Chemical weathering rates in an icehouse world: Insights from the isotopic record in soils

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Chemical weathering of silicate rocks appears to have regulated Earth's climate over its history as first discussed by [1]. How this process operates in an icehouse world is poorly understood. Recent studies [2] suggest that repeated glacial (enhanced physical weathering) – interglacial (increased silicate chemical weathering) cycling may have led to enhanced CO_2 drawdown in the Quaternary. Soil chronosequences provide a useful natural laboratory to understand these processes but have thus far been subject to a limited number of studies using an integrated isotopic approach e.g. [3].

We have analysed soil leaches from a Scottish soil chronosequence with ages 0.1-13 ka, to investigate the isotopic composition of labile material accessible to chemical weathering, and which could be used to trace delivery of chemical weathering products to the present and past oceans [4] . The isotopic composition of Pb released from these soils by leaching is consistently more radiogenic than the bulk C horizon, in accord with previous studies [3] which suggest that release of radiogenic Pb from accessory phases accompanies early rapid chemical weathering. In contrast to earlier studies, however, we find that in these relatively young soils the Pb released becomes more radiogenic with increasing age up to 13 ka. The behaviour of Sr is more complex: the isotopic composition released by leaching is highly dependent on the technique used and shows no pronounced trend with age.

These and additional data will be used to investigate the extent to which soils remain out of steady state with respect to the weathering release of a number of elements and how the isotopic signal is transferred to local streams and ultimately to the ocean.

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Atmospheric evidence for recent global ocean deoxygenation

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Direct measurements of changes in atmospheric O_2/N_2 ratio now span nearly two decades. Together with the observed trends in atmospheric CO_2 concentration, the O_2/N_2 data provide a tight constraint on the O_2 and CO_2 exchanges with the land and oceans over this period.

The major terms in the global budgets for O_2 and CO_2 over this period are: (1) fossil-fuel burning, (2) oceanic CO_2 uptake in response to rising atmospheric CO_2, and (3) sources and sinks of CO_2 and O_2 from the land biota. A critical examination suggests, however, that the combined budgets of O_2 and CO_2 cannot be balanced without including a fourth component, reflecting non-steady ocean behavior such as ocean warming, circulation changes, and changes in the marine biological pump. This fourth component may have contributions from non-steady state air-sea fluxes of CO_2, O_2, and N_2, but the O_2 contribution almost certainly dominates. The magnitude the fourth component is consistent with models suggesting that global warming should be causing oceanic outgassing of O_2 of order 30 Tmol O_2 yr^{-1}. The implied O_2 outgassing is several times larger than expected from the effect of warming on O_2 solubility, so would be associated with an increasing O_2 deficiency in the ocean interior at the global scale.

The argument hinges critically on being able to estimate precisely the amount of CO_2 the ocean would take up in the absence of warming, as constrained by oceanic measurements of chlorofluorocarbons (CFCs). This CFC constraint will be reviewed. The implications of the atmospheric contraint on projected future deoxygenation will also be discussed.