Plenary Address by the Houtermans Medalist

What earthworms get up to in soil

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Introduction

Earthworms are wonderful and important creatures. Soil contains far more individual bacteria or fungi than earthworms but the biomass of these different organisms, a good indicator of metabolic activity, is very similar with earthworms being present at levels of 10 – 150 g m^{-2} of soil. Earthworms can consume a mass of soil up to 30 times their own mass in a single day equating to 50 – 1000 x 10^6 g of soil per ha per year. Earthworm burrows can contribute up to 1 % porosity to soils with total burrow length reaching 100 m m^{-3} soil. Clearly earthworms can have a major impact on soil.

Earthworms and microflora

We have performed experiments characterising the gut flora of earthworms and also investigating the dependence of earthworms on their gut flora for survival. A further point of considerable significance for biogeochemists is that any microbially mediated soil process should occur more rapidly in the earthworm gut or casts where the bacteria to soil ratio is greater than that in the bulk soil.

Earthworms and mineral weathering

There are no documented studies regarding the impact of earthworms on mineral weathering despite the mass of soil which they can consume. We are pursuing laboratory experiments, in which earthworms are fed minerals, and field studies, in which mineral-spiked soil is kept in earthworm-rich and earthworm-free conditions to determine whether earthworms influence the weathering rates of minerals in soil.

Earthworms and metals

Earthworm metal uptake depends on metal speciation. This is most readily demonstrated by keeping earthworms in solutions and manipulating the solution chemistry. Rates of metal uptake are rapid initially and then slow down. Essential metals are regulated, non-essential metals accumulate. Metals accumulate in a variety of compartments: with proteins, though this compartment fills relatively quickly and, as metal-rich granules, the presence of which are indicative of long term chronic exposure to metals. Earthworms can adapt, either physiologically or genetically to metal-rich conditions. Earthworms change metal speciation after metal uptake and alter metal speciation in the bulk soil.

Chemical weathering, land plants, and CO_2 sinks: Role of ecological disturbance

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Chemical weathering transfers atmospheric CO_2 to subsurface waters and thence to hydrologic, pedologic, and lithospheric reservoirs with turnover times varying from 10 to 100,000,000 years. Land plants, by the bioturbation and acidification functions of their root sytems, are usually assumed to increase the overall rate of transfer relative to landscapes without such vegetation.

We are attempting to test this hypothesis in experimental mesocosm ecosystems at Hubbard Brook Experimental Forest, NH, USA. These large "sandbox" lysimeters crudely represent primary successions with and without vascular plants. We have monitored outflow rates and Ca+Mg and HCO^{3-} concentrations in two of the sandboxes over a 20-year period. One of the sandboxes grew trees for the first 15 years at which time the trees were carefully harvested, eliminating photosynthetic inputs to the subsurface, without physical disturbance. Another box was kept bare of rooted plants. In the forested sandbox Ca and Mg effluxes were 1600 and 300 molc/ha/yr respectively at the beginning of the experiment, waning to less than one third of these rates by time of harvest. After the harvest, cation concentrations increased dynamically while HCO^{3-} concentrations remained relatively steady. Postharvest cation effluxes increased 5-6 times relative to preharvest rates, but even following 5 years of strict regrowth suppression, the cumulative effluxes had not equaled those of the adjacent bare sandbox. These results underline the importance of physical landscape disturbance (experiment initiation in this case) as a driver of chemical weathering. They also suggest that if rooted plants do in fact increase the chemical-weathering CO_2 sinks, the frequencies and magnitudes of ecological disturbances (harvest in this case) are key factors. The results further suggest that ecological disturbances affect the lithospheric (Ca+Mg) sink differently than the hydrologic (HCO^{3-}) sink.