Bedrock to soil: Earth's weathering engine

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Seawater chemistry responds to changes in terrestrial weathering over time in response to the forcing functions of tectonism, climate, and anthropogenic activity. Many researchers have attempted to read the effects of weathering solute fluxes in sediments in the rock record. For example, the Sr isotope record in marine limestones has been interpreted with respect to continental weathering fluxes due to changes in Earth's weathering engine. Our ability to predict such fluxes forward in time is limited because of difficulties in calculating weathering fluxes and the rates of formation of soils on weathering or eroding bedrock.

Weathering solute fluxes are recorded in many areas as chemical and textural profiles imprinted on regolith. These profiles, when observed on noneroding regolith in the absence of significant deposition, propagate downward as the regolith pile thickens with time. Such a profile can be described as a quasi-stationary state. If the rate of erosion of such regolith is increased larger than the weathering advance rate, the regolith thickness must decrease with time. For such a condition, the regolith eventually disappears unless some process accelerates the weathering advance rate. During weathering, as regolith thins, the rate of weathering advance can increase because porefluid chemistry at the bedrock interface becomes more corrosive. Thus, the rates of erosion and weathering advance can be coupled through porefluid chemistry, maintaining regolith thickness at steady state values. Solute fluxes and regolith profiles can be predicted for simplified lithologies under these assumptions.

The weathering advance rate is not, however, observed to be the same when calculated at the watershed, soil profile, and hand specimen scales. Several phenomena contribute to this observation. Approaches will be described to understand the prediction and modeling of weathering advance rates across scales as well as the controls on weathering solute fluxes.

The role of impurity doping during oriented α-alumina-on-mullite growth

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This work presents a recent case study on the benefits of impurity doping for producing unique ceramic microstructures which are difficult to process by other means.

Topotactic orientation relationships between thin α-alumina (00•1) platelets and Czochralski grown 2/1 mullite substrates are discussed in the light of annealing experiments of 2/1 mullite (001), (010) and (001) single crystals sections in the two-phase regime <mullite plus α-alumina> (1200-1650°C) in different atmospheres (dry vs. wet air) at normal air pressure.

Thermal decomposition of 2/1 mullite gives rise to the simultaneous formation of α-alumina platelets and an initially siliceous glassy phase completely wetting the platelets. Its chemical composition is shifted to a Na-Mg-Ca bearing alumosilicate composition via uptake of network modifying cations from external impurity sources (kiln furnace material, alumina reaction tube) during the annealing experiments. It is this glassy phase modified via impurity doping which filled the mullite dissolution paths driven forward by the platelets and provided a build-in flux for platelet growth.

In wet annealing experiments employing higher gas velocities and temperatures the glassy phase is lost due to substantial silica and alumina volatilization. With no more sink for impurity doping provided, the unique corundum-on-mullite microstructure gives way to complex etching patterns of the mullite surfaces due to selective corrosion by the water vapor-rich atmosphere.