

Particle-scale mineralogical and morphological factors that affect rock weathering: Investigating reactive specific surface area

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Enhanced rock weathering (ERW) relies on the use of natural or industrially processed rocks, which can be classified by widely used terms (e.g., basalt, olivine, serpentine), classes of minerals (e.g., plagioclase, pyroxene, amphibole), or specific major constituent mineral phases (e.g., anorthite, wollastonite, diopside). Some of these rocks may contain secondary phases, including carbonates, and may be partly weathered or hydrothermally modified, such as metabasalt. These mineralogical complexities also result in morphological complexities at both the macro-scale (e.g., within ore bodies or crushed rock) and the micro-scale (e.g., within individual particles after comminution).

This can manifest as multiphasic particles where the main weatherable mineral is still attached to a secondary phase, or as particles containing complex networks of inclusions and veins that cannot be liberated by conventional comminution feasible for ERW purposes. Consequently, it is often insufficient to consider soil-amended rocks as simply mixtures of mineral phases that weather independently and potentially to completion. Multiphasic particles may weather incompletely and face issues of passivation and secondary mineral formation. These factors should be accounted for in reactive transport modeling, monitoring, verification, and reporting (MRV) methodologies, and carbon drawdown predictions. Although they may lead to attenuated weathering rates and reduced carbon drawdown estimates, greater confidence in the weatherability of rocks can also enhance MRV confidence and strengthen ERW carbon pricing.

Using backscatter electron (BSE) imaging and electron-probe microanalysis (EPMA), combined with image analysis and machine learning, we have been investigating approaches to improve weathering predictions. Our aim is to obtain more accurate descriptions of reactive specific surface area (RSSA) for each mineral phase present in the comminuted rock, both initially and as the mineral weathers (i.e., $d(RSSA)/dt$ or $d(RSSA)/d(X_i)$). Additionally, this work aims to develop automated image analysis protocols that can infer these values from BSE and EPMA data, to screen potential rocks for ERW and assess variability in rock properties from batch to batch. In this presentation, we will illustrate the results obtained so far and detail the protocols tested.