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Insights on Denudation Controls of Volcanic Tropical Islands from Meteoric 10Be/9Be Ratios

Weathering of volcanic rocks accounts for approximately one third of global CO_2 consumption in the silicate weathering cycle. Tropical volcanic islands contribute to this process due to their extreme denudation rates, thought to be mainly driven by high and episodic precipitation, which may sustain high weathering fluxes. However, how total denudation (D) divides into erosion (E) and weathering (W) fluxes, and what controls their long-term rates on tropical islands remains unclear. This uncertainty arises from the lack of methods to quantify these rates over centennial to millennial timescales. Common approaches face challenges like absence of quartz for in situ-10Be or unevenly-distributed olivine for in situ-3He analysis, limited long-term observational data for gauging, and the impacts of caldera collapse and infilling of river valleys from eruptions that complicate erosion rate estimates from topographic reconstructions. The recently developed meteoric 10Be/9Be ratio that uses meteoric 10Be as an atmospheric flux tracer together with stable 9Be released during rock weathering provides an alternative to estimate D and weathering intensity from soils to entire watersheds independent of specific minerals.

We applied this method to Réunion and Guadeloupe, two islands with extreme precipitation regimes (up to 11,000 mm/yr), steep slopes, high elevations, and warm mean annual temperatures. Both islands have catchments on lavas of similar emplacement ages (5 Kyr to 1.8 Myr), but differ mainly in lithology: Réunion's hotspot volcanism produces basalts, whereas Guadeloupe's arc volcanism generates andesites. To isolate key controlling parameters, we sampled catchments with uniform lava deposition ages across varying precipitation regimes.

Preliminary results reveal a stark contrast in denudation (D). On Réunion, catchment-averaged D´s are 4,000 t/km²/yr (n=11, ranging from 11 t/km²/yr in very small catchments to 15000 t/km²/yr), while Guadeloupe´s average D is 300 t/km²/yr (n=13, ranging from 100 to 1000 t/km²/yr). Weathering intensity measured on sediment from Guadeloupe are, on average, significantly higher than for Reunion. This result aligns with the observation that lower erosion rates promote more intensive soil leaching. Our denudation rates compare well to published gauging-based rates of 1200 to 9,000 t/km²/yr for Réunion1 and 800 to 4,000 t/km²/yr for Guadeloupe2. Large-scale topographic reconstructions range from 9,000 to 28,000 t/km²/yr for Réunion3,4 and 1,250 to 5,250 t/km²/yr for Guadeloupe´s youngest volcanic complex5.

Our preliminary findings suggest that volcanic emplacement age does not control D, while the role of lithology requires further investigation. Future work will involve determining local depositional fluxes of meteoric 10Be, and analyzing additional data from weathering profiles and river sediments.

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