Mafic Magmatic Origin of Orogenic Gold Systems

Daniel Wiemer[1], Steffen G. Hagemann[2], Anthony I.S. Kemp[2], Walter K. Witt[2], Jon Hronsky[3], Graham C. Begg[4], Trevor Ireland[5], Chris Fisher[2], Laure Martin[2], Nicholas Hayward[6], Carlos Villanes[7]
[1]Economic Geology Research Centre, James Cook University, Townsville, Australia, [2]Centre for Exploration Targeting, University of Western Australia, Perth, Australia, [3]Western Mining Services Pty Ltd, Perth, Australia, [4]LithoAtlas Pty Ltd, Perth, Australia, [5]School of the Environment, University of Queensland, Brisbane, Australia, [6]PredictOre Pty Ltd, Perth, Australia, [7]Compania Minera Poderosa S.A., Lima, Peru

Orogenic gold deposits are classically associated with metamorphic dehydration of crustal rocks, and over-pressurized fault valve mechanisms mainly at the mesothermal brittle-ductile transition. Granites, as alternative sources of Au-ore fluids are considered viable, if spatial and temporal relationships with gold mineralization are established. However, granites are not always observed in gold camps, or pre- or post-date mineralization. Furthermore, degassing of common granitic arc magma during crustal ascent precludes expulsion of typical orogenic aqueous-carbonic fluids (XH2O = 0.75-0.95 mol%) at meso- to hypozonal crustal levels (~2-6 kbar). Higher Au-solubility and metal-carrying capacity is shown for mafic magmas, especially for hydrous alkaline members. The latter, however, are volumetrically subordinate, questioning whether they can produce large deposits.

We report on low-preservation-potential incompatible element enriched hydrous mafic rocks as gold parental magmas. Petrological modelling demonstrates initial ascent of hydrous amphibole-rich magma mush stalling in the deeper mid-crust (>20 km; not exposed at mesozonal levels; common arc geotherm ~75 mW/m2). Near-solidus magmatic mineral assemblages (~660°C, 7kbar) match Ti-in-zircon temperatures spanning sub-solidus replacement (epidote) and thermal rejuvenation during magmatic recharge (amphibole breakdown). Antecrystic zircon confirm that the magmatic plumbing system evolved over >30Myrs through episodic (~5-Myr-duration) mafic recharge prior to final emplacement at mesozonal crustal levels. We show that volatile saturation and degassing of previously underestimated CO2-H2O contents during crustal passage can generate orogenic-like fluids. A mechanism for deep-seated fluid expulsion is recorded in observed amphibole breakdown during recharge. Hafnium-O in zircon isotopic data inform on a pre-enriched subduction-related metasomatized upper mantle source for the Au-parental mafic magma. For the first time, we present a power-law-like correlation between apparent trends for different Au-grades as a function of starting parental magma compositions (>5,500 data), showcasing a reduced grade-potential with increasing silica index confirming the higher capacity of mafic endmembers to produce higher-grade (and likely larger) deposits.