

### **Anoxia in Ancient Epeiric Seas: The Limits of Modern Analogs**

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Widespread anoxia is a characteristic of many ancient shallow (<200 m) epeiric seas, such as those developed on the North American craton during portions of the Devonian, Pennsylvanian, and Cretaceous. Modern anoxic basins with seafloors at bathyal depths such as the Black Sea (~2250 m) and the Cariaco Basin (~1400 m) do not represent good analogs for such seas, and large modern epeiric seas such as Hudson Bay and the Gulf of Carpentaria exhibit little depletion of dissolved oxygen owing to relatively unrestricted circulation and comparatively low productivity<sup>1</sup>. The Baltic Sea is the only modern sea to exhibit benthic anoxia, and then mainly in its deepest basins and on a temporally transient basis. Further, redox conditions within the Baltic have deteriorated during the past few centuries in response to anthropogenic nutrient loading. In view of the lack of close modern analogs for ancient anoxic epeiric seas, it is worthwhile to consider whether environmental conditions within epeiric seas differed in some fundamental respects in the past to facilitate development of widespread marine anoxia. For example, episodes of increased productivity may have been stimulated as a consequence of elevated nutrient fluxes, with the latter due to intensified weathering as a function of (1) CO<sub>2</sub> outgassing during intervals of rapid seafloor spreading, as during the Cretaceous<sup>2</sup>, (2) methane release due to evolution of seafloor clathrates and/or permafrost warming, as potentially at the Permian/Triassic boundary<sup>3</sup>, and (3) pedogenesis due to the spread of vascular land plants, as during the Middle-Late Devonian<sup>4</sup>. In other cases, specific paleoceanographic factors may have come into play, as with the lateral advection of oxygen-depleted waters from the eastern tropical Panthalassic Ocean into the North American interior sea during the Late Pennsylvanian<sup>5</sup>. The influence of such non-uniformitarian processes needs to be investigated systematically in the context of modeling studies of ancient epeiric seas.