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Weathering-intensifying and -mitigating processes in granitic rock along a climate gradient of the Chilean Coastal Cordillera

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Weathering of rocks is a key process for soil formation, landform evolution, setting subsurface rock mechanics, and the supply of nutrients to organisms. Both fluid flow and thus climate as well as the presence of flow paths and porosity are thought to control the depth of weathering reactions. However, the depths predicted by models do not always agree with field observations. Validating such models by field studies thus helps to calibrate our concepts of weathering at depth.

We drilled two weathering profiles down to ~90 m and ~40 m along the Chilean Coastal Cordillera to explore the effect of climate on deep weathering and found a shallow weathering profile in humid climate that developed on granite and a deep weathering profile in Mediterranean climate that formed on granodiorite. We used geochemical methods like X-ray fluorescence, oxalate/dithionite extractions and electron microprobe as well as mineralogical methods such as X-ray diffraction of bulk and clay samples to elucidate the chemical and mineralogical transformations involved in the weathering advance. We identified several mineral-based processes that can be reinforced by subcritical cracking or tectonic fracturing. 1) Intensifying processes: weathering-induced fracturing by Fe(II) oxidation and swelling of expandable clay minerals that promote the access of fluids. 2) Mitigating processes: clogging by precipitation of secondary minerals that shield the primary minerals from further reactions, reduce the porosity and seal the deep subsurface from surface inputs. As a consequence, the decrease of weathering-limiting O_2 with depth does not only depend on the consumption by oxidation of silicate-bound Fe(II), but also on other processes that control the permeability.

Our results show that the weathering products of silicate minerals can lead to positive and negative feedback mechanisms. We conclude that the formation of secondary minerals and topographic/tectonic preconditioning control the weathering processes at depth and determine the regolith thickness.