

The lab-field discrepancy for mineral kinetics: why we need to study the critical zone

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When I first began graduate work in the 1980s studying the kinetics of geochemical reactions in the laboratory, I assumed we would be able to extrapolate those rates easily to the field for quantitative predictions. As a junior graduate student with a chemistry bachelor's degree, I naively thought such extrapolation would be straightforward. But early papers by Jerry Schnoor, Tomas Paces, Tim Drever, Art White, Mike Velbel, and many others showed that rates estimated in the field were almost always slower than rates in the lab, often by orders of magnitude. And now, almost 40 years later, we still see that same discrepancy as we try to predict rates in the field for long-timescale problems (how will weathering rates be affected by changing climate?) and short-timescale problems (how will weathering rates be affected if we grind up basalt and add it to soils to enhance reactivity?).

Although the discrepancy remains, many researchers in the interim have perfected ways to estimate rates of weathering in the field by targeting mineral abundances and porefluid chemistries in soil profiles (1-D data), mineral abundances along hillslopes (2-D), or solute fluxes from aquifers or watersheds (3-D). Many researchers now model weathering with elegant and complex reactive transport models. In this talk I will discuss the lab-field discrepancy and reasons why we observe it. One of the reasons for the discrepancy is that scaling up from lab to field incorporates new reactive transport steps not important in the lab that become rate-limiting. But only a few minerals have been studied from atomic interface scale to grain scale to pedon scale to borehole scale to watershed scale in ways that can be compared across space and time. This is one of the many reasons why we need to study the critical zone as a whole and not just as separate parts.