Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.38297

Producing predictive reactive transport modelling of acid rock drainage migration in aquifer systems at mine sites: Characterization, experiments and numerical modelling

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Contamination of groundwater and loss of containment of acid rock drainage from mine site facilities to groundwater systems is a commonly occurring factor that needs to be addressed in mitigation and closure strategies. Reactive transport modelling is a critical component for the testing of those strategies prior to their implementation. In order to generate realistic reactive transport models an appropriate regime of characterization and experiments evaluating the physical and geochemical conditions affecting flow and transport is required. In this study, predictive reactive transport models of a mine site that displayed groundwater contamination below and downstream from tailings accumulations were produced and tested against historic groundwater quality. Geochemical characterization included determining the source terms and identifying the attenuation mechanisms that were present in the groundwater systems. The attenuation mechanisms were best understood through conducting extensive geochemical protocols including bulk chemistry, mineralogy, cation exchange capacity, acid-base accounting and scanning electron microscopy with elemental analysis coupled with static reactor experiments and dynamic flow through columns. Reaction path and reactive transport models that history matched the experiments were combined with post-experiment characterization to help identify the mechanisms of attenuation. To upscale, aquifer physical and geochemical heterogeneity, including the locations and history of the source terms were defined and incorporated into the reactive transport models. Initial 1D models were developed then evolving source terms were applied. Once these models were determined to be representative of the site scale conditions, the outputs were used to history match monitoring wells. Fine tuning of the flow systems and the source term fluxes led to acceptable fits to the groundwater chemistry evolution. 2D models were then constructed to incorporate additional complexity. Once a suitable match was achieved, remediation, mitigation and closure strategies could be applied to evaluate their effectiveness.