Onset of Oceanic Anoxic Event 2 in the Lower Saxony Basin – Insights from high-resolution stable isotope stratigraphy and geochemical modelling

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The Oceanic Anoxic Event (OAE) 2 spanning the Cenomanian-Turonian boundary (93.5 Ma) represents a major perturbation of the global carbon cycle and is marked by organic-rich sediments deposited under oxygen-depleted conditions. In many studies the eruption of the Caribbean LIP is considered to be the cause for rapidly increasing CO₂ concentrations and resulting global warming accompanied by widespread oceanic anoxia. In the Lower Saxony Basin of northern Germany, the deposits of the OAE 2 are exposed in several industry drill cores. In this study, the lower part of the OAE 2 has been studied in the HOLCIM 2011-3 drill core. Sedimentary rocks are composed of limestones, marly limestones, marls and black shales and have been analysed with a high-resolution stable isotope approach (approximately one sample every 2 cm) combined with geochemical modelling. Using stable carbon isotopes, bulk rock parameters and petrographic analysis, the onset of OAE 2 has been investigated in detail. The high-resolution δ¹³C curve exhibits overall stable values around 3 ‰ before the onset of the Plenus event. This background level is interrupted by three short-lived and small but significant negative carbon isotope excursions (CIEs) down to δ¹³C values of 2.5 ‰, 2.7 ‰ and 1.9 ‰. Immediately before the main rise in the Plenus bed, a longer-lasting negative CIE down to 2.8 ‰ is observed, preceding the large positive CIE of the OAE 2 to values of 5.2 ‰ over 33 ka. Thereafter, the δ¹³C values decrease to 3.5 ‰ over a period of approximately 130 ka. The results can be correlated with the lower-resolution data set of Voigt et al. (2008) but enable a more accurate characterization of the subtle features of the CIE and hence events before and during this time interval. Carbon cycle modelling with the modelling software SIMILE using a model based on Kump & Arthur (1999) reveals that the negative excursion before the Plenus bed can be explained by a massive volcanic pulse releasing of 0.95*10¹⁸ mol CO₂ within 14 ka. This amount corresponds to only 81 % of the calculated volume of CO₂ release during emplacement of the Caribbean LIP by Joo et al. (2020). In the model the volcanic exhalation increases atmospheric CO₂ concentrations. This will increase global temperatures, intensify the hydrological cycle and thus increase nutrient input into the ocean, resulting in an expansion of the oxygen minimum zone, the development of anoxic conditions and an increase in the preservation potential for organic material. In the model enhanced primary productivity and organic matter preservation...
can be controlled by the implemented riverine phosphate input and the preservation factor for organic matter. For the positive anomaly, the riverine phosphate input must be nearly doubled (from 0.01 μmol/kg PO$_4$ to 0.019 μmol/kg) for the period of the increasing δ$^{13}$C values (app. 33 ka), with a concomitant rise of the preservation factor from 1 % to 2 %. This model scenario accurately reproduces the major features of the new high-resolution δ$^{13}$C record over the onset of the OAE 2 CIE.