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The role of coastal sulfate-driven anaerobic oxidation of methane in the onset of the 8.2 ka cooling event

SHUYA HUANG[1], XIA ZHANG[2] AND CHUNMING LIN[2]

[1]State Key Laboratory of Marine Geology, School of Ocean and Earth Sciences, Tongji University
[2]State Key Laboratory of Critical Earth Material Cycling and Mineral Deposits Research, School of Earth Sciences and Engineering, Nanjing University

Atmospheric methane concentrations are strongly coupled to global climate perturbations. A distinct decrease in atmospheric methane concentration just before the 8.2 ka BP cooling event has been reported, yet its triggers and potential climatic influence remain unconstrained. Here, we report phosphorus and iron speciation data, along with records of vivianite and ^{34}S-enriched pyrite in an early-middle Holocene sediment succession (~10–7 ka BP) from the Qiantang River mouth, eastern China. Our data confirm sustained sulfate-driven anaerobic oxidation of methane (SD-AOM) during a paleoenvironmental transition from estuarine to marine settings. This SD-AOM was likely triggered by the increased sulfate flux following a sea-level jump associated with the drainage of Laurentide proglacial lakes during 8.9–8.2 cal. ka BP. Under these non-steady depositional conditions, the SD-AOM persisted within a fixed sediment layer for approximately 0.5–1.0 ka.

The non-steady-state depositional conditions induced by the early Holocene sea-level jump and the accompanying transgression were widespread in coastal systems during the same period. This may have facilitated the nearly synchronous initiation of SD-AOM in newly submerged coastal systems worldwide, thereby driving a functional shift of these submerged coastal systems from methane sources to sinks. Extrapolated globally, methane consumption driven by SD-AOM in newly submerged coastal zones accounted for 43–88% of the total methane emission reduction during 8.45–8.25 cal. ka BP, thereby accelerating climate cooling and potentially contributing to the onset of the 8.2 ka BP cooling event. Although previous studies have demonstrated that the weakening of the Atlantic Meridional Overturning Circulation is the primary cause of the 8.2 ka event, this study seeks to dissect the methane flux in coastal systems along their climatic effects following the meltwater pulse event, providing a new perspective to understanding past analogues for the potential future freshening of the northern Atlantic and abrupt climate anomalies caused by the melting of Northern Hemisphere glaciers.