The impact of subsurface silicate weathering on the long-term C cycle

A.D. JACOBSON[1] AND M.G. ANDREWS[1]

[1]Northwestern University, Evanston IL, 60208, USA (adj@earth.northwestern.edu, Grace.Andrews@soton.ac.uk)

Traditional models of the long-term C cycle assume that all volcanic C is outgassed into the atmosphere as CO_2, which regulates climate and weathers silicate rocks at the Earth's surface. However, in many volcanic settings, ascending CO_2 weathers silicate rocks in the subsurface such that a substantial fraction of the volcanic C flux enters the atmosphere-ocean system as HCO_3 [1, 2]. To understand the implications for climate regulation, we included a term for subsurface silicate weathering in the long-term C model developed by Kump and Arthur (1999) [3]. We also examined the role of hydrothermal calcite, which temporarily squesters volcanic HCO_3 until it dissolves at the surface later in time.

Subsurface silicate weathering indirectly affects climate by reducing the flux of volcanic C input to the atmosphere as CO_2, which in turn reduces the flux of CO_2 removed by surficial silicate weathering. The net result is that the atmosphere stabilizes at lower pCO_2 values, and hence a cooler climate, compared to the case where no subsurface silicate weathering occurs. Hyrothermal calcite is only a factor when the timescale of formation and weathering exceeds 1 Myr. In this case, the atmosphere stabilizes at relativley higher pCO_2 values but still lower levels compared to case when no subsurface silicate weathering occurs.

Nevertheless, the proportion of volcanic C introduced as HCO_3 does not affect pCO_2 and climate. Volcanic HCO_3 contributions, whether from direct hydrothermal inputs or calcite dissolution, should be subtracted from measured riverine HCO_3 fluxes before using the fluxes to parameterize silicate weathering feedback functions. The same logic applies to riverine fluxes of Ca and Sr, which can be used to trace HCO_3 sources. The only scenario where calcite weathering may be neglected is when calcite sequesters CO_2 after atmopsheric injection and dissolves quickly (<1 Myr). However, this scenario does not apply to volcanic settings, such as Iceland, where the hydrothermal calcite that adds riverine HCO_3 upon weathering [4] sequesters volcanic CO_2 prior to atmopsheric injection and is older than 1 Myr.

[1] Rad et al. (2007) Earth Planet. Sci. Lett. **262**, 109-124. [2] Dessert et al. (2009) Geochim. Cosmochim. Acta **73**, 148-169. [3] Kump and Arthur (1999) Chem. Geol **161**, 181-198. [4] Jacobson et al. (2015) Earth Planet. Sci. Lett. **416**, 132-142.