Colloidal Transport: a Solution to the High-Grade Gold Ore Paradox?

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A major shortcoming of existing genetic models for epithermal gold deposits is that they do not satisfactorily explain the formation of ultra-high-grade ores. The transport of gold as dissolved species in a hydrothermal liquid has long been the accepted means of gold mobilisation and epithermal ore formation. Gold concentrations in the fluids responsible for epithermal mineralisation, however, are typically on the order of 10 to 30 ppb, which are far too low to explain concentrations of 10's of thousands of grams per tonne Au in veins in some deposits. Formation of such veins by direct precipitation of native gold or electrum from the ore fluids would require that fractures remain open for extremely long periods of time or that fluid fluxes be extraordinary.

A potential solution to the paradox of ultra-high grade gold deposition, in geologically realistic time-frames, may be offered by colloidal transport. We have undertaken a study of high-grade gold mineralisation at the Brucejack epithermal gold-silver deposit, NW British Columbia, Canada, to evaluate this possibility. Images obtained using transmitted electron microscopy show that: (1) gold commonly occurs as < 1 to 10 nm wide spherical nanocrystals of electrum embedded within a calcite matrix; (2) larger (100 to 500 nm wide) particles of electrum, also embedded in calcite, are composed of hundreds of nanoparticles, each displaying distinct crystal lattice plane orientations; and (3) the margins of > 1 μm wide electrum masses surrounding the calcite matrix comprise nanoparticulate electrum partially crystallised to massive monocrystalline electrum. These images provide compelling evidence for the formation of colloidal suspensions of electrum and their flocculation.

We present a model in which high-grade epithermal gold mineralisation develops through boiling- and/or seawater-mixing-driven colloid suspension and flocculation of gold nanoparticles that were transported by a carbonate fluid from a mineralised source at depth. Our model offers a solution to the longstanding problem of high-grade gold transport and deposition in epithermal vein systems, as well as an explanation for the extraordinary and challenging grade variability often encountered during the mining of these deposits.