Geophysical Research Abstracts
Vol. 21, EGU2019-11999, 2019
EGU General Assembly 2019

Hydromechanical development of fault-controlled orogenic gold deposits: A numerical approach to constrain the spatial distribution of mineral reserve.

Pablo Iturrieta, Ashley Stanton-Yonge, Pamela Pérez-Flores, Gerd Sielfeld, and José Cembrano
School of Engineering, Pontificia Universidad Católica de Chile, Santiago, Chile (pciturri@uc.cl)

The genesis of hydrothermal ore deposits is enabled by fluid flow through the crust, which is a complex multi-physics phenomenon comprised of mechanical, thermal and chemical rock-fluid interactions. Development of fracture networks at different scales, along with decompaction and evolution of connected interstitial voids, enhances the rock permeability through extensional deformation. This in turn, allows the hydrodynamical properties of syn-kinematic flow to evolve not only transiently, but also heterogeneously in space. Orogenic gold deposits, regardless of the gold origin, requires an efficient fluid flow and storage mechanism, such as fault systems, to provide necessary thermodynamic conditions for gold precipitation. If a fault system geometry is known up hand, it is in the general interest to determine quantitatively its hydromechanical control on the distribution of precipitation zones within a deposit. Studying this relation would provide further guidelines for the exploration of gold deposits while constraining their economic feasibility before and during exploitation.

In this work, we propose a novel finite element modelling framework to study the formation of orogenic gold deposits from an hydromechanical point of view, suitable to an arbitrary fault system geometry and tectonic boundary condition. We determine the spatial correlation between the rock deformation/stress and fluid velocity/pressure fields with the distribution of gold grade. To model the hydromechanical coupling between fluid flow and host rock deformation, we represent the rock as a poro-elasto-plastic material, where flow is enhanced by both decompaction and permeability evolution through dilational deformation. Pre-existent faults are modeled as frictional contact surfaces, whose hydrodynamical behavior is incorporated with an auxiliary sub-model of Darcy-Brinkman fluid flow. We address the uncertainty of tectonic boundary conditions by constraining the model to field fault-slip analysis. Finally, we confront benchmark simplified scenarios (i.e. step-over, duplex and fault intersection) to two real ore deposits mapped in the northern and central Chilean Andes: a kilometric strike/slip fault-vein deposit with overlapped brecciated hydrothermal textures, where mineralization occurs mainly (and heterogeneously distributed) throughout the fault volume; and a duplex fault system, where mineralization exists in both main fault-veins and secondary vein arrays.

Results from benchmark scenarios are consistent with previously reported studies. Furthermore, particularities arise for each case-study: (1) For a single vein-fault deposit, geometrical irregularities allow the localization of fluid overpressure zones. Consecutive faulting implies high fluid pressure drops (flash vaporization) within a trajectory sub-parallel to σ_2 projected onto the fault surface, which may be consistent with high ore grade bodies and overlapped breccia textures. This is also observed in lithological contacts (intrusive/limestone) cross-cutted by the fault (2) In a duplex fault system, similar conditions are found in rock volumes adjacent to, rather than within, fault intersections. These results highlight the opportunity of performing numerical modelling for an increased constrain of any mineral reserve. Further development of this approach would include (i) best fit techniques for in-situ data to improve the model accuracy and (ii) increase the model complexity by incorporating the thermo-chemical evolution of fluids throughout their pathway, while identifying other modes of gold precipitation such as boiling and cooling.