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Global comparison reveals biogenic weathering as driven by nutrient limitation at ecosystem scale

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A substantial contribution of biogenic weathering in ecosystem nutrition, especially by symbiotic microorganisms, has often been proposed, but large-scale in vivo studies are still missing. Here we compare a set of ecosystems spanning from the Antarctic to tropical forests for their potential biogenic weathering and its drivers.
To address biogenic weathering rates, we installed mineral mesocosms only accessible for bacteria and fungi for up to 4 years, which contained freshly broken and defined nutrient-baring minerals in soil A horizons of ecosystems along a gradient of soil development differing in climate and plant species communities. Alterations of the buried minerals were analyzed by grid-intersection, confocal lascer scanning microscopy, energy-dispersive X-ray spectroscopy, and X-ray photoelectron spectroscopy on the surface and on thin sections. On selected sites, carbon fluxes were tracked by 13C labeling, and microbial community was identified by DNA sequencing.
In young ecosystems (protosoils) biogenic weathering is almost absent and starts after first carbon accumulation by aeolian (later litter) inputs and is mainly performed by bacteria. With ongoing soil development and appearance of symbiotic (mycorrhized) plants, nutrient availability in soil increasingly drove biogenic weathering, and fungi became the far more important players than bacteria. We found a close relation between fungal biogenic weathering and available potassium across all 16 forested sites in the study, regardless of the dominant mycorrhiza type (AM or EM), climate, and plant-species composition.
We conclude that nutrient limitations at ecosystem scale are generally counteracted by adapted fungal biogenic weathering. The close relation between fungal weathering and plant-available nutrients over a large range of severely contrasting ecosystems points towards a direct energetic support of these weathering processes by the photoautotrophic community, making biogenic weathering a directional on-demand process common in all types of ecosystems.