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# Was the North Atlantic Ocean well-ventilated during Oceanic Anoxic Event 2 in the mid-Cretaceous?

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The geological record provides evidence for the periodic occurrence of water column anoxia and the formation of organic-rich deposits in the North Atlantic Ocean during the mid-Cretaceous. Both changes in primary productivity and oceanic circulation likely played a role in the development of the low oxygen conditions. Several studies suggest that an increased input of phosphorus from land initiated such events. Other proposed mechanisms invoke a vigorous upwelling system and a circulation pattern that acts as an effective trap for nutrients from the Pacific.

Here, we use a detailed biogeochemical box model for the North Atlantic Ocean to analyse under what conditions anoxia could have developed during Oceanic Anoxic Event 2 (94 Ma). The model explicitly describes the coupled water, carbon, oxygen and phosphorus cycles for the deep basin and continental shelves. In our simulations, we assume the vigorous water circulation from a recent regional ocean model study. Our model results for pre-OAE and OAE2 conditions are compared to sediment records of organic carbon and proxies for photic zone euxinia and bottom water redox conditions (e.g. isorenieratane, carbon/phosphorus ratios). Our results show that a strongly elevated input of phosphorus – either from terrestrial sources or from the Pacific – is a requirement for the widespread development of low oxygen zones in the North Atlantic during OAE-2. Model results suggest that rates of primary productivity increased by at least an order of magnitude upon the transition from pre-OAE to OAE2 conditions. Our model captures the regional trends in anoxia as deduced from observations, with euxinia spreading to the northern and eastern shelves but with the most intense euxinia occurring along the southern coast. However, anoxia in the northern deep basin is difficult to achieve in the model. This suggests that the proposed ocean circulation may be too vigorous and/or that anoxia in the North Atlantic may have been less widespread than previously thought.