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Osmium-isotope records of volcanism and weathering before and during the Valanginian Weissert Event

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The Valanginian Weissert Event (~134 Ma) represented the first major carbon-cycle disturbance of the Cretaceous Period, characterized in the sedimentary record by a prolonged positive excursion in carbon-isotope ratios. The event has been widely linked with climate cooling, documented in several geographic regions; however, some areas show minimal evidence of temperature change at that time, or even warming and enhanced humidity around the onset of the event. Moreover, although the carbon-isotope excursion has generally been attributed to enhanced burial of organic matter, there is no evidence of widespread marine anoxia that would have promoted such deposition. Consequently, key questions remain regarding the causes of climate and environmental degradation during the early Valanginian. Understanding changes in volcanic activity and silicate weathering rates through late Berriasian to early Valanginian times is crucial for resolving this debate, as both processes influence atmospheric $p\mathrm{CO_2}$ levels and global temperatures. In particular, volcanism associated with formation of the Paraná-Etendeka large igneous province (LIP) during the Valanginian has long been proposed as the ultimate trigger of the Weissert Event via carbon emissions and greenhouse warming,but weathering of juvenile LIP basalts could equally have caused climate cooling.

In this study, we investigated the osmium-isotope composition ($^{187}Os/^{188}Os$) of deep-marine organic-rich Berriasian–Valanginian sediments from two proto-Atlantic Ocean archives (DSDP sites 534 and 603). Given the palaeoenvironmental setting of the two sites, the recorded $^{187}Os/^{188}Os$ seawater compositions of the proto-Atlantic should be representative of the global ocean. We find that seawater $^{187}Os/^{188}Os$ shifted from ~0.6 to ~0.75 during the latest Berriasian, suggestive of an increased flux of radiogenic osmium to the ocean during that time, likely resulting from enhanced weathering of the continental crust. Interestingly, however, there is no evidence of global climate warming during the late Berriasian that would have caused this weathering. Following the late Berriasian radiogenic shift, seawater osmium gradually changed to a more unradiogenic isotopic composition (~0.45) during the early Valanginian; the lowest $^{187}Os/^{188}Os$ values correlating with both the peak in the Weissert Event carbon-isotope excursion and evidence for climate cooling. This unradiogenic shift could reflect a decline in weathering of radiogenic crustal material;

however, it also stratigraphically correlates with geochronological and geochemical evidence for the time of maximum igneous activity on the western (Paraná) part of the Paraná-Etendeka LIP. Therefore, we conclude that the early Valanginian shift to unradiogenic $^{187}Os/^{188}Os$ seawater compositions resulted from erosion of juvenile primitive basalts, suggesting that combined weathering of the continental crust and the Paraná-Etendeka LIP played a key role in causing the global cooling associated with the Weissert Event.