An essential role for sulfur in sulfide-silicate melt partitioning of Au and magmatic Au transport at subduction settings

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Sulfide-silicate melt partitioning controls the behavior of Au in magmas, which is critical for understanding Earth's deep Au cycle and formation of Au deposits. However, the factors that affect the sulfide-silicate melt partitioning of Au remain unresolved. Here we present constraints from laboratory experiments on the partition coefficient of Au between monosulfide solid solution and silicate melt ($D_{Au}^{MSS/SM}$) under conditions relevant for magmatism at subduction settings. We show that $D_{Au}^{MSS/SM}$ varies from 10 to 14000, which is positively correlated with the melt sulfur content $[S]_{melt}$ and sulfur fugacity over a range of oxygen fugacities. Using the correlation between $D_{Au}^{MSS/SM}$ and $[S]_{melt}$, we find that ancient-to-modern slab melts carry negligible to less than 25% of slab Au to the subarc mantle; however, Au-enrichment can occur in monosulfide solid solution-saturated arc magmas that differentiated under moderately oxidized conditions with oxygen fugacity 0-1.5 log units above the fayalite-magnetite-quartz buffer. We conclude that moderately oxidized mafic-to-intermediate magmas with high contents of alkali metals, sulfur, and water, owning to their low $D_{Au}^{MSS/SM}$ and efficient magma-to-fluid transfer of Au and sulfur, have a high potential to form large-to-giant Au deposits.