Constraining global-scale weathering models through nano-scale ectomycorrhiza-mineral interactions

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Mycorrhizal fungi act through chemical interactions at nanometer scale to weather minerals, and transport weathering products to plant symbionts through metre scale mycelial networks at diurnal timescales [1]. Biologically-mediated soil development occurs at regional scale over millenia (ka) and coupling between ecological, geological and atmospheric systems is apparent over evolutionary (Ma) timescales [2]. Our hypothesis is that quantification of biologically-driven weathering reactions at molecular scale provides a basis for new conceptual approaches to processes such as soil formation and atmospheric CO_2 evolution that occur over much larger temporal and spatial scales.

Our results demonstrate that fungal hyphae-grain contact leads directly to mass loss from mineral grains over time [3]. Cell exudates and nanoscale cell-mineral interaction forces progressively modify mineral surfaces and alter the pore microenvironment conditioning subsequent biotic and abiotic weathering mechanisms. Crucially, these processes are directed by mycorrhiza towards mineralogies which yield most nutrients for plants [1]. These data support nanoscale reaction models which will provide essential source terms for coupled weathering-reactive transport models at the soil profile scale. This conceptualisation of soil profile weathering is transferred to global scale models by aggregating soil profile descriptions at continental scale. The resulting global models thus reflect processes that are transferred from both the nanometer and soil profile scale as constraints on global weathering and its mathematical description.

[1] Leake *et al*. (2008) *Mineral. Mag*. **72**, 85–89. [2] Taylor *et al*. (2009) *Geobiology* **7**, 171–191. [3] Bonneville (2009) *Geology* **37**, 615–618.

Forward modeling mantle properties from basalt compositions

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Petrologists have long utilized basalt compositions to gain insights into the thermal, compositional and dynamic structure of the Earth's mantle (mantle signal). In heterogeneous mantle source domains this approach is made difficult because basalts are aggregates of melts derived over ranges of pressure and temperature from sources with different melting behaviors. A fundamental link between basalt composition and the conditions governing melt generation (i.e. potential temperature, upwelling rate and source composition) is the manner in which melts aggregate (pool) within the melting regime. To evaluate how melt pooling influences the mantle signal in basalt compositions derived from heterogeneous mantle sources, we use REEBOX_PRO, a forward polybaric melting model that simulates melting of a source comprised of peridotite and pyroxenite by relating potential temperature, upwelling rate and source composition. Several melt pooling scenarios are examined, including pooling over the entire melting regime, pooling over single melting columns, and pooling in actively upwelling mantle. The model results indicate that given the large number of variables in the system, it is extremely difficult to constrain simultaneously the composition of the source and the conditions of melt generation. However, as is the case for a homogeneous source, the volume of basalt significantly limits the range in potential temperature, upwelling rate and the style of melt pooling for a heterogeneous source, and in this way provides the link between mantle properties and basalt compositions.