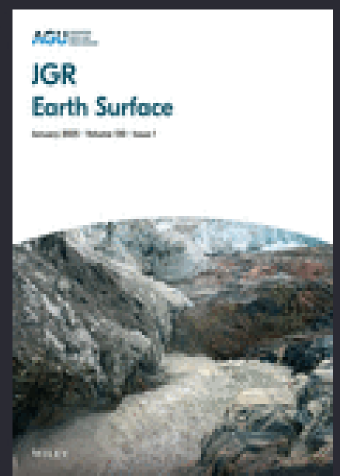
Page 1 / 20

DETAILS | RELATIONS



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ARTICLE

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Abstract

Weathering of ultramafic rocks emplaced at low latitude during arc-arc and arc-continent collisions may provide an important sink for atmospheric CO_2 over geologic timescales. Accurately modeling the effects of ultramafic rock weathering on Earth's carbon cycle and climate requires understanding mass fluxes from ultramafic

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RESEARCH ARTICLE

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Chemical Weathering and Physical Erosion Fluxes From Serpentinite in Puerto Rico

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Key Points:

- Denudation in tropical serpentinite mountains occurs primarily through chemical weathering, producing large dissolved Mg^{2+} fluxes
- Weathering fluxes from serpentinite are more strongly controlled by runoff than by physical erosion
- The runoff dependence of weathering implies that ultramafic rocks may participate actively in the negative silicate weathering feedback

Supporting Information:

Supporting Information may be found in the online version of this article.

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Abstract

Weathering of ultramafic rocks emplaced at low latitude during arc-arc and arc-continent collisions may provide an important sink for atmospheric CO_2 over geologic timescales. Accurately modeling the effects of ultramafic rock weathering on Earth's carbon cycle and climate requires understanding mass fluxes from ultramafic landscapes. In this study, physical erosion and chemical weathering fluxes and weathering intensity are quantified in 15 watersheds across the Monte del Estado, a serpentinite massif in Puerto Rico, using measurements of in situ ^{36}Cl in magnetite, stream solute fluxes, and sediment geochemistry. Despite high relief in the study watersheds, erosion fluxes are moderate (22–109 tons km^{-2} yr^{-1}), chemical weathering fluxes are large (55–143 tons km^{-2} yr^{-1}), and weathering intensities are among the highest yet reported for silicate-rock weathering (up to 0.88). We use these data to parameterize power-law relationships between weathering, erosion, and runoff. We interpret the relative importance of climate versus erosion in setting weathering fluxes and CO_2 consumption from the best-fit power-law slopes. Weathering fluxes from tropical, montane serpentinite landscapes are found to be strongly controlled by runoff and weakly controlled by the supply of fresh rock to the weathering zone through physical erosion. The strong runoff dependence of weathering fluxes implies that, to the extent that precipitation rates are coupled to global temperature, ultramafic landscapes may be important participants in the negative silicate weathering feedback, increasing (decreasing) CO_2 consumption in response to a warming (cooling) climate. Thus, serpentinite landscapes may help stabilize Earth's climate state through time.

Plain Language Summary

The break-down of extremely Mg-rich silicate rocks, known as ultramafic rocks, may be important for removing CO_2 from the atmosphere over million-year timescales. However, chemical weathering and physical erosion rates in landscapes containing these rocks are not well known. To better understand how fast ultramafic rocks remove CO_2 from the atmosphere, we determined erosion and chemical weathering rates on ultramafic rocks in Puerto Rico using measurements of rare atoms produced by radiation from space in the mineral magnetite and stream solute and sediment chemistry. We found that weathering rates are faster than erosion rates, even in steep mountainous watersheds. We also found that weathering rates depend more on the amount of water flowing through soils than on physical erosion. This implies that CO_2 consumption from weathering of ultramafic rocks responds strongly to changes in precipitation rate but only weakly to rock uplift and changes in erosion rate.