Quantifying denudation and weathering rates from meteoric Be-10 to stable Be-9 ratios on a volcanic tropical island

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Abstract

Over geological timescales, Earth's climate is regulated by silicate weathering. This process is most effective under conditions of fresh mineral supply, warm temperatures, and heavy rainfall. Mafic rocks such as basalt or andesite, being rich in Ca and Mg, can contribute up to 35% of the global silicate flux. Consequently, volcanic tropical islands likely play an important role in the long-term carbon cycle.
Quantifying denudation rates and weathering efficiency of these landscapes, however, is hindered by the methodological approach. Difficulties arise from estimating long term runoff needed for dissolved gauging and from the absence or spatial heterogeneity of suitable minerals for in-situ cosmogenic-derived denudation rates. In this study, conducted on the island of Guadeloupe, we employ mineral-independent meteoric cosmogenic 10Be/9 Be combined with chemical depletion fractions from river sediments' geochemistry as weathering intensity proxy. This combination allows us to partition millennial-scale denudation rates into chemical and physical fractions for the first time in mafic lithologies.

Our denudation rates span 150-1500 t/km^2/yr, where high denudation correlates with lower weathering intensities. Combined, the resulting weathering rates reach 30-150 t/km^2/yr. Overall, our weathering rates fall within the range of published multi-annual gauging records and represent some of the highest long-term chemical fluxes recorded in the literature for silicate settings.
Our results indicate that weathering in Guadeloupe is extremely efficient when compared to granitic lithologies under similar climate and denudation regimes. This highlights the high potential of CO2 drawdown from volcanic tropical islands and the importance of constraining their long-term weathering and denudation rates.

Keywords: Denudation, Mafic lithologies, meteoric, 10/9Be, weathering intensity

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