Economic Geology,
Vol. 96, 2001, pp. 91-107

Gold Content of Eastern Manus Basin Volcanic Rocks: Implications for Enrichment in Associated Hydrothermal Precipitates

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Abstract

Hydrothermal precipitates associated with active vents in the eastern Manus back-arc basin, Papua New Guinea, are among the most gold rich yet discovered on the modern sea floor. The volcanic rocks associated with this mineralization were investigated to determine if they are sufficiently enriched in gold to account for the gold content of the sulfides by simple leaching and to determine whether or not any evidence for a magmatic fluid exists. The gold content of unaltered volcanic glass and glassy volcanic rocks from the eastern Manus basin ranges from <1 to 15 ppb and averages 6 ± 3 (1σ) ppb. These concentrations are similar to volcanic rocks from the Lau, Japan, and Yamato back-arc basins but are significantly higher than those from midocean ridges and submarine-arc volcanic rocks.

Modeling of the PACMANUS hydrothermal system indicates that for a stationary reaction zone unacceptably high leaching and transport and precipitation efficiencies are required to derive gold in the sulfides by leaching processes. Downward migration of the high-temperature reaction zone, as the magma that is driving the circulation cools, will result in exposure of the hydrothermal fluids to much more rock than in the static scenario. Consequently sufficient gold may be leached to account for the gold in the sulfides.

Primitive mantle-normalized metal contents of PACMANUS sulfides are similar to those of associated volcanic rocks, rather than the basement volcanic rocks that are the more likely source of leached metals. This similarity implies a close genetic relationship between the metal content of the host volcanic rocks and the sulfides, such as derivation from the same magma. A significant positive correlation of gold and copper contents of the volcanic rocks indicates a similar behavior of these two metals during magmatic evolution. During fractional crystallization both metals are initially enriched in the melt. Peak concentrations of copper and gold in the melt are reached at an SiO_2 content of 57 percent, after which the concentration decreases rapidly. Such a rapid decrease is believed to be due to a combination of magnetite fractionation and pre-eruptive degassing of the andesitic magma.

A dual source of gold is proposed for the PACMANUS deposit, whereby gold is leached from the subsea-floor rocks but is also added to the hydrothermal system by a direct contribution from an exsolved magmatic fluid. Such a dual source may be an important factor in generating the gold-rich precipitates found in western Pacific submarine arcs and back arcs.