SFB 754 | Ocean Deoxygenation: Drivers and Consequences · Past · Present · Future ·

Contribution ID : **159** Type : **Poster**

Rapid climate change and oceanic anoxia in the Cretaceous greenhouse

Predicted increases in atmospheric carbon dioxide and global warming have many possible environmental consequences, including increasing ocean acidification, deoxygenation and the development of large harmful bacterial blooms. Notably, there are initial indications of increasing levels of anoxia in the oceans today. These environmental phenomena have been recorded during greenhouse climates in Earth's geological past and are often associated with mass extinction events. Therefore, the Earth's geological record provides a powerful and important analogue to infer the ecological consequences of future climate scenarios.

The Cretaceous greenhouse record includes Ocean Anoxic Event 2 (OAE-2) at the Cenomanian-Turonian boundary – the warmest interval in the last 100 million years – which is often seen as the archetypal marine deoxygenation event. Despite ~40 years of research, key questions remain concerning the role and extent of oceanic stratification, the importance of salinity stratification (i.e. fresh-water input), the implications of primary marine productivity and the effects of anoxia in controlling nutrient budgets, nitrogen fixation, and resulting ecosystem structure.

Middle and high paleolatitude data are critical for deciphering inter–hemispheric climate synchronicity, but are notably scarce. The Cretaceous Western Interior Seaway (WIS) of North America, stretching from the Gulf of Mexico to the Arctic Ocean, provides a broad latitudinal range to investigate OAE-2. In addition, it has been postulated that anoxic trends within this semi-restricted epeiric seaway may be antiphase to that of the open ocean, and produces a unique setting to investigate the mechanisms behind anoxia.

This project will utilise organic geochemistry as its main tool to assess levels of anoxia and wider changing environmental conditions during OAE-2 across the WIS latitudinal gradient. Molecular fossils (biomarkers) and stable isotopes will be used to study physical and biogeochemical evolution of the WIS during the mid-Cretaceous by reconstructing variations in water column oxygenation, stratification, sea surface temperatures, organic matter provenance and, in concert with paleontological data, planktonic ecology.

The overarching goals are to test hypotheses regarding: a) the role of anoxia as a kill-mechanism in extinction events; b) the role of precipitation and salinity stratification as precursors for ocean deoxygenation; c) the role of productivity and changing ecology on ocean deoxygenation and black shale formation; d) the lag time between anoxic conditions, black shale deposition and carbon isotope excursions; and e) the occurrence of elevated SSTs at high latitudes, which might allow proxy and model data to better constrain latitudinal thermal gradients.

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Track Classification : 09 Ocean Deoxygenation - How the Past can Inform the Future