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Consequences of moderate ∼25,000 year lasting methane emission into the mid-Cretaceous ocean

T. Wagner (1), J. Herrle (2), P. Hofmann (3), S. Schouten (4), I. Stuesser (3), J.S. Sinninghe Damsté (4), K. Wallmann (5)

(1) Newcastle University, School of Civil Engineering and Geosciences, GBR (Thomas.wagner@ncl.ac.uk), (2) University of Alberta, Department of Earth and Atmospheric Sciences, Canada, (3) University of Cologne, Department of Geology, Germany, (4) Royal Netherlands Institute for Sea Research, Department of Marine Biogeochemistry and Toxicology, The Netherlands, (5) IFM-GEOMAR Leibniz-Institute of Marine Science Kiel, Germany

Atmospheric CO_2 concentrations in the early Albian about 112 Myrs ago are reconstructed to have ranged from 500-3000 ppm. For future climate the consensus view of climate scientists is that doubling or even higher increase of modern levels of atmospheric CO_2 will occur by 2100, placing future levels of atmospheric CO_2 well within the range of early Albian greenhouse conditions. This study focuses on the early Albian Oceanic Anoxic Event (OAE) 1b and explores how the Earth system responded to a moderate ∼25,000 year climate perturbation that possibly was less than 1˚C in global average temperature as deduced from coupled atmosphere-land-ocean modelling. DSDP Site 545 at Mazagan Plateau off NW Africa produced a striking high resolution record of OAE 1b providing insights into the time scales of rapid climate change and the functioning of regional climate and oceanography in response to a climate perturbation during a key period of past extreme warmth.

The molecular and isotopic records at DSDP Site 545 show that surface waters off NW Africa almost instantaneous warmed by about 3.5˚C along with a ∼1.5 ‰ depletion in ^{13}C of higher plant leaf waxes at the onset of OAE 1b, followed by enhanced sequestration of carbon as organic carbon-rich sediments. This observation provides compelling evidence supporting the concept that millennial and shorter-scale climate change during extreme warm climate conditions can be closely linked to methane emission events.

Assuming methane emission to be the primary trigger of OAE 1b modelling proposes a moderate ~25,000 year climate perturbation that is quantified to be less than 1˚C in global average temperature. The simulations further suggest that climate perturbation associated with the onset of OAE 1b caused almost instantaneous warming of the atmosphere on the order of 0.3˚C followed by a longer (~45,000 year) period of ~0.8˚C cooling. The marine records confirm that these moderate swings in global climate had immediate and severe consequences for African continental supply of mineral matter and nutrients (phosphorous) and subsequent oxygen availability and organic carbon burial in the eastern subtropical Atlantic, however, without turning the ocean anoxic.

The results from this study combining detailed geochemical marine records with biogeochemical modelling provide new views into the atmosphere-land-ocean relationships of the late Albian subtropical Atlantic and help identifying the succession of processes leading through one of the shortest OAEs in the Palaeogene-Cretaceous greenhouse. Perturbation of marine hydrates is a well recognized geo-hazard and this case study emphasizes their impact on global climate. With this integrated approach this study provides implications for future climate-ocean scenarios.