Hydrothermal Transport of Ag, Au, Cu, Te, and Other Metals in High-Temperature Geothermal Systems, North Island, New Zealand: Implications for Genesis and Exploration of Epithermal Deposits

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We sampled and analyzed the concentrations of Ag, As, Au, Cd, Cu, Hg, Mn, Mo, Ni, Pb, Se, Sb, Te, Tl, W, and Zn in deep hydrothermal solutions at 195° to 320°C in wells drilled to 3-km depth in geothermal systems of the North Island, New Zealand. Six of the systems are located in the central Taupo volcanic zone, and one is located adjacent to an intraplate mafic (felsic) volcanic center.

The aqueous concentrations of metals range widely from 0.1 to >1,000 µg/kg with a large degree of intersystem variability. The correlations between metals are poor, except for Ag and Te, As and Sb, and Au and Ag. The correlations between metals and Cl and H_2S are also poor, with the exception of Rotokawa, where the highest concentrations of Ag, Au, Cu, and Te correlate with the highest concentration of aqueous H_2S. The complex trends in metal concentrations strongly suggest that the hydrothermal supply of metals is time dependent and controlled by processes related to both magmatic intrusion and heating of deep country rock.

Hydrothermal fluxes of Ag (6–8,000 kg/y), Au (0.9–66 kg/y), Cu (30–23,500 kg/y), and Te (2–10,400) kg/y are unevenly distributed between the geothermal systems, with most precious metal being fluxed at Rotokawa and Mokai. The high concentrations of Ag, Au, and Te in these two systems are attributed to direct fluid input from magmatic intrusions of intermediate and mafic compositions, respectively.

Compared to their deep counterparts, hydrothermal solutions collected from production wells at the surface are strongly depleted in Ag, Au, Cd, Cu, Pb, and Te, because they deposit quantitatively due to gas loss, boiling, and cooling in the well. The As, Mn, Mo, Ni, Sb, Tl, and Zn concentrations are measurably higher in boiled solutions, making them available to form metal anomalies in shallow-level and peripheral parts of the system.

Strong hydrothermal metal flux and deep boiling likely promote epithermal ore genesis and the development of large ore deposits. However, even moderate metal fluxes can lead to ore mineralization as long as the duration of focused fluid flow and boiling can be sustained.