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The Hemlo Gold Deposit, Ontario: An Example of Melting and Mobilization of a Precious Metal-Sulfosalt Assemblage during Amphibolite Facies Metamorphism and Deformation

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Abstract

The timing of mineralization at the Hemlo gold deposit has long been a controversial issue. We present arguments that use partial melting of the ore assemblage to explain the mechanism of ore mobilization and resolve problems with the model of premetamorphic mineralization. The results have implications for mine exploitation and exploration strategies. We show that the ore mineral assemblage underwent partial melting during middle-amphibolite facies metamorphism (600°–650°C, 6–7 kbars), primarily through breakdown of stibnite and arsenopyrite in a high-f_{S_2} environment. Concurrent deformation led to segregation of the resulting Sb- and As-rich sulfosalt melt. Interaction between this melt and a range of unmelted sulfides led to further melting and incorporation of other elements into the melt. The gold-bearing melt was mobilized from compressional high-strain sites into dilational domains such as boudin necks and extensional fractures developed in competent lithologies. Ore minerals that did not melt significantly (pyrite, molybdenite, pyrrhotite, and sphalerite) were not extensively mobilized and largely remained within high-strain compressional domains. This segregation of melt from residue thus resulted in the observed heterogeneous distribution of ore minerals within the deposit. Crystallization of the sulfosalt melt produced a diverse suite of ore minerals, dominated by stibnite and realgar and containing an array of rare sulfosalts, native elements, intermetallic compounds, and tellurides. Some sulfosalt melt persisted to low temperature (<300°C), allowing continued small-scale, localized mobilization during late deformation. Although gold occurs at moderate concentrations within the compressional high-strain domains, it is particularly concentrated in the dilational domains, a consequence of its mobilization within a sulfosalt melt. Our model of partial melting of the ore mineral assemblage with consequent mobilization explains how ore minerals that are unstable even at greenschist facies conditions came to be hosted in structures that formed at or near the peak of amphibolite facies metamorphism.

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