Importance of biological processes in the critical zone: insights from Mg isotopes

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The critical zone is characterized by complex interactions between rock, water and plants. In this study we focussed on the influence of the biomass in riverine chemistry and for this purpose, we analyzed the isoptic composition of Mg expressed as δ^{26}Mg in three types of water samples: large rivers, seepage landslide and vegetated streams in Western Southern Alps (WSA) of New Zealand. The comparison between theses different localities limits spatial variability in lithological control. More, the contrast between landslide seepage and vegetated streams aims to assess the role of biological pumping on Mg budget. The δ^{26}Mg measured in WSA ranges between: -1.38±0.11‰ to -0.71±0.05‰ on the DSM3 scale at 95% confidence level using the standard bracketing technique by MC-ICP-MS after chemical purification. In the 2 studied landslide areas, the difference between landslide seepages and vegetated streams is subtle and not greater than -0.15‰. Vegetated streams are, nevertheless mass-dependently slightly enriched in light isotopes. Biological pumping preferentially uptakes heavy isotopes while degradation of organic matter will return light Mg to the stream. To distinguish between these processes, different models have been tested. Based on the geometry of landslides' scars, a simple open system (Rayleigh) has been considered. The remineralisation of the organic matter in landslide seepage tends to rise the δ^{26}Mg together with an increase in the K/Mg of the water. On the other hand, a biological uptake will deplete the vegetated streams in K and ^{26}Mg. None of those 2 models are supported by the data. Therefore, we have considered a third model based on recent findings (Emberson et al. 2017) suggesting a rapid weathering of Mg-bearing silicate minerals such as biotite. In that case, the isotopic signature of Mg and chemical composition in WSA could be explained only if the incongruent dissolution of biotite is associated with Mg isotope fractionation.

Emberson, R., Galy, A., Hovius, N. (2017) Combined effect of carbonate and biotite dissolution in landslides biases silicate weathering proxies. Geochimica et Cosmochimica Acta, 213, 418-434.