Why would plants accelerate weathering? An eco-geochemical model

KATE MAHER[1] AND FRIEDHELM VON BLANCKENBURG[2]

[1]Department of Earth System Science, Stanford University, Stanford, CA, USA, kmaher@stanford.edu

[2]Earth Surface Geochemistry, GFZ German Research Centre for Geosciences, Potsdam, Germany, fvb@gfz-potsdam.de

Earth's biosphere is thought to exert a substantial influence on chemical weathering rates. Plants potentially influence weathering rates directly through changes in root architecture, localized etching at the surfaces of minerals by symbiotic mycorrhiza, or via indirect drivers, such as the production of belowground CO_2. In contrast, ecosystems are also highly efficient at retaining and recycling nutrients such that they can add additional biomass without accessing appreciable nutrient from the rock. Thus, in spite of observations of enhanced mineral solubilization in the rhizosphere, the influence of vegetation on chemical weathering fluxes (*i.e.*, the net export of dissolved solute) remains unclear.

To evaluate the extent to which vegetation need to alter the balance of fluxes in the regolith to maximize productivity, we developed a plant growth model that drives growth according to foliar P and Ca levels and includes nutrient uptake in addition to the root and foliar turnover that establish recycling rates. The plant growth model is coupled to a weathering model that accounts for erosion, water flow, regolith thickness, mineral solubilization rates, secondary minerals, sorption, and nutrient storage in organic phases. Phosphorous is derived from an accessory phase, such as apatite, whereas Ca is derived from the primary silicate minerals.

Plant growth in the model is limited by the supply of mineral to regolith, resulting in a relative increase in growth rates with increasing erosion rate. Numerical experiments comparing the effects of select plant nutrient acquisition strategies, water flow, soil respiration, and regolith thickness reveal that most nutrient acquisition strategies that increase plant growth decrease weathering rates relative to the base case. Factors that increase weathering rates, such as increased water flow and soil CO_2, diminish plant growth by reducing the recycling capacity. The magnitude of these effects are moderated by the underlying erosion rate and geochemical processes, suggesting that biologically enhanced weathering will be most effective at high erosion rates.