

Rapid Calcium Carbonate Precipitation in the Presence of Dissimilar Metals

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Calcium carbonate (CaCO_3)—the ubiquitous filler of toothpaste, paper, and concrete—is a biomineral made by the mineralization of CO_2 . In fact, the conversion of silicate rocks into carbonate rocks is the natural mechanism for CO_2 sequestration on million-year timescales. As such, CO_2 mineralization has stimulated vigorous efforts to engineer carbon-capture solutions that may be deployed on much shorter time-scales. It is known that one can deposit CaCO_3 from aqueous solutions by shifting the pH during electro-precipitation (EP), where an overpotential is applied between the substrate and a counter-electrode. This presentation will discuss this process using galvanic couples. The presence of dissimilar metals in mineral-rich soils suggests that electro-motive forces will become established when soils get wet and that these couples may drive the EP of carbonates from the soil-based solutions. The viability of EP as a soil-based carbon-capture strategy is unexplored. Hence, the goal of this study is to measure CaCO_3 growth rates in galvanically driven solutions to gain a quantitative understanding of the control-parameters for these systems. To this end, this study employs a purpose-built quartz crystal microbalance (QCM) coupled to a long working distance optical microscope that permits the rapid nucleation of a known masses and numbers of CaCO_3 seeds on QCM plates. By transferring these seeded plates to solutions with different dissimilar metals, we determine the intensive (*i.e.* mass independent) growth rates of CaCO_3 as a function of galvanic couple-type. We find that the normalized growth rate scales with the open circuit potential in galvanic systems up to potentials of ~ 0.5 V. This effect permits galvanic systems to drive rates up to $20 \times$ faster than the baseline rate associated with the bulk supersaturation-level. We also find that these rates scale with overpotential in potentiostatic systems, indicating that open circuit potential and overpotential play similar roles. Finally, we have observed that a galvanic couple consisting of gold and aluminum electrodes that were immersed in wet soil and bridged with a wire induces the growth of heavy patches of solid carbonate on the gold electrode. This finding demonstrates that galvanic current through soil can induce carbonate-mineralization.

Biography: Bret Flanders was trained as a physical chemist (U Chicago) under the advisorship of Norbert Scherer, with whom he studied the far-infrared ultrafast dynamics of chemical reactions in the condensed phase. Following a postdoc at U Kansas with Robert Dunn, where he learned near-field microscopy and other scanning probe microscopies, he developed an interest in electrochemical synthesis and crystallization. Since beginning his independent career in 2002, he has focused on the soft matter physics and materials science of nanowire growth; adhesion and wetting of droplets and cells; nanocrystal film assembly; the barrier crossing kinetics of crystal growth.