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Enhanced rock weathering: What amendment should we use, what should we measure, and why can't geochemists predict this stuff?

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Researchers are now enhancing rock weathering to accelerate removal of carbon dioxide from the atmosphere. Most have focused on the use of basalt for enhanced rock weathering but a more justifiable amendment could be carbonate rock: limestones weather much faster than basalt. In addition, most researchers focus on measurements of the shallow soil, leaving questions about what happens downstream of the amendment layer. To ascertain atmospheric carbon dioxide drawdown, measurements have been made to different pools: i) soil gases; ii) solid phases in topsoil; iii) solid phases in deep soil; iv) porefluids in soil; v) ground or surface waters; vi) biota. Each of these pools respond to amendments at different rates. Soil gas measurements emphasize changes in soil organic matter as a new steady state re-establishes (over short timescales, loss of organic carbon as a gas flux can be faster than consumption of atmospheric carbon dioxide until a new steady state is achieved). Likewise, release of Mg and Ca from the amendment may accumulate on exchange sites, and not be released to leachate until a new steady state arises. Given these and other effects, some suggest carbon dioxide removal must be assessed by measuring waters downstream, rather than in soil. Such monitoring could also target how much calcite precipitates. Our inability to model many of these rates and reservoirs accurately may seem confusing since scientists have developed models that can predict systems as complex as weather and climate. This modelling limitation highlights the complexity of the feedbacks that couple the pools of carbon (gas, aqueous, organic, inorganic solid-phase, biota) in weathering systems. Reactive transport models (RTMs) must also include many phases whose interfacial extent and reactivity are unknown as well as reactions and transport whose timescales vary drastically. Finally, the huge observational datasets that could be used to improve RTMs through data assimilation and machine learning are generally missing. One approach to move forward might be to focus on the many studies of the use of lime in agricultural systems for crop productivity: analysis of data from these systems could reveal best practices for using carbonate rock for ERW.