Mineralogy of Ni-Cu-Platinum-Group Element Sulfide Ore in the 800 and 810 Orebodies, Copper Cliff South Mine, and P-T-X Conditions during the Formation of Platinum-Group Minerals

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Abstract

The 800 and 810 orebodies are two major deposits in the Copper Cliff South mine, located at opposite contacts between the quartz diorite of the Copper Cliff offset dike and metapelite of the McKim Formation. The Copper Cliff South mine is one of the richest Cu-Ni- platinum-group elements (PGE) deposits in the Copper Cliff offset dike. The ore is composed of variable proportions of pyrrhotite, chalcopyrite, and pentlandite and occurs as massive sulfides, semimassive sulfides with inclusions of quartz diorite and wall rocks, net-textured sulfides, disseminated sulfides, and veins. Sphalerite and magnetite are also present in minor amounts. The primary magmatic minerals in the quartz diorite are plagioclase, quartz, amphibole, and biotite.

The most common platinum-group mineral (PGM) in the Copper Cliff South mine is sperrylite ($PtAs_2$). It occurs in every textural type of ore, typically enclosed by chalcopyrite, pyrrhotite, pentlandite, cobaltite, and hydrous silicates such as chlorite, amphibole, and epidote. Sperrylite may be homogeneous, zoned (with Sb-rich cores and Sb-poor rims), associated with hollingworthite (RhAsS) and cobaltite, or it may contain inclusions. The Pd-bearing minerals are froodite ($PdBi_2$) and michenerite (PdBiTe), which are most commonly enclosed by silicates (chlorite, biotite, quartz) or chalcopyrite. Hollingworthite invariably occurs in the center of zoned cobaltite in veins or in disseminated sulfides. Argentian gold ($Au_{0.56}$ $Ag_{0.44}$) occurs as small grains in chalcopyrite and in a veinlet with parkerite ($Ni_2Bi_3S_2$). The most abundant Ag mineral is hessite (Ag_2Te), which is present in almost every sample with galena, gersdorffite, and locally PGM. Volynskite ($AgBiTe_2$) occurs as a zoned grain with tsumoite (BiTe) in the center. The most common trace minerals spatially and genetically associated with PGM are tsumoite, galena, gersdorffite, cobaltite, hessite, melonite, and native Te.

The Copper Cliff South mine area was affected by more than one hydrothermal event, deformation, and metamorphism, all of which affected the primary igneous textures and mineralogy of the rocks. The first hydrothermal event was responsible for the extensive remobilization of metals, including some PGE. This is revealed by the presence of PGM in large veins in quartz diorite and metapelite and by chlorite, amphibole, epidote, biotite, and quartz that often enclose PGM. The temperature at the time of this event was estimated in samples containing garnet and biotite in equilibrium to be 327° to 540°C. Pressure, estimated using amphibole chemistry, may have been as high as 3 to 4 kbars. The fluid responsible for the transport of metals was very rich in Cl and oxidizing. The fluid composition, temperature, and/or pressure changed with time, suggested by the presence of zoned minerals, including sperrylite, gersdorffite, and cobaltite. Based on the textural relationships, sperrylite precipitated before tellurides and galena, and after or at the same time as michenerite. A second hydrothermal event produced calcite-bearing veinlets that cut larger veins.

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