Metal isotopic distributions in mycorrhizal trees: Weathering manifestations and within-plant fractionations

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Although it is well known that organisms contribute significantly to the weathering process and to the distribution of elements within continental environments, the degree to which biota actively drive weathering versus the degree to which organisms benefit from nutrients released during largely inorganic weathering processes remains unknown [1]. Furthermore, the relative influence of different organisms on key elemental cycles, such as the base cations, especially Ca and Mg, is poorly understood. To address these questions, we have carried out a series of geochemical studies on semi-hydroponically cultured trees (*Pinus sylvestris*, *Acer saccharum* and *Betula alleghaniensis*) grown with appropriate mycorrhizal symbionts (ectomycorrhizal or arbuscular) in different geologic substrates (carbonate versus granitic) and under different nutrient regimes (N-limited in high or low nutrient supply and P-limited). Plant tissues across these biogeochemical experiments were studied for elemental abundances and Pb, Ca and Mg isotopic signatures. We conclude from our approach that: (1) Pb isotopes effectively complemented elemental signatures to identify key mineral dissolution reactions (e.g., the dissolution of phosphate phases in P-limited cultures); (2) for the same geologic substrate, arbuscular fungus did not demonstrate substantive phosphate dissolution; (3) the presence of mycorrhizal fungus significantly affected the Ca and Mg elemental distributions within the plant tissues but had a more muted effect on the Ca isotopic distributions; (4) foliar and root tissues recorded distinctive isotopic compositions (e.g., differences up to 0.6 ‰ $\delta^{44/40}$Ca); and (5) ectomycorrhizal symbioses may drive Mg isotopic variations during weathering.

[1] Brantley *et al*., *Geobiology*. 2011.

Nanomagnetism of iron meteorites identified by X-ray photo-emission electron microscopy

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Paleomagnetic signals stored within meteorites are a key source of information regarding many processes in the early solar system. An increasing body of traditional macroscopic paleomagnetic evidence suggests that, while molten, the liquid cores of the meteorite's parent asteroids generated magnetic fields with comparable strength to those of present-day Earth. We have applied nanoscale magnetic techniques to show that spinodal nanostructures within meteorites are capable of providing a time-resolved record of dynamo activity of their parent asteroids - analogous to that stored in the Earth by the spreading ocean crust - across the first 100-200 Ma of the asteroid's history, a prospect that could revolutionise our understanding of asteroid development.

To investigate this magnetic nanostructure, we performed the first meteoritic high-resolution X-ray photo-emission electron microscopy experiments (on the Tazewell IIICD iron metoerite). The results display a distinct and unique magnetic pattern that is dependent on the underlying nanostructure. The spinodal region, termed the 'cloudy zone' (CZ), extends 2-10μm and is composed of tetrataenite (chemically ordered FeNi) embedded in a hitherto unobserved ordered Fe_3Ni phase. Within this region, a complex magnetic state is observed with interlocking groups of all three tetrataenite twin orientations. A clear variation in the amount of each twin with increasing lateral distance across the CZ (decreasing age of tetrataenite formation) is also present. The observed magnetisation pattern bears resembalence to anti-phase boundaries (APBs) that appear to coarsen over time. These results provide both a fundamental understanding of the CZ magnetisation as well as the magnetic state formed in the absence of a dynamo field. Chondritic meteorites can carry an analogous magnetic remanence that was influenced by a dynamo field. By comparing the results in this study to those of chondritic meteorites, we will identify both the direction and magnitude of this dynamo field over a 100 Ma period.

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