Zn isotope fractionation in the soil-plant system (a pot experiment)

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Zinc isotopes constitute a precious tool to trace metal sources and better understand the cycling of this micronutriment in the environment. The aim of the present study is to investigate the Zn isotope fractionation for evaluating the interaction between plant species and soil types, in order to better characterize Zn migration through the soil-plant system.

Three contrasted soils, originating from a zone with intense metallurgical activites in Belgium, have been used for the culture experiment conducted in controlled conditions: a calcareous soil ($\delta^{66}Zn_{bulk\ soil}$ = +0.06‰) and an acid shale-derived soil ($\delta^{66}Zn_{bulk\ soil}$ = +0.08‰) both essentially feeded by aerial fallouts, and a slag heap-derived soil ($\delta^{66}Zn_{bulk\ soil}$ = +0.37‰). Two plant species have been chosen: a dicot species (rape) and a monocot species (ryegrass). The Zn isotopic compositions have been measured in roots ($\delta^{66}Zn$ = +0.01 to +0.43‰) and in shoots ($\delta^{66}Zn$ = -0.23 to +0.28‰).

The results show that (a) the Zn isotopic compositions of all materials reflect the Zn isotopic signatures of the main Zn inputs (aerial fallouts *vs* smelter-slag residues); (b) light Zn isotopes are preferentially accumulated in shoots; (c) the magnitude of Zn fractionation during Zn transport from roots to shoots appears to be related to the cation exchange capacity of roots (CECR) and the water use efficiency (WUE). The plant species affects the Zn signature in plant parts through the density of negative charges in the roots, *i.e*. CECR being larger for the dicot species implies a larger Zn isotope fractionation between shoots et roots. In addition, the WUE might regulate a form of isotopic selection by controlling the efficiency of Zn adsorption on cell walls.

In the soil-plant system, enrichment in light Zn isotopes is favoured into the plants. As Zn is subsequently recycled to the soils through dead plant material return, the plant cover plays a key role on Zn fractionation in soils.

Early fossilization process of cyanobacteria in modern microbialites

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Most extant life diversity is microbial. Despite so, microbes are rarely described in the rock record. Part of the problem comes from the difficulty to identify microfossils unambiguously, since they can be morphologically confused with abiotic biomorphs [1]. Therefore, identifying traces that can be diagnostic of microbial fossils is crucial. To contribute to this aim, we studied the ongoing fossilization of cyanobacterial cells in modern microbialites from Alchichica Lake (Mexico). Alchichica Lake is a Mg-rich hyperalkaline crater lake (pH 8.9) containing living stromatolites composed of aragonite [$CaCO_3$] and hydromagnesite [$Mg_5(CO_3)4(OH)_2 \bullet 4(H_2O)$] [2]. Cyanobacteria comprise most of the microbialite biomass. Scanning electron microscopy coupled with confocal laser scanning microscopy were used to co-localize cyanobacterial cells and associated minerals. These observations showed that cells from the order Pleurocapsale become specifically encrusted within aragonite with an apparent preservation of cell ultrastructures. Early fossilization gradients from living to totally encrusted cells span distances of a few hundred micrometers. Cells with increasing levels of encrustation where observed down to the nm-scale by transmission electron microscopy performed on Focused Ion Beam (FIB) ultrathin (<100 nm) foils. Two types of aragonite crystals differing by their morphology were seen within and outside cells. Synchrotron-based scanning transmission x-ray microscopy (STXM) analyses at the C and N K-edges [3] were performed on the same FIB foils. They provide information on the evolution of carbon and nitrogen speciation along this early fossilization gradient. We propose a model of the early fossilization process of these cyanobacteria and their associated organic molecules.

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