Controls on deep subsurface weathering and implications for the global weathering thermostat

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The drawdown of CO_2 by chemical weathering of silicate minerals is thought to moderate global climate over geological timescales. Weathering occurs within the Critical Zone, the terrestrial zone in which multiple Earth systems interact to produce soil and support life. Granitic rocks make up ~25% of the Earth's surface and weather 10s of meters below the surface in a range of climate zones. Thus much of the weathering occurs well below the zone of direct influence of surface processes, such as vegetation growth. However, the extreme interconnectivity of factors affecting weathering hinders our ability to determine the impact of individual weathering factors. Furthermore, studies of granitic catchments show siginificant variation in weathering intensity and extent, despite similar mineralogies [1]. Such heterogeneity in weathering presents an obstacle for modelling silicate weathering rates over geological time.

As a step towards disentangling the controls on weathering and identifying key parameters to enable better modelling of deep weathering on a global scale, we compiled a set of elemental data from the literature on deep granitic boreholes from diverse climatic regimes around the world. We also measured the elemental chemistry of an additional borehole from a temperate forest (Czech Republic) and calculated mass transfer [2] with depth for all major rock-forming elements from each borehole. Some granitic profiles exhibit significant loss of elements over very short distances, while others show only gradual losses. A strong, positive, linear correlation was identified between mass transfer and mean annual precipitation (r^2=0.83). Correlation between mass transfer and mean annual temperatures were not statistically significant (r^2=0.28). Preliminary results from statistical correlations and reactive transport models indicate that climate, particularly precipitation, exerts a dominant control on the morphologies (reflecting the depth and rate of mass transfer) of granitic weathering fronts by affecting the geochemical saturation state of the subsurface water. These insights will be used to inform global weathering models through geological time.

[1] Bazilevskya *et al*. (2013) *ESPL* **38,** 847-858. [2] White (2002) *ChemGeol* **190,** 69-89.