Increasing Land Surface Reactivity from $^{10}Be/^{9}Be$ and $^{7}Li/^{6}Li$ Records explains Late Neogene cooling

JEREMY K. CAVES RUGENSTEIN[1], DANIEL E. IBARRA[2], FRIEDHELM VON BLANCKENBURG[3]

[1]Earth Sciences, ETH Zürich, 8092 Zürich, Switzerland
[2]Geological Sciences, Stanford University, Stanford, California 94305, USA
[3]Earth Surface Geochemistry, GFZ German Research Centre for Geosciences, Potsdam, Germany (* correspondence: fvb@gfz-potsdam.de)

The cause of late Neogene $p\mathrm{CO}_2$ decline and ensuing cooling is frequently attributed to increased erosion and attendant increases in silicate weathering. However, the magnitude of the weathering increase—and even its existence—remains controversial, with both carbon cycle models and marine $^{10}\mathrm{Be}/^{9}\mathrm{Be}$ suggestive of a minimal change in weathering. We present a parsimonious carbon cycle model that predicts two weathering-sensitive isotopic tracers ($\delta^{7}\mathrm{Li}$ and cosmogenic $^{10}\mathrm{Be}/^{9}\mathrm{Be}$, both measured in marine sediment) to reconcile these seemingly contradictory observations. Assuming an approximate doubling of mountain erosion since 11 Ma, we show that the resulting increase in silicate weathering flux from mountains resulting from the increased supply of unweathered rock is offset by climatically-driven decreases in silicate weathering in lowlands. This shift in weathering from lowlands to mountains and a global decline in weathering intensity is recorded in seawater $\delta^{7}\mathrm{Li}$, which is sensitive to the ratio of erosion to weathering. We propose that increased mountain erosion has resulted in a more reactive Earth surface that produces the same silicate weathering flux, but at a lower temperature and $p\mathrm{CO}_2$. Globally constant silicate weathering fluxes resulted in a null change in marine $^{10}\mathrm{Be}/^{9}\mathrm{Be}$. Thus, declining $p\mathrm{CO}_2$ and cooling during the late Neogene reflects a change in how the Earth surface partitions the products of denudation into weathering and erosion.