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Uplift, Chemical Weathering, Climate and Atmospheric CO_2: Connections and Disconnections

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Chemical weathering and carbonate sedimentation is the major route by which carbon is removed from the ocean-atmosphere system on geologic timescales. An understanding of the first order controls on chemical weathering rates is therefore central to elucidation of the controls on atmospheric CO_2 levels over Earth History. The nature of these controls remains, however, the focus of considerable debate. On one hand it is argued that ambient temperature and precipitation patterns exert a first order control on chemical weathering rates through their influence on chemical kinetics (e.g. Berner, 1994). Others, however, maintain that it is the physical break-up of rock during orogeny, glaciation and freeze-thaw cycles that limits the rate of chemical denudation of the continents (e.g. Raymo, 1991). The two camps support fundamentally different views on the controls on atmospheric CO_2 levels over geologic time scales and the role of mountain building in climate change.

It has previously been argued (Oxburgh, 1998) that the osmium isotope composition of Pleistocene marine sediments responds to, the changes in chemical weathering of the continents that accompany glacial cycles. Existing data suggest that the relationship between climate and weathering is not straightforward. Chemical weathering rates respond to climate but only during periods of extreme cold and aridity. At other times chemical weathering on the continents seems to be independent of climatic variability and must therefore controlled by some other factor such as mean global relief.

Both physical and climatic influences appear important in determining chemical weathering rates on the continents. Although an over-simplification, it is useful to contemplate chemical weathering as either 'physically-induced' (by orogeny and physical weathering) 'chemically-induced' (by acceleration of the rates of chemical reactions). A conceptual model can then be developed that describes the links between chemical weathering, climate and atmospheric CO_2 levels. The following are the major implications of this model:

While the net global chemical weathering rate must always balance net outgassing rates (on timescales of 10^4 yrs), the balance between physically- and chemically- induced chemical weathering changes as a function of mean global relief. This balance is related to the average weathering intensity on the continents. - Orogeny is a likely cause of global cooling, however this uplift-driven cooling is not associated with a change in net chemical weathering rate of the continents. - There is no simple relationship between atmospheric CO_2 levels and global chemical weathering rate.

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