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Tectonic uplift and denudation rate influence soil chemical weathering intensity in a semi-arid environment, southeast Spain: physico-chemical and mineralogical evidence

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Tectonic uplift is known to influence denudation rates. Denudation, including chemical weathering and physical erosion, affects soil production rates and weathering intensities. At topographic steady state, weathering can be transport- or weathering-limited. In the transport-limited regime, low denudation rates should lead to comparatively high weathering intensities, while in the weathering-limited case high denudation rates are associated with lower weathering intensities. Here, we test if this relationship applies to semi-arid environments where chemical weathering is generally slow.

Three catchments (EST, FIL and CAB) were studied in the Internal Zone of the Betic Cordillera in southeast Spain, spanning a range of increasing uplift rates (10-170 mm/kyr) and increasing denudation rates (20-250 mm/kyr) from EST to CAB. In each catchment, two ridgetop soil profiles were sampled down to the bedrock. The three catchments have similar vegetation and climatic conditions, with precipitation of 250- 315 mm/yr and mean annual temperature of 15-17 °C.

The mineralogy of the bedrock, as determined by XRD, is similar across the three catchments and is characterized by the presence of quartz, muscovite, clinochlore, biotite and plagioclase. This primary mineral assemblage is also found in the catchment soils, indicating that the soils studied derive from the same parent material. The soil clay-size fraction is dominated by kaolinite, vermiculite and illite. However, the proportions of the soil primary and secondary minerals vary between the catchment sites. The abundance of biotite decreases from CAB (14%) to EST (4%), whereas the quartz and clay contents show an opposite tendency (from 30 to 69% and 9.9 to 14.3%, respectively). Further, the abundance of vermiculite increases from CAB to EST. The results are interpreted in terms of increasing weathering intensity from CAB to EST by weathering of biotite into vermiculite and enrichment of soils on more weathering resistant quartz.

Soil weathering intensity in each catchment was assessed previously [1] using three independent weathering indices: the Total Reserve in Bases (TRB = [Ca2+] + [Na+] + [K+] + [Mg2+]), soil Fed/Fet ratio (Fe-oxides/total Fe), and Cation Exchange Capacity (CEC). In agreement with the soil mineralogy, the physico-chemical analyses revealed increasing weathering intensity from CAB to EST.

We postulate that the higher chemical weathering intensity in EST reflects lower denudation and uplift rates compared to CAB and therefore, soil chemical weathering intensity in this semi-arid environment may be controlled by denudation and uplift rates

[1] Ameijeiras-Mariño et al, EGU 2014-9714-1