Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37574

# Isotopic Constraints on Extreme Methane Accumulation in the Long-Term Isolated Ferruginous Monimolimnion of Lake Kilevann

**BERTRAM REVENTLOW**[1,2], BERTRAM BOEHRER[2], FLORIAN MEIENBURG[1], JOSHUA MARKS[2], MARIUS FEUERLE[1], MARTINA SCHMIDT[1] AND WERNER AESCHBACH[1]

[1]Institute of Environmental Physics, Heidelberg University
[2]Helmholtz Centre for Environmental Research – UFZ Magdeburg

Iron-rich meromictic lakes are recognized as modern analogues for the ferruginous oceans of the Precambrian, providing insights into ancient biogeochemical cycles [1].

One example is Lake Kilevann in southern Norway, a 100 m deep meromictic lake, which became disconnected from the ocean approximately 10,000 years ago due to isostatic adjustment [2]. An exceptionally stratified layer of ancient seawater remains trapped in the deepest 40 m. Except for particulate fluxes and extremely slow molecular diffusion, this monimolimnion is isolated from the overlying oxic mixolimnion and the atmosphere. Consequently, iron and manganese have accumulated alongside organic matter, while sulphate from the original seawater has precipitated entirely as iron sulphide, establishing reducing conditions analogous to early Earth's oceans.

The prolonged isolation of the water has led to multiple unique physical and biogeochemical phenomena. We report methane and carbon dioxide concentrations among the highest recorded in lakes worldwide, reaching full saturation in the lowest 30 m of Lake Kilevann. To constrain the carbon cycle in the lake, we combined $\delta^{13}C$ of carbon dioxide and methane as well as radiocarbon analyses, revealing a biogenic carbon source with exceptionally long residence times in the monimolimnion. Constant $\delta^{13}C$ fractionation between methane and $CO_2$ indicates that hydrogenotrophic methanogenesis within the water column is the primary contributor to the lake's immense methane reservoir. Preliminary noble gas measurements show a strong depletion, pointing towards ebullition constituting a major carbon flux to the overlying oxic water, despite the monimolimnion's considerable depth. The combined isotopic evidence constrains carbon sources and transport pathways, revealing the mechanisms sustaining methane accumulation and carbon turnover under long-term ferruginous conditions.

[1] Swanner, Elizabeth D., et al. "The biogeochemistry of ferruginous lakes and past ferruginous oceans." *Earth-Science Reviews* 211 (2020): 103430.

[2] Creel, Roger C., et al. "Postglacial relative sea level change in Norway." *Quaternary Science Reviews* 282 (2022): 107422.