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Petrogenesis of Cu-Ag Skarn Mineralization at the McKenzie Gulch Area Northern New Brunswick: Relating Dike Swarms Emplacement and Skarn Evolution Using LA-ICP-MS U-Pb Zircon and Titanite Dating Techniques

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Early to Middle Devonian intermediate to felsic porphyry dike swarms at the McKenzie Gulch (MG) area intrudes the Upper Ordovician through Silurian calcareous sedimentary rocks of the Matapédia Group. These intrusive rocks are associated with numerous Cu ± Ag skarn occurrences. The type example is the Legacy deposit containing approximately 1.5Mt grading 0.87 % Cu and 10.29 g/t Ag. The skarn mineralization occurs mainly as veins, disseminations, and replacements. These occurrences are localized between two northeast-trending, dextral strike-slip fault systems, the MG Fault to the west and the Rocky Gulch Fault to the east, all associated with Acadian Orogeny.

Garnets from the MG skarn belong to the grossular-andradite solid solution ranging in composition from $Adr_{16}Gr_{82}$ to almost pure andradite - $Adr_{99}Gr_{1}$, with the other garnet end-members collectively less than 5%. Pyroxenes belong to diopside-hedenbergite solid solution with composition ranging from $Di_{31}HD_{60}$ to $Di_{93}Hd_{7}$, whereas other pyroxene members collectively account for less than 10%. These calc-silicates can be subdivided into two categories: an early prograde; and a later retrograde skarn facies. The latter tends to occur mostly along late calcite veins associated with epidote, amphibole, titanite, and sulfide mineralization. There is a general tendency for increasing andraditic and hedenbergitic components from the prograde to retrograde garnets and pyroxenes, respectively. This Fe-enrichment is also recorded by intracrystalline chemical zonation, respectively with grandite and diopsidic cores rimmed by more andradite and hedenbergitic compositions, but reverse zoning also occurs. Combining the major element composition of garnets with their textural and optical characteristics, this study concludes that grandites (Al-rich) formed under low water/rock ratios, in equilibrium with metasomatic fluids whose composition was locally buffered by the host rocks, whereas andradite (Fe-rich) resulted from rapid growth, with relatively high water/rock ratios, and in equilibrium with a magmatic-derived fluid. Oscillatory zoning and hydrofracturing observed in these skarn facies are some of the features that reflect the chemical and physical variability of the system. In general, there is a relationship between the composition of pyroxenes and garnets of the skarn alteration facies and the dominant metal of the mineralized skarns. These facies plot in the compositional field of both Cu- and Zn-dominated skarns.

Zircon from plagioclase-hornblende and quartz-plagioclase dike swarms, which intrudes the ore body and hydrothermal titanite from skarn ores were successfully dated by laser ablation inductively coupled plasma-mass spectrometry (LA-ICP-MS) to constrain the timing of multiple dike emplacements and that of skarn mineralization. These analyses yielded weighted mean $^{206}Pb/^{238}U$ age of 386 ±2.3 Ma for zircon and 387 ±3.6 Ma for titanite, in agreement with each other within analytical uncertainty. Consequently, this study concludes that the MG Cu-Ag skarn mineralization was contemporaneous with the intrusion of the compositionally variable dike swarms and that it represents distal components of a magmatic-hydrothermal system at depth.