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Characterising mineral and metal transport in acidic rivers under current and future climatic conditions

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The natural occurrence of acid waters in mountainous porphyry Cu systems poses challenges for water management in a context of increasing water demand and global environmental change. Therefore, understanding related processes and their influence on water quality is critical for environmental studies and impact assessments. In this study, we develop a transport and a hydrogeochemical model by coupling five components: (i) a hydrological model to determine streamflow along the river; (ii) a hydrodynamic model to solve 1D Saint-Venant equations; (iii) a sediment transport model to estimate erosion and sedimentation rates; (iv) a solute transport model, based on the 1D OTIS model; and (v) a hydrogeochemical model, where PHREEQC is used to solve speciation and batch reactions. Our study domain is the Yerba Loca Creek basin (Central Chile), where different sources of information are available to validate the various model components. The upper basin waters show low pH (around 3) and high concentrations of aluminum, copper, iron, manganese, and sulfate. Acidity and metals are the consequence of water-rock interactions over hydrothermal alteration zones, rich in sulfides and sulfates, covered by seasonal snow and glaciers.

Historical simulations show that the proposed modeling scheme is able to reproduce observed mineralogical and chemical processes. In particular, we successfully simulate mineral precipitation/dissolution processes within different pH ranges: schwertmannite formation occurs for $2.5<pH< 4.5$, followed by hydrobasaluminite formation for $pH > 5$, and brochantite for $pH > 6$. To characterize the effects of climate change, meteorological variables from two GCM's are downscaled to the basin using the Quantile Delta Mapping method for bias correction, and the 0.05ºx0.05º national climate product CR2-MET as an observational product. Projected changes in precipitation patterns (i.e. quantity and spatial distribution) are expected to impact water quality at the Yerba Loca catchment. Further, larger volumes of acid waters coming from hydrothermal altered zones are expected due to larger precipitation amounts over the upper basin - projected by one of the GCMs -, worsening water quality.