

The high manganese content of the Cottonbelt specimen is reflected in the chemistry of nearly all minerals which are known to take up manganese; even the magnetite and the sphalerite contain significant amounts.

Feldspars containing essential barium, such as at the Big Ledge deposit, occur exclusively in mineral deposit settings, especially metamorphosed mineral deposits (Deer *et al.*, 1966).

Despite the high metamorphic temperatures experienced by the specimens from Cottonbelt and Big Ledge, compositional zoning in the carbonate, kutnohorite (CB-H12), and the potassium feldspar, hyalophane (BL-H555), have not been significantly modified by diffusion. Growth zoning features in both of these minerals are locally sharply defined implying that diffusion of the zoned components (Mn in kutnohorite and Ba in hyalophane) is relatively slow.

The specimen from Big Ledge contains the assemblage necessary for pressure-sensitive buffering the composition of sphalerite – the sphalerite geobarometer (sphalerite+pyrrhotite+pyrite). Assuming that the peak metamorphic temperature experienced at Big Ledge was similar to that at Cottonbelt (650°-700°C, Höy, 1987) the 16 mole per cent FeS in the sphalerite in BL-H555 implies a formational pressure less than 40 megapascals (4 kilobars) whether the thermodynamic calibration or the experimental calibration is used (Toulmin *et al.*, 1991). This is in distinct contrast with the 70 megapascals (7 kilobars) peak metamorphic pressure estimated for the Cottonbelt region and may imply significant resetting of the sphalerite composition during cooling.

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