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Mobilization of Gold as a Polymetallic Melt during Pelite Anatexis at the Challenger Deposit, South Australia: A Metamorphosed Archean Gold Deposit

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Abstract

The Challenger gold deposit in South Australia is hosted by pelitic migmatites that underwent peak metamorphism at ~7.5 ± 1.5 kbars and at least 800ºC. Nd model ages suggest a protolith age of ~2900 Ma. Zircon U-Pb and garnet Sm-Nd dating indicates that peak metamorphism occurred at ~2440 Ma and that garnet was present during this event. At this time in situ vapor-absent melting affected the pelitic host rock, indicating that peak metamorphism occurred without introduction of a foreign fluid or melt. Thus, evidence indicating the presence of ore minerals during peak metamorphism implies a prepeak mineralization event. This evidence includes the occurrence of invisible gold in löllingite but not in adjacent arsenopyrite, and the presence of spherical gold sulfide inclusions in peak metamorphic garnet and other silicates. Textures developed between pyrrhotite, löllingite, arsenopyrite, and gold; the lack of silicate alteration minerals supports this conclusion.

Experimental evidence is presented to support our interpretation that a gold-rich polymetallic melt was mobilized into leucosomes synchronously with silicate melt during peak metamorphism. Visible gold is restricted to migmatitic leucosomes and, to a lesser extent, melanosomes. Large inclusions of gold with coexisting arsenopyrite, pyrrhotite, and bismuth are hosted within peak metamorphic silicate minerals and at grain boundaries. Trails of micrometric spherical inclusions of predominantly gold and bismuth propagate along annealed fractures from these larger inclusions. We show that these gold sulfide inclusions represent the crystallized products of an immiscible polymetallic melt. Metamorphism of the Challenger deposit resulted in partial melting of the pelitic host rock and formation of this gold-rich melt. These two melts were synchronously redistributed to accumulate as leucosomes during development of a stromatic migmatite. Formation of a polymetallic melt thereby enabled extensive mobilization of gold, producing leucosomes enriched in gold. This occurred because the immiscible metallic melt was physically entrained rather than chemically dissolved within the silicate melt.

Gold-rich shoots at Challenger parallel the plunge of ptygmatically folded leucosomes that are shown to be parasitic to a larger scale fold geometry which appears to be structurally related to the ore shoots. It is interpreted that concurrent migration of polymetallic and silicate melt allowed concentration of gold into a series of dilational structures which developed within the larger scale fold geometry.

Challenger represents a new deposit type. Other deposits around the world, such as Renco and Griffins Find, are hosted in granulite facies rocks, but Challenger is the first reported example of leucosome-hosted gold in migmatites.