Geochemical and mineralogical heterogeneity in a full-scale waste-rock pile

MELANIE ST-ARNAULT*[1], BAS VRIENS[2], BERN KLEIN[1], K. ULRICH MAYER[2], ROGER D. BECKIE[2]

[1] Norman B. Keevil Institute of Mining Engineering, The University of British Columbia, Vancouver, BC, V6T 1Z4, Canada * m.st-arnault@alumni.ubc.ca

[2] Department of Earth, Ocean and Atmospheric Sciences, The University of British Columbia, 2020-2207 Main Mall, Vancouver, BC, V6T 1Z4, Canada

The extraction of ore results in the accumulation of waste rock that is typically stored on-site in large piles that can reach several hundred meters tall. These piles are highly heterogeneous systems where weathering of the waste rock results in elemental transfer to solutes and is governed by multiple intricately coupled physical and geochemical processes. Hydraulic retention of drainage percolating through the waste-rock pile allows solutes to react or precipitate along the way, complicating leachate predictions. Currently, the quantification of such geochemical and mineralogical processes for hydro-geochemical models strongly relies on upscaling of laboratory data, while verification with data from large-scale field systems is scarce.

Here, we present data from two ~140 m deep instrumented boreholes in a large scale, heterogeneous waste-rock pile. A high-resolution, continuous mineral weathering and reactivity profile could be obtained by contrasting conventional bulk lithology and geochemistry parameters with mineral properties such as alteration, texture, and arrangement. This approach allowed us to identify the heterogeneous in-situ conditions and processes that govern the waste rock weathering after 10 years of exposure to wet and dry season cycles.

Five reactive zones were distributed along the boreholes, identified by high sulfide and metal concentrations, elevated temperature and reduced oxygen contents, as well as pervasive secondary mineral precipitation. Anomalously unaltered layers within the reactive zones could be explained by oxygen depletion but also by sulfide passivation and potential galvanic interactions between sulfide minerals. This work shows that microscale mineralogical data may be used to refine characterization of waste rock reactivity, identify processes that might inhibit or catalyze mineral reactivity, and ultimately contribute to more accurate drainage composition predictions.