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Eustacy, euxinia and extinction during the Devonian-Carboniferous transition

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The Devonian-Carboniferous (D-C) transition (~360 million years ago) marks a fundamental shift in the Earth system primarily related to changes in the oxidation state of surface environments that profoundly altered the trajectory of life on Earth. The pulsed biotic crises of this transition (e.g., Annulata, Dasberg, Hangenberg) were plausibly linked to complex physical and biogeochemical feedbacks driven in-part by the continued evolution and spread of vascular plants in terrestrial environments that enhanced weathering rates, soil formation, and the delivery of nutrients to the oceans, while simultaneously transferring carbon from the atmosphere to Earth's surface and water from the surface to the atmosphere through photosynthesis and evapotranspiration, respectively. The continued spread of terrestrial plants may thus have resulted in long-term climatic cooling, the expansion of continental ice sheets, and a shift in the redox balance of the ocean-land-atmosphere system, including widespread deposition of anoxic black shale in epicontinental seas. In this study, we present an integrated sedimentological and geochemical study of black shale from the Bakken Formation (Williston Basin, USA) that spans three key Late Devonian biotic events. High stratigraphic resolution mineralogical, elemental, and biogeochemical data from two continuous drill cores, as well as redox-sensitive elemental data from an additional 90 drill cores (~11,000 datapoints) open a unique spatiotemporal window into sea level, climate, redox, and extinction events across the D-C transition. Our dataset allows for the detailed documentation of a stepwise transgression of toxic euxinic waters into the shallow oceans that drove a series of Late Devonian extinction events. Other Phanerozoic extinctions have also been related to the expansion of shallow water euxinia, indicating that hydrogen sulfide toxicity was a key driver of Phanerozoic biodiversity.