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Ecosystem Pressure in the Early Eocene Lake Uinta, Green River Formation, Utah: Hydrological and Biogeochemical Cycling During Rapid Warming Events

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Understanding past climatic states and ecological modes, especially in times of extreme warmth, is crucial for future predictions of biotic change during the new warm mode we have created. The Early Eocene Climatic Optimum (EECO, 53-50 Ma) provides a natural experiment of the impacts of extreme global warming on the Earth system.

The Early-Eocene aged Green River Formation is world-famous for its fossils including some of the best-preserved examples of early Cenozoic flora and fauna. However, this otherwise fossiliferous deposit has a 120-metre-thick interval of lacustrine strata devoid of macroscopic animal fossils, but extremely rich in organic matter (up to 50% TOC) known as the Mahogany Zone. To investigate the response to a prolonged hot-house climate in a lacustrine basin and extreme biotic stress, we used molecular fossils extracted from the Mahogany Zone from a transect of cores through the margin and centre of Uinta Basin, Utah. Quantitative δ13C data from this terrestrial succession can be correlated to marine sections through astrochronology tied to 21 U-Pb and 40Ar/39Ar dates from ashes.

Our results of compound-specific hydrogen isotopic analyses of n-alkanes, isoprenoids and hopanes, in concert with high-resolution sedimentary logs, additional lipid biomarker profiles, and organic petrographic data, allow the differentiation of hydrological change from broader ecosystem change during the EECO. We conclude that lake conditions experienced lethally warm waters optimal for algal productivity, enhancing anoxia in the water column to the point where conditions in the habitable area were too extreme for macrofauna to thrive.