Mesocosm-scale experimental quantification of plant root-fungal associations on Carbon fluxes and mineral weathering

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The rise of vascular land plants in the Paleozoic is hypothesized to have driven lower atmospheric CO_2 levels through enhanced weathering of Ca and Mg bearing silicate minerals. However, this view overlooks the fact that plants and their associated mycorrhizal fungi co-evolved over this time with many of the weathering processes usually ascribed to plants actually being driven by the combined activities of roots and mycorrhizal fungi. Here we present initial results from a novel mesocosm-scale laboratory experiment designed to allow investigation of plant-driven carbon flux and mineral weathering at different soil depths, and under ambient (400 ppm) and elevated (1500 ppm) atmospheric CO_2.

Three species of plants were chosen to address the impact of evolutionary trends in symbiotic mycorrhizal association and rooting depth on biologically driven silicate weathering under the different CO_2 regimes. Gymnosperms were used to investigate potential differences in the weathering capabilities of two fungal symbioses: *Sequoia sempervirens (*arbuscular mycorrhizal, AM*) and Pinus sylvestris* (ectomycorrhizal, EM). A shallowly rooted fern, *Osmunda regalis* (AM), provided contrast to the more deeply rooted trees. Plants were grown in mesocosms with mineral-containing horizontal mesh-covered cores inserted at each of four depths which allow separation of root and fungal influences on weathering.

Preliminary results indicate marked differences between the growth responses of species to elevated CO_2, as well as their nutritional and water requirements. Bulk solution and mineral core leachate chemistries differ between plant-free controls, plant species, minerals, and CO_2 levels, potentially giving insight into mechanisms and degree of mineral weathering in these mesocoms. ^{14}C labelling of the above-ground shoots indicates preferential allocation of photosynthate to fungal partners associated with basalt as compared to granite, tying carbon flux to mineral element release. Ongoing measurements will characterize the extent of fungal colonization on basalt and granite, assess mineral weathering, and quantify biomass element uptake in these systems.

Of tilts and tetrahedra in feldspars: From structure to thermodynamic properties

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The complex and often non-linear structural response of framework minerals to changes in pressure, temperature, and especially composition (e.g. the plateau effect), invalidates the naïve use of simple solution models to define the thermodynamic properties and elasticity of real minerals. The solution is to develop models to predict the thermodynamic and elastic properties of mineral solid solutions based directly upon crystal chemistry and implicitly incorporate the atomic-scale mechanisms of the structural response of the mineral to the intensive thermodynamic variables. For example, in previous work it has been shown that the bulk modulus and shear modulus of perovskites scales linearly with the ratio of compressibilities of the two cation sites within the structure because this ratio controls the tilt rates of the octahedra within the structure.

Megaw [1] showed that the rigid-unit deformations of the tetrahedral framework of feldspars can be decomposed in to four tilts of the four tetrahedra that comprise the 4-rings that lie parallel to (010). Analysis of the high-pressure and high-temperature data now available, from both experiment and DFT calculations, shows that two tilt mechanisms are dominant. In particular, we have found that changes in the wrinkle tilt are responsible for changes in the length of the feldspar crankshaft, and are thus responsible for 70% of the volume change of alkali feldspars with P, T, or X. This provides the structural mechanism to explain the observation (Hovis *et al.* [2]) that the thermal expansion of alkali feldspars scales with the room-pressure volume.

[1] Megaw (1974) in *The Feldspars* (eds McKenzie & Zussman). [2] Hovis *et al.* (2008) *Am. Min.* **93**, 1568.

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