Temporal constraints on magma dynamics resulting in porphyry copper deposit formation

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The timing and duration of volatile exsolution repsonsible for porphyry-style copper mineralisation are ultimately controlled by the dynamics within the long-lived magmatic systems that supply the metals and ore-forming fluids. Volatile saturation occurs in response to changes in pressure, temperature and crystallinity of the source magma. We examine the temporally constrained relationships between mineralisation and magma dynamics at depth in one of the world's youngest exposed porphyry systems, the Koloula Poprhyry Prospect, Solomon Islands.

Geological relationships and high precision ID-TIMS U-Pb zircon dating constrain assembly of the shallow level pluton to <150 kyr. Mineralising poprhyry intrusions followed within ca. 50 kyr. Discrete mineralising intrusive events are separated by 34 ± 24 kyr, also constraining the duration of the first, ore-forming hydrothermal event. Dates define both protracted zircon crystallisation at depth and rapid recycling to the crustal level of porphyries.

We apply a multifaceted approach combining: textural analysis of zircons; U-Pb geochronology; Ti-in zircon thermometry; and geochemical modelling of zircon dissolution rates and magma crystallinity-temperature relationships for suitable approximations of conditions in the underlying plutonic system. Results show that magmas resided in a highly crystallised (>50%), volatile saturated, immobile state for extended periods at depth preceeding porphyry formation. Liberated mobile melt fractions that transported the requisite components for mineralisation to shallow levels were transient, existing for <10–20 kyr.

Intrusion of andesitic magmatism under the highly crystallised silicic pluton provided the energy for thermal rejuvenation. Porphyry formation was likely promoted by rejuvenation following the addition and percolation of hot volatiles, during low fluxes of andesitic magma; rather than extensive magma mixing, which occurred during high fluxes.