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Could Fe-metabolizing microbes weather sub-surface minerals in a semi-arid climate?

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Mineral weathering shapes Earth's surface by transforming bedrock to soil in the 'critical zone'. Among these transformation processes, microbial weathering plays an important role, as it contributes to all stages of rock-soil transformation such as primary rock colonization, rock breakdown, saprolite formation, and element cycling. Fe-metabolizing microorganisms, i.e. Fe(II)-oxidizing and Fe(III)-reducing microorganisms, are key players in weathering as they can directly attack minerals via their metabolism. However, most direct evidence for the role of these microbes in critical zone processes comes from shallow and humid tropical soils and saprolite, or from transects across corestones. Much less is understood about the direct role of these microorganisms in critical zone processes in more arid climates.

In this study we have obtained drill cores from the critical zone of a semi-arid region of the Chilean Coastal Cordillera (Santa Gracia Reserve). Despite receiving only 66 mm of rain per year, the weathering profile is very deep (>80 m). The rock material of the drill core is a Cretaceous quartz monzodiorite rich in hornblende, biotite and chlorite with ca. 1-2 wt.-% Fe(III) oxyhydroxides and

very low TOC content. Using cultivation-based methods we found microaerophilic Fe(II)-oxidizing bacteria in zones of weathered saprolite (up to ca. 25 m depth) and at the weathering front (70-76 m), while Fe(III)-reducing bacteria, grown either with dihydrogen or organic carbon, were successfully enriched from samples across the whole 87 m profile. A robust contamination control confirmed that cultivated microbes were from the in-situ community and not related to drill fluid contamination.

These findings suggest there is potential for Fe-metabolizing microbes to contribute to mineral-weathering processes even in deep weathering profiles in semi-arid environments. The occurrence of cultivatable Fe(II)-oxidizing bacteria is controlled by the presence of highly fractured zones functioning as fluid and oxygen transport pathways. It is notable that despite the fact that much of the silicate minerals contain Fe(II), Fe(III)-reducing bacteria are more common. The co-occurrence of Fe(II)-oxidizing and Fe(III)-reducing bacteria in some isolated parts of the profile could represent a self-sustaining cycle of iron redox reactions.