The middle Miocene Climatic Optimum triggered by magmatic activity: insights from osmium isotopes and a carbon cycle model

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The middle Miocene Climatic Optimum (MMCO) represents a prolonged global warming event which is associated with a long-lasting positive carbon-isotope excursion [1]. This climatic change and fluctuation in the global carbon cycle interrupted a general cooling trend during the Cenozoic and may have reshaped biotas over local to global scales [1, 2]. However, underlying mechanism responsible for the MMCO and the isotope excursion has remained evasive. To understand the mechanisms involved, we obtained a high-resolution Os isotope ($^{187}Os/^{188}Os$) record of Miocene seawater using (hemi)pelagic sediments from ODP Sites 1184 and 1218 (Leg 184 and 199, respectively) and IODP Sites U1338 and U1438 (Expedition 321 and 351, respectively), following the leaching method of Ravizza and Paquay (2008) [3] to derive only hydrogenous Os isotopic composition. Our result was generally consistent with previous low-temporal-resolution record [4]. However, we found a small negative Os isotope anomaly at ~14-16 Ma: i.e., $^{187}Os/^{188}Os$ gradually decreased between 20-16 Ma, showed the lowest value of ~0.7 at ~14-16 Ma, and then gradually increased to ~0.85 by 11 Ma. Such a negative isotope excursion can be explained by ~50% increase of non-radiogenic Os input from the mantle sources which seems to be consistent with the eruption of Columbia River flood basalt and a rapid seafloor spreading during the middle Miocene [5, 6]. We employed a carbon cycle model to test the biogeochemical responses to 50% increase of magmatic activity similar to that of Kump and Arthur (1999) [7] but considers greenhouse effect of atmospheric CO_2 and temperature dependence of silicate weathering rate. Seawater phosphorous concentration was also calculated by assuming that seawater phosphorous concentration is a linear function of the weathering rate. The model demonstrates that the perturbation in magmatic activity can elevate *p*CO2 to ~400 ppmv from pre-industrial CO_2 level (280 ppmv) and cause a positive carbon excursion of ~1 per mil due to enhanced organic carbon burial. These values are consistent with previous boron and carbon isotope records of pelagic sediments [1], suggesting that the eruption of Columbia River flood basalt and the rapid seafloor spreading triggered the biogeochemical perturbations during the middle Miocene.

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