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Fertility of Archean metasedimentary rocks and the formation of orogenic gold deposits: Insights from low-detection limit Au analyses and LA-ICP-MS analyses of sulfides.

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The sources of metals and fluids in orogenic Au-deposits of Archean age is a longstanding debate among researchers. The metamorphic model, which suggests that the metals and fluids that form the deposits are produced from metamorphic devolatilization reactions from metasedimentary rocks at deeper levels in the terrane, is well accepted for the Phanerozoic but less so for the Archean. This study tests the metamorphic model in the Archean-aged Abitibi Greenstone Belt, Canada. A complete set of metasedimentary rock samples was collected from the Pontiac subprovince, the Cadillac group and the Porcupine assemblage and then analyzed for Au, As, Sb, Se, Te, Bi at Stockholm University using low-detection limit methods. The analyses showed that the Au-content of the Pontiac samples decreases systematically from 4.2 ppb (range 0.25-30 ppb) in biotite zone greenschist facies to 0.33 $\pm$0.1 ppb in sillimanite zone amphibolite facies samples. Based on average values, this corresponds to 92% depletion in Au during prograde metamorphism. Similar, systematic depletions are also observed for As and Sb; the sillimanite zone rocks are 98% and 78% depleted respectively. Values for Se, Te and Bi show no systematic change with increasing metamorphic grade. The Pontiac amphibolite facies samples are also depleted in C (-90%) and H_2O (-34%). The main pulse of water liberation occurred between garnet and staurolite zone, which coincides with the bulk of whole-rock depletions in Au, and other metals. In-situ LA-ICP-MS analyses of sulfides shows that Au is hosted in pyrite and that concentrations are above detection limits only in the biotite and garnet zone samples. Pyrrhotite contains no Au above detection limits at any metamorphic zone. These indicate that the controlling mechanism for metal liberation during metamorphism is the Py-Po transition. Mass balance calculations show that >10t Au, >32000t As, >360t Sb and >20Mt C were mobilized from each km^3 of Pontiac rocks metamorphosed up to sillimanite zone amphibolite facies conditions. The timing of metamorphism of the Pontiac rocks coincides the timing of orogenic Au-deposits formation ($\approx$2670 Ma). Thus, they possibly represent a high-fertility metasedimentary source of metals and fluids to the Archean orogenic-Au deposits of SE Abitibi. Even though metasedimentary rocks are less abundant in Archean greenstone terranes such as the Abitibi compared to Phanerozoic metasedimentary terranes, they show significantly higher metal fertility most likely due to the higher solubility of Au in the anoxic, HS-rich Archean oceans. This indicates that the metamorphic model and specifically the metamorphism of metasedimentary rocks may be applicable to at least some Archean aged greenstone terranes.

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