Boron isotopes as a proxy of primary mineral weathering mechanisms

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Determining the current state of mineral weathering in soils is a key point to understand and model pedogenic processes. Nevertheless, it remains a real challenge given to the difficulty to get informations on the mineral sites actually active and the non-stoichiometric release of site-forming cations.

Boron has been demonstrated experimentaly to be located in different reactive sites of pure biotite (replacing silicon in tetrahedrons or adsorbed in interfoliar sites) with very contrasted isotopic compositions (up to 80 ‰ difference between interfoliar and lattice sites, Voinot et al., in prep). This huge isotopic partitionning between the different mineral sites allowed to distinguish between transformation and dissolution reactions with an higher sensitivity than classic chemical tracers (K and Si).

To assess the ability of boron to better characterize the current weathering state in soils, quantitative mineralogical analyses have been coupled to boron isotopes in a series of sorted minerals (< 50 µm) with varying weathering rates along an Alocrisol profile developped on a granitic bedrock (Breuil-Chenue forest, France). Distinction has been made between rather transforming (biotite, plagioclases) or dissolving minerals (muscovite, K-feldspars).

For biotite and muscovite, even though deep weathering processes lead to low dissolution and transformation rates, we observe that the bulk B chemical and isotopic compositions seem to rapidly equilibrate with the surrounding soil solution. Shallower soil layers show similar B behavior in fine grain fraction of these two minerals, whereas coarser grains tend to accumulate boron in their structure (up to 4 time the initial boron content). Plagioclases dissolve very quickly in the weathering sequence to be replaced mainly by kaolinite, with a strong concentration increase and still seem to equilibrate isotopically with the soil solution. K-feldspars show no specific weathering mechanisms other than dissolution and this is reflected by a progressive depletion with invarious isotopic composition.

In a second series of samples (from the same site but this time on total soil) we assessed the evolution of these mechanisms in presence of organic matter and close to vegetation (comparison of bulk vs rhizospheric soil subsamples in the < 2 mm fraction) in shallower horizons (0 to 23 cm) under two different tree species (beech and spruce). Very shallow processes (0-3 cm horizon) are characterized by a strong organic matter influence (in both bulk and rhizospheric soils), with contrasted boron isotopic compositions between the two tree species (about 8 ‰). In the 10-23 cm horizon, this influence is greatly disminished and lets place to a more mineralogy-controlled mechanism with similar isotopic signature under spruce and beech.

Oxic-anoxic oscillations driven by infaunal hydraulic activity

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Over the last few years we have investigated some of the most important bioturbating infaunal groups with respect to their hydraulic activity and the related porewater advection and oxygen dynamics. This was done by combining time-lapse photography, porewater pressure sensing and planar optode imaging of oxygen. Despite species-specific traits, the investigated crustaceans, bivalves and polychaetes all engage in hydraulic activities that cause intermittent and bidirectional transport of water away and towards the organisms [1, 2]. As a consequence, the sediment surrounding the burrows, as well as the sediment surface, experience frequent oscillations between oxic and anoxic conditions on the scale of minutes to hours.

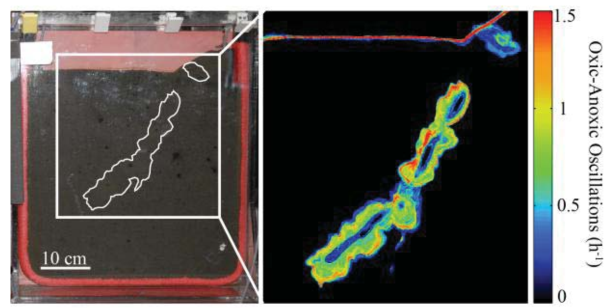

Figure 1: Two-dimensional representation of oxic-anoxic oscillations induced by hydraulic activity of the ghost shrimp *Neotrypaea californiensis*.

The sediment characterized by oscillatory conditions is limited to a thin layer around burrows in muddy environments but can be substantial in intermediate to high permeability sediments. Oscillatory conditions induced by hydraulically active organisms are expected to have significant implications for the distribution of microbial communities, with the durations of oxic and anoxic periods being a crucial determinant of biogeochemcial pathways and rates.

In this talk we will visualize the dynamic nature of geochemical conditions in the presence of hydraulically active organisms, and present quantitative data analysis and reactive-transport model simulations to explore the species- and sediment-specific oscillatory character of bioturbated sediments.

[1] Volkenborn et al. (2010) *Limnol. Oceanogr.* **55**, 1231-1247.
[2] Woodin et al. (2010) *Integr. Comp. Biol.* **50**, 176-187.