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Post-glacial Peatland Development and Fluvial Carbon Dynamics during the late Holocene Revealed by Lipid Biomarkers

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Peatlands represent a large terrestrial carbon reservoir because of their capacity for organic matter sequestration and preservation, despite occupying only ~3% of the global land surface. Understanding how peatlands formed and evolved during glacier retreat and sea-level rise since the Last Glacial Maximum is critical for constraining carbon dynamics under past and future climate variability. Peat deposits preserve abundant molecular biomarkers that enable the reconstruction of long-term environmental change and carbon dynamics. Here, we investigate lipid biomarkers from a 5-m peat core collected in Lower Oder Valley, located ~40 km south of the river's outflow into the Baltic Sea through the Szczecin Lagoon. Given that peat is primarily composed of plant-derived organic matter, long-chain *n*-alkanes are applied to trace vegetation and environmental changes, while GDGTs are used to reconstruct past temperature and pH variability. In addition, GDGTs also serve as reliable markers for peat origin of organic matter.

The onset of peat formation in the Lower Oder Valley was estimated at ~6 ka ago using radiocarbon dating, coinciding with the formation of the Szczecin Lagoon and the accumulation of approximately 5 m of peat to the present today. Total organic carbon (TOC) increases from ~2% at peat initiation to ~20%, followed by a decline to ~10% around 5 ka. This interval was characterized by more loamy lithology and lower bulk $\delta^{13}C$ values, likely reflecting a cold and dry climate phase. Subsequently, TOC rises to ~35%, accompanied by higher bulk $\delta^{13}C$ toward modern conditions. The carbon isotopic composition of long-chain *n*-alkanes ($\delta^{13}C_{wax}$, nC_{27}-nC_{31}) mimics the trend of bulk $\delta^{13}C$, exhibiting a total variability of ~6‰ over the past 6 kyr. Ongoing absolute temperature reconstructions based on brGDGT-based proxies and hydrogen isotopic composition of leaf waxes ($\delta^{2}H_{wax}$) will provide an independent climatic framework to further constrain peatland carbon accumulation and preservation dynamics.