Goldschmidt 2024 Abstract
https://doi.org/10.46427/gold2024.24212

# Using reduced complexity geochemical models to manage decision error risk on carbon mineralization projects

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Geochemical modeling can form a powerful technical basis for making decisions in service of society. This use case is distinct from those which aim to advance basic or applied science. When making decisions on the basis of a geochemical model, identifying the quality of the model output is a necessary component to managing the risk of decision errors.

Byproducts of the mining industry, such as non-ore grade rock and crushed mineral residues ("tailings"), are being actively studied for potential use in carbon mineralization projects. While the past decade has seen significant scientific progress in understanding the mechanisms controlling mineralization, companies are seeking to make decisions now, on the basis of best available information, about where to most effectively invest resources to meet their targets for carbon reduction. In this presentation, a quantitative approach to managing the risk of decision errors is developed. The method forecasts carbon mineralization rates with a "nested complexity" approach to systematically link uncertainty in model parameters to the quality of the model output. Once this link is made, it is leveraged to identify model parameters which represent the greatest opportunity for refinement, relative to achieving the quality targets on the modeled forecast.

The nested complexity approach will be demonstrated for carbon mineralization forecasts in a gabbroic composition non-ore grade material from a potential mine site. At the most reduced level of complexity, this model forecast is constructed with empirically defined cation release rates, and otherwise relies upon assumptions on dissolved carbonate concentration, steady-state flow rate, and thermodynamically controlled mineral precipitation. While such a model construct can be precise, its utility will be limited by how closely the actual system matches the empirical basis for cation release and other assumptions. Despite those limitations, this reduced complexity model forms the basis for a series of increasingly complex constructs, which maintain coherency with the reduced complexity construct, such that uncertainty analyses at the reduced complexity level indicate where additional "process resolution" is required to meet quality targets for the modeled forecast.