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Unraveling the Geologic History of the Hemlo Archean Gold Deposit, Superior Province, Canada: A U-Pb Geochronological Study

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Abstract

The Hemlo deposit is one of Canada's largest gold camps. Gold is both structurally and lithologically controlled, but shows unusual relationships relative to many other Archean lode deposits. Field evidence suggests that gold was emplaced within mechanical and chemical traps along a jog in a major sinistral shear zone, most likely during early formation of second-generation (G_2) structures, which represent the most intense phase of regional deformation. Mineralization was followed by amphibolite-facies regional metamorphism.

U-Pb geochronology has been carried out on zircons from rocks associated with the deposit, in order to determine the precise chronology of geologic events and their relationship to mineralization. Zircon populations are commonly affected by both inheritance and hydrothermal/metamorphic crystal growth. Meaningful and precise age information can only be determined by precise single zircon dating on rocks from a well constrained, structural, and stratigraphic context.

Gold is mostly found near the deformed contact between the Moose Lake quartz porphyry volcanic complex and stratigraphically underlying metasedimentary rocks. These rocks have been folded by a camp-scale, noncylindrical F_2 fold. Zircon from the Moose Lake quartz porphyry is dominated by inheritance and gives ages that extend from ~2800 to ~2690 Ma. Metasedimentary rocks that underlie and overlie the Moose Lake porphyry show a much narrower range of provenance ages, and are dominated by 2,690- to 2,693-million-year-old zircon. Two detrital zircons from a metasedimentary rock directly beneath the porphyry define an age of 2685 ± 4 Ma. This should be an older age limit on volcanism, deformation, and gold mineralization. The four youngest near-concordant zircons from the Cedar Lake pluton define a magmatic age of 2680 ± 1 Ma. This pluton was emplaced prior to or early during G_2 deformation, while emplacement of gold was most likely controlled by G_2 structures. Therefore, 2680 ± 1 Ma probably also represents an older age limit on gold mineralization. A feldspar porphyry dike that cuts gold ore gives a younger age bracket of 2677 ± 1 Ma.

The results of zircon dating suggest that a volcanosedimentary complex was constructed in the area over the period of 2693 to 2685 Ma. This developed on earlier crust, ca. 2720 Ma in age, but there is evidence from detritus and xenocrysts for older rocks dating back to over 2800 Ma. Deposition of supracrustal rocks was followed by granodiorite plutonism at 2680 ± 1 Ma, then major deformation (G_2) and gold mineralization, overprinted by amphibolite-facies metamorphism (previously dated at 2676 Ma from titanite ages). Late-tectonic "sanukitoid suite" plutons were emplaced at 2677 ± 1 Ma. Thus, the primary gold-forming event occurred near the beginning of a period of plutonism and crustal reworking that lasted, at most, a few million years. This time association supports the view that granitoid magmas were the source of auriferous fluids. Plutons intruded into an actively deforming crust and were probably also the heat source for regional metamorphism. The most likely environment was a tectonically active, Timiskaming-type sedimentary basin. Similarly aged basins are found in the Timmins area to the east and the Shebandowan greenstone belt to the west.

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