

Soil aggregate-scale chemical gradients resulting from coupled biogeochemical and transport processes

CÉLINE PALLUD^{1*} AND MATTEO KAUSCH¹

¹Environmental Science, Policy and Management (ESPM), University of California, Berkeley, USA (*correspondence: cpallud@berkeley.edu)

A continuing challenge in environmental science is to understand and predict how concentrations of nutrients and contaminants vary over space and time in natural systems. Within soils, biogeochemical processes controlling elemental cycling are heterogeneously distributed owing partly to the physical complexity of the media. Structured soils are composed of individual aggregates that form a network of interconnected microenvironments. The aggregate scale (mm-cm) is of particular interest due to the sharp transition in pore size between the aggregates themselves and the macropores surrounding them. The objective of this study is to investigate the coupling of physical (transport) and biogeochemical processes that affect small-scale iron transformations and that control selenium sequestration within soils.

We present a combined experimental and modelling study on single artificial soil aggregates assessing the biogeochemical processes governing transformations of redox sensitive elements (iron and selenium) in a complex but controlled setting representative of natural systems. Circumventing byproduct accumulation and substrate exhaustion common in batch systems and avoiding the poor physical analogy to aggregated soils of homogeneously packed columns, our novel experiments mimic soils using constructed cm-scale aggregates in flow-through reactors, which results in diffusively and advectively controlled regions. A newly developed reactive transport model is used to delineate transport regimes, identify reaction zones, and estimate kinetic parameters and reaction rates at the aggregate scale.

Overall, our findings demonstrate significant aggregate-scale variations in biogeochemical processes and consequent distribution patterns of solid phases within soils. We show that those chemical gradients are mainly controlled by diffusive mass-transfer limitations of both solute delivery to the aggregates and metabolite removal from the aggregates. This highlights the importance of appreciating the spatial connection between reaction and transport fronts and of obtaining information on transport-limited, intra-aggregate biogeochemical dynamics to better understand reactive transport of redox-sensitive species in structured soils.

Formation of chondritic meteorites

H. PALME

Sektion Meteoritenforschung, Forschungsinstitut und Naturmuseum Senckenberg, Senckenberganlage 25 D-60325 Frankfurt, Germany
(palmehbert@googlemail.com)

More than 99% of the mass of the solar system is in the Sun. The chemical composition of the Sun and similar stars is well known from absorption line spectroscopy. The Sun has about equal numbers of Mg, Si and Fe atoms. Planetesimals with these characteristics are parental to primitive, undifferentiated or chondritic meteorites. Bulk Earth, Venus and Mars also have approximately solar ratios of Mg, Si and Fe. CI-chondrites match solar abundances to within a few percent. Small deviations from solar abundances in other groups of chondritic meteorites reflect nebular processes prior to accretion to larger objects: (a) Loss or gain of refractory phases (Ca, Al, Ti), (b) variable accumulations of forsteritic olivine and (c) of metallic FeNi and (d) incomplete sampling of volatile elements. In addition, large variations in oxygen contents are observed. Each chondrite group is formed from a comparatively small isolated nebular reservoir [1].

On a cm scale chondritic meteorites are chemically uniform [2]; on a mm scale and below they are extremely variable. Chondrules, mm sized once molten silicate droplets, and fine grained matrix are two major components of chondrites. They are chemically complementary: The low average Fe/Mg and Si/Mg of chondrules is balanced by higher atomic ratios in matrix yielding the chondritic bulk composition. Both components must have formed from a single solar-like reservoir [3]. This is an important often neglected constraint for chondrule formation models. The reason for the enormous chemical variability of chondrules is unclear. Yet, the bulk composition of primitive chondrites requires that it must have been established in a closed reservoir of chondritic composition.

Each chondrite group has its own stable isotope signature [4]. The Earth and the other planets were built of a series of chondritic planetesimals. But stable isotopes indicate that the presently known population of chondrite parent bodies did not significantly contribute to the Earth [5].

Lit.:

- [1] Palme H. and O'Neill H.St.C. (2003) in: *Treatise on Geochemistry, Volume 2-The Mantle and Core*, ed: Carlson, R.W., Elsevier-Pergamon, Oxford, pp. 1-38. [2] Stracke A. *et al* (2012) *Geochim.Cosmochim. Acta* **85**, 114-141. [3] Hezel D.C. and Palme H. (2010) *Earth Planet. Sci. Lett.* **280**, 85-93 [4] Warren P. (2011) *Earth Planet. Sci. Lett.* **311**, 93-100.