EGU2020-20554, updated on 25 Oct 2020
https://doi.org/10.5194/egusphere-egu2020-20554
EGU General Assembly 2020

Neogene changes in land surface reactivity and implications for Earth system sensitivity to carbon cycle perturbations

Jeremy Caves Rugenstein[1,2], Daniel Ibarra[3,4], and Friedhelm von Blanckenburg[5,6]
[1]Max Planck Institute for Meteorology, Land in the Earth System, Hamburg, Germany (jeremy.rugenstein@mpimet.mpg.de)
[2]Department of Geosciences, Colorado State University, Fort Collins, CO, USA (Jeremy.Rugenstein@colostate.edu)
[3]Earth and Planetary Sciences, University of California, Berkeley, USA (dibarra@berkeley.edu)
[4]Institute at Brown for Environment and Society, Brown University, Providence, RI, USA
[5]GFZ German Research Centre for Geosciences, Earth Surface Geochemistry, Potsdam, Germany (fvb@gfz-potsdam.de)
[6]Institute of Geological Sciences, Freie Unversität Berlin, Berlin, Germany

Long-term cooling, pCO_2 decline, and the establishment of permanent, polar ice sheets in the Neogene has frequently been attributed to increased uplift and erosion of mountains and consequent increases in silicate weathering, which removes atmospheric CO_2. However, geological records of erosion rates are potentially subject to averaging biases and the magnitude of the increase in weathering fluxes, and even its existence, remain debated. Moreover, a weathering increase scaled to the hypothesized erosional increase would have removed nearly all carbon from the atmosphere, leading to proposals of compensatory carbon fluxes in order to preserve carbon cycle mass balance. In contrast, increasing land surface reactivity—resulting from greater fresh mineral surface area or an increase in the supply of reactive minerals—rather than an increase in the weathering flux, has been proposed to reconcile these disparate views. We develop a parsimonious carbon cycle model that tracks two weathering-sensitive isotopic tracers (stable $^{7}Li/^{6}Li$ and cosmogenic $^{10}Be/^{9}Be$) to show that an increase in land surface reactivity is necessary to simultaneously decrease atmospheric CO_2, increase seawater $^{7}Li/^{6}Li$, and retain constant seawater $^{10}Be/^{9}Be$ since 16 Ma. We find that the global silicate weathering flux remained constant, even as the global silicate weathering intensity—the fraction of the total denudation flux derived from silicate weathering—decreased, sustained by an increase in erosion. Thus, long-term cooling during the Neogene reflects a change in the partitioning of denudation into weathering and erosion. Variable partitioning of denudation and consequent changes in silicate weathering intensity reconcile marine isotope and erosion records with the need to maintain mass balance in the carbon cycle and without increases in the silicate weathering flux. These changes in land surface reactivity through time suggest that the Earth system's response to carbon cycle perturbations is not constant and that today's Earth can more efficiently remove excess carbon than during analogous perturbations observed in the geologic record.