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Secular variation of ocean Pb isotopes as a monitor of glacial-interglacial weathering rate variability

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The rate of continental weathering plays a central role in regulating atmospheric carbon dioxide concentration, and hence global climate, on both long and short time scales. Yet the role played by weathering in generating and maintaining the Earths present ice-house conditions is uncertain. We propose that Pb isotopes in the oceans offer a previously un-exploited means of recording past weathering rates. Here we use a new high-resolution technique to resolve changes in the Pb isotope composition of the oceans on a 10-20 kyr timescale.

Ferromanganese crusts are faithful recorders of the isotopic composition of oceanic water from which they precipitate. Their slow growth rate (1-10 mm/Myr), however, typically prohibits sampling at an age resolution of less than 200 kyr. Consequently, most studies are concerned with long-term secular changes in isotopic composition. With the advent of laser ablation multi-collector mass spectrometry, however, $<$5 kyr resolution is readily achievable, even on crusts growing at rates of $<$2 mm/Myr with little loss in analytical precision. Our data show that over the last 1.5 million years there have been large glacial-interglacial swings (over 1%) in the Pb isotopic composition of the North Atlantic. These swings in isotopic ratio are most readily explained in terms of weathering intensity in the source areas of the Pb through an established relationship between soil age, soil Pb isotopic composition, and cationic weathering flux (Harlavan et al., 1998; von Blanckenburg and Nägler, 2001). We find that during the glacial periods of the last 500 ka, relatively unradiogenic Pb predominates, reflecting a weathering intensity $\sim$2.5 times lower than interglacial periods. When scaled to land area, this decrease offsets the increase in weathering rate thought to occur as a consequence of sea level fall due to ice sheet growth (Gibbs and Kump, 1994). We suggest that the interplay between these two processes (sea level fall and ice sheet size) ensures that global weathering rates remain constant over short to intermediate (10^3-10^5 years) time scales despite large, glacially induced changes in regional weathering rates. On the long term the trend to more radiogenic compositions over the last 1.8 Myr suggests an overall increase in silicate weathering rates and therefore that glacial physical erosion, coupled with interglacial chemical weathering, may be a long term CO_2 sink.

References:

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