

Rhizosphere iron-redox cycling: Electron transfer reactions that drive mineral weathering

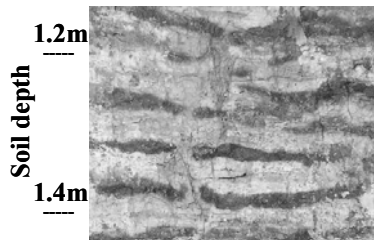
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Roots in wetlands soils are often characterized by orange-colored mottling (iron plaque), a sign that plants supply O₂ to their roots, part of which microbes use to oxidize FeII. In this study we describe a reverse Fe-redox cycle, in which rhizospheres act as conduits of organic reductants that stimulate reductive dissolution Fe (hydr)oxides in the near-root environment. In subsoil rhizospheres where O₂ resupply may be sluggish, FeII is translocated into nearby root-free areas where Fe(II) is oxidatively precipitated. Organic matter in these deep rhizospheres has strikingly modern $\Delta^{14}\text{C}$ values, and FAME analyses indicate the presence of quinoid moieties, electron shuttles used by microbes to exploit the free energy derived from electron transfers¹⁻². Redox cycling of Fe generates a prominent proton flux, with the proton burden is heaviest away from the near-root environment where Fe is oxidized. Oxidation of Fe adsorbed to the soil cation exchange complex generates co-adsorbed protons which protonate the soil cation exchange complex, and facilitate mineral



dissolution and clay disintegration into colloid-sized particles susceptible to hydrologic transport. The result is clay-enriched rhizospheres with low diffusivity and elevated exchangeable acidity creating favorable conditions for further iron reduction. Such Fe-redox cycling illustrates how rhizospheres significantly interact with the whole soil environment.

References

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[2] Coates, J.D. *et al.* (2002), *App Enviro Microbio* **68**, 2445-2452.

Worm excretion processes and the weathering of Icelandic basalt

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The chemical weathering of rocks is no longer considered to be a purely inorganic process. Microbes can exert a strong control on the weathering rates of silicate minerals. However, the role of macrobiotic sediment ingestion processes and the possible links to chemical weathering are still relatively underestimated. It is important to understand any controls macrobiota might exert on weathering rates since sediment ingestion processes are ubiquitous in the natural environment. Using a series of tightly controlled experiments that simulate marine depositional environments, it is shown that chemical weathering can be enhanced by the ingestion processes of annelid worms. Specimens of the common lugworm, *Arenicola marina*, lived in and consequently ate a mixture of mature, aeolian sand and crushed, unweathered basalt from Iceland. This 'synthetic mud' was determined to be clay mineral free by X-Ray Diffraction (XRD) and Fourier Transform Infrared (FTIR) spectroscopy. The faecal material produced by the worms was also analysed using XRD and FTIR. Faecal casts produced by the worms were regularly sampled along with samples from the control tanks. The mineralogy of the faecal casts were significantly different from the original crushed basalt fed to the worms. The primary plagioclase underwent significant dissolution along with olivine and pyroxene. A variety of secondary neofomed clay minerals (bio-clays) were present in the worm faecal casts, produced by the sediment ingestion and digestive processes. These bio-clays include kaolinite, illite and vermiculite. This enhanced weathering process happens within in a few gut cycles of *A. marina* (approximately 12 hours); a reaction many orders of magnitude faster than inorganic processes. These experiments have revealed a new way to form clay minerals by a macrobiologically-enhanced weathering process that is extremely rapid by geological standards.