Re and Os evidence of widespread anoxia and increased continental weathering during the Toarcian Oceanic Anoxic Event

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The Toarcian Oceanic Anoxic Event (T-OAE; ~183 Ma) is associated with the widespread deposition of organic-rich facies and a perturbation to the global carbon cycle recorded in all carbon reservoirs. The eruption of the Karoo-Ferrar Large Igneous Province (~183 – 180 Ma) and resultant global warming are thought to have triggered a cascade of biogeochemical feedbacks that resulted in environmental deterioration and ultimately marine anoxia. For example, an increase in continental weathering may have delivered enough nutrients through riverine input to stimulate bioproductivity and cause ocean deoxygentaion. However, geochemical evidence of ocean anoxia during the T-OAE is contradictory; some studies suggest widespread anoxia or low-oxygen conditions, whereas others show variation in redox conditions with a focus on local controls.

We have analyzed the Re-Os isotopic system (n = 34) from an organic-rich sedimentary succession (upper Pliensbachian to middle Toarcian) in western North America in order to test whether ocean anoxia was widspread and if continental weathering rates increased during the T-OAE. Re abundances range from 31 to 256 ppb before and after the Toarcian carbon isotope excursion (CIE), and decrease significantly to 4 – 17 ppb during the CIE. Similarly, Re/TOC values range from 10 to 30 before and after the CIE, whereas CIE values are ~3. The T-OAE interval is characterized by more radiogenic $^{187}Os/^{188}Os$ values ($^{187}Os/^{188}Os_i$ = ~0.6), whereas the pre- and post-T-OAE intervals are characterized by less radiogenic values ($^{187}Os/^{188}Os_i$ = ~0.25 and ~0.4, respectively). We interpret the T-OAE Re data as the result of a drawdown of the marine Re reservoir due to increased water column anoxia. Likewise, we interpret the $^{187}Os/^{188}Os_i$ data as a result of increased riverine delivery of continental materials due to enhanced weathering, which increased by four- to five-fold during the T-OAE. Although increased weathering may have contributed to widespread marine anoxia, it may also have constituted an important negative feedback on atmospheric pCO_2 levels during the T-OAE.