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Experimental determination of Au solubility in rhyolite melt and magnetite: Constraints on magmatic Au budgets

ADAM C. SIMON,[1,*] THOMAS PETTKE,[2] PHILIP A. CANDELA,[1] PHILIP M. PICCOLI,[1] AND CHRISTOPH A. HEINRICH[2]

[1]Laboratory for Mineral Deposits Research, Department of Geology, University of Maryland, College Park, Maryland 20742, U.S.A.
[2]Isotope Geochemistry and Mineral Resources, Federal Institute of Technology, ETH Zentrum NO, CH-8092, Zurich, Switzerland

ABSTRACT

The solubility of Au metal in rhyolite melt and coexisting magnetite has been determined at 800 °C, 140 MPa, and $f_{O_2} \approx$ NNO in a Au-metal saturated, sulfur-free, vapor-brine-silicate melt system. Whole crystals of magnetite suspended within quenched rhyolite glass were analyzed by LA-ICP-MS. These data yield a solubility of Au in magnetite on the order of 2 µg/g. The solubility of Au metal in rhyolite melt hosting the magnetite crystals is on the order of 500 ng/g. These data indicate a partition coefficient for Au between magnetite and melt, $D_{Au}^{Mt/melt} \approx 4$. Using reasonable estimates of the mass fraction of magnetite that crystallizes in crustal magmatic systems, we modeled the proportion of Au sequestered by magnetite during fractional crystallization. We considered fractionation in two steps: the idealized derivation of a rhyolite by fractionation of basalt at depth, and the closed-system crystallization of the rhyolite in a magma chamber below the site of ore deposition. Magnetite sequesters 14–54% Au from basaltic parent melt that produces a rhyolite melt via crystal fractionation, at modal abundances of 1–5%. Less then 4% Au is sequestered from a crystallizing rhyolite melt because of low modal abundances of magnetite (<~2%). Our experimental and model results suggest that early crystallization of magnetite can play a mitigating role in the ability of a calc-alkaline magmatic system to yield a Au-rich ore fluid.