The optimal pathways leading to earthquake-enhanced gold precipitation in the epithermal environment

P. SÁNCHEZ-ALFARO[12]*, M. REICH[12], T. DRIESNER[3], G. ARANCIBIA[24], P. PÉREZ-FLORES[24], J. CEMBRANO[24], J. ROWLAND[5] AND C. HEINRICH[3]

[1]Dept. of Geology, Universidad de Chile, Santiago, Chile (*correspondence: vsanchez@ing.uchile.cl)
[2]Andean Geothermal Center of Excellence (CEGA), Universidad de Chile, Santiago
[3]ETH Zürich, Isotope Geochemistry and Mineral Resources, Zürich, Switzerland
[4]Dept. of Structural Engineering, Pontificia Universidad Católica de Chile, Santiago, Chile
[5]School of Environment, The University of Auckland, Auckland, New Zealand

Hydrothermal ore deposits result from the combination of a sustained flux of metal-rich fluids and an efficient precipitation mechanism. Earthquakes may trigger gold precipitation in the epithermal environment but its efficiency and time-integrated contribution is poorly quantified.

In order to quantify the feedbacks between earthquake-driven fracturing and metal precipitation in the shallow crust, we have constrained the past and present physico-chemical conditions of a geothermal system in the highly seismic Chilean Andes. We combined temperature measurements in the deep wells with geochemical analyses of fluid samples retrieved from the reservoir. In addition, we reconstructed the paleo-fluid conditions using microthermometry and LA-ICP-MS data of fluid inclusions from a deep borehole core. The effect of pressure and enthalpy changes on precipitation was evaluated by calculating the solubility of Au in P-H space, and the impact of externally-forced, seismic perturbations on fluid parameters was constrained using a thermo-mechanical piston model for a "suction pump" mechanism. The reconstructed P-T-H-X fluid trajectories indicate that fluids feeding the hydrothermal reservoir reach boiling conditions with a high gold budget (~1-5 ppb) at saturated liquid pressures between 50 and 120 bar.

Our results show that if hydrothermal ore fluids reach this optimal threshold for metal precipitation, small adiabatic pressure changes (~50 bar) triggered by transient fault-rupture can drop gold solubility by up to two orders of magnitude. We conclude that such externally-forced perturbations, equivalent to low magnitude earthquakes (Mw<2) significantly enhance gold precipitation efficiency.