Numerical Modeling of Mass Loadings from Waste Rock Piles Affected by Heterogeneity and Structure

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Placement methods and material availability during construction of a waste rock pile (WRP) may create significant heterogeneities in physical and geochemical parameters (such as grain size, permeability, mineralogy and reactivity) and influence the internal pile structure. Due to the enormous scales of WRPs and current sampling tools available, it is difficult to capture the heterogeneities of a pile using laboratory- or field-scale studies; therefore the effects of observed pile heterogeneities on drainage water quality remain poorly understood. To this end, numerical models provide a suitable approach to explore the impact of these physical, chemical, and structural heterogeneities on discharge quality.

This study investigates the influence of heterogeneities and pile structure on acid rock drainage, metal leaching and attenuation through 2D numerical simulations using the reactive transport code MIN3P-HPC. Specifically, sensitivity of drainage quality on key parameters such as grain size distribution, sulfide mineral weathering rates, abundance and distribution of primary minerals, as well as pile structure as a function of construction methods including end-dumping and push-dumping are investigated. Geochemical reactions considered include sulfide mineral oxidation, pH buffering by calcite dissolution, as well as the formation and re-dissolution of secondary phases ferrihydrite and gypsum. Simulation results indicate that the inclusion of heterogeneities in numerical models leads to prolonged weathering and metal release (typically 2-3 times longer than for the homogeneous reference case), which is an important factor to consider when determining long-term water treatment requirements. Furthermore, simulations suggest that the construction method of a pile may cause differences in overall peak mass loading rates in basal pile drainage, which are monitored against water quality criteria designated to protect the receiving environment. WRPs simulated in this study demonstrate that physical and chemical heterogeneity may significantly impact drainage water quality and mass loadings.