Quantifying aeolian additions to Shale Hills soils through analysis of surface manganese enrichment

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The Shale Hills catchment is a recently established Critical Zone Observatory in central PA, USA used to investigate regolith evolution and element cycling in shale terrains. We have observed elevated manganese concentrations in the surface soils of this critical zone. Throughout the northeastern US, Mn toxicity has contributed to forest decline in catchments such as Shale Hills [1, 2]. Peak phytotoxicity is observed at higher elevations, and it has been proposed that acidic atmospheric deposition on ridges increases Mn bioavailability [1]. The source of high Mn concentrations in these soils remains unclear; however, we find that Mn enrichment is best explained by aeolian input. In Shale Hills, our studies demonstrate a strong Mn addition signal in ridge soils relative to the basin floor. Mn is enriched relative to bedrock in both the organic layer (<42,500 ppm Mn) and upper 20-30 cm of mineral soil (<14,400 ppm Mn). Slight Mn depletion is also observed at depths greater than 30 cm, suggesting biogenic nutrient cycling as a mechanism for Mn redistribution in the soil profile.

We are evaluating rates of atmospheric Mn deposition through formulation of simple models describing Mn deposition, advection, and biotic fluxes. We will examine the strong Mn addition signal to evaluate regional phytotoxicity and broader impacts of aeolian deposition on soil systems.

[1] Horsley S.B., Long R.P., Bailey S.W., Hallett R.A. & Hall T.J (2000) *Can. J. For. Res.* **30**, 1365-1378. [2] Kogelmann W.J. & Sharpe W.E. (2006) *J. Environ. Qual.* **35,** 433-441.

Some implications of the basal magma ocean model for Earth's formation and segregation

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Shock wave measurements, ab initio calculations, and extrapolations from static experiments are all consistent with a decreased or negative volume difference between melt and solid at lowermost mantle conditions owing to the relatively greater compressibility of the liquid. As a consequence, melt is only modestly more difficult to generate at high pressures than at low pressures and is capable of being more dense than solids at equilibrium owing to the slight incompatibility of iron. The high temperatures of Earth's core-mantle boundary (CMB) in the past- which is required of any credible thermal history- then implies that the lowermost mantle was likely to have been extensively melted in the early Earth, with the slightly higher density of melt gravitationally stabilizing it as a layer between the overlying solid mantle and the underlying liquid metal core. In a previously published study [1], we focused upon the long-term evolution of such a "basal magma ocean" (BMO) and showed that it cooled and fractionally crystallized very slowly due to the limiting process of sluggish convection in the overlying solid mantle. Most importantly for geochemistry, we showed how it can retain Earth's missing budget of incompatible elements as well as reconcile differences in $^{142}Nd/^{144}Nd$ between terrestrial samples and chondrites. In this talk, we will present briefly several new research results concerning the Hadean BMO: Scenarios for the formation of the BMO, the initial conditions for mantle, BMO, and core evolution, and their relationship to core super-heat and the phase diagram of the mantle, chemical re-equilibration of the BMO with the top of Earth's core and the possible role of a thin stably stratified core layer, and implications for coupled Nd and Hf systematics affected by BMO formation and crystallization that relate to estimates for the timing of core formation.

[1] Labrosse *et al.* (2007) *Nature.*