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Osmium Isotope Evidence of Increased Chemical Weathering Rates During the Late Paleocene Thermal Maximum

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The interplay between global temperature and chemical weathering rates is a critical part of the ongoing debate over the underlying mechanisms that both perturb and stabilize earth's climate system. The hypothesis that a feedback between global temperature and silicate weathering rates acts to stabilize the long-term climate of the earth (1) is appealing because of its simplicity, but is extremely difficult to test. If this feedback plays an important role in regulating earth's climate on this time scale, then the unusual warmth of the Late Paleocene Thermal Maximum (LPTM: (2)) should be accompanied by a net increase in global silicate weathering. The LPTM is identified in the geologic record by an abrupt shift to more negative carbon isotope values in both marine and terrestrial sections (3 4). This carbon isotope event (CEI) is coincident with oxygen isotope data that indicate warming of surface waters at high and mid-latitudes of as much as 15ºC (5) and more moderate warming in the tropics. Given our current understanding of the marine Os cycle, a pulse of intensified chemical weathering is expected to produce an excursion to higher $^{187}Os/^{188}Os$ followed by a recovery to lower ratios. This study was designed to seek evidence of such an Os isotope excursion. We have documented a large (10%) increase in the $^{187}Os/^{188}Os$ ratio at two widely separated sites that is coincident with the LPTM CIE. One site is in the North Atlantic (DSDP 549) and the other is in the Indian Ocean (DSDP 213). Based on the coherence of these two records with one another and with existing data from Pacific sediments we conclude that there was a transient whole ocean shift to higher seawater $^{187}Os/^{188}Os$ ratios during the LPTM. The transient nature of the excursion and independent supporting data indicative of an accelerated hydrologic cycle (5) have led us to interpret this Os isotope excursion as evidence of a globally significant increase in chemical weathering which resulted in an increased Os flux to the oceans. This interpretation supports the operation of a positive feedback between warm global climate and global chemical weathering rates and suggests that carbon dioxide drawdown associated with such a feedback may have played an important role in arresting LPTM warming. The validity of this interpretation depends critically upon our assumption that the $^{187}Os/^{188}Os$ of riverine flux did not change significantly during the LPTM. Equally important to the validity of this interpretation is the requirement that the onset of the LPTM to be too abrupt to allow the CIE to result from perturbations in the burial and erosion of sedimentary organic matter. Comparison of the LPTM Os isotope excursion to those associated with recent glacials (6) reveals a coherent picture in which brief periods of extreme warmth and humidity are characterized by excursions to high $^{187}Os/^{188}Os$ ratios while the opposite is true of brief episodes of extreme cold and aridity. Thus available Os isotope data suggest that a weathering based mechanism does indeed act to ameliorate earth's climate (1) on time scales of 10,000 to 100,000 years.

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