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The Influence of Mineralogy and Water Content on Drainage Quality in Weathered Mine Waste Rock

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Water substantially but differently influences the physical versus geochemical stability of mine waste materials. The impacts of water saturation on mineral weathering dynamics (mineral-water interactions), hydrogeological transport, and subsequent bulk leachate quality remain challenging to assess, particularly for heterogeneous materials.

We conducted controlled weathering experiments with synthetic, copper (Cu)-sulfide-rich waste rock at five discrete water saturation levels, and applied automated mineralogical and geochemical analyses, equilibrium modelling, and statistical techniques to quantitatively assess select mineral dissolution and precipitation reactions and their controls on leachate quality. Microscale compositional and textural mineralogical data was collected using a methodology that reduces biases introduced from particle segregation and phase dissolution during sample preparation [1].

We observed significant differences in leachate hydrochemistry among experimental conditions, which could be quantitatively reconciled with the mineralogical composition and textural properties of the waste rock materials, as well as prevailing moisture levels. Higher degrees of water saturation were associated with higher leachate pH (average of 6.14 at full saturation versus 5.37 at 5% saturation), higher porewater alkalinity, and a reduction in the size of carbonate phases over the experimental period, from 200µm to 145µm at water saturations from 5% to 100%. Leachate concentrations of iron and Cu increased with lower moisture levels, with Cu concentrations surging 24-fold in samples at 5% saturation compared to those at full saturation. Geochemical equilibrium modelling and multivariate statistical analyses allowed us to correlate reduced water saturation in waste rock to increased sulfide oxidation rates but decreased carbonate dissolution, corroborated by changes in the sizes, liberation, and association of sulfide- and carbonate-phases during weathering, but not their bulk abundance. Our findings highlight the value of diligent mineralogical sample preparation and quantitative mineralogical assessments of mine waste rock materials and their water content for effective mine waste management.

[1] Saberi & Vriens (2022), *Microscopy and Microanalysis* 29(1), 94-104.