Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.29952

Integrating microscale, bulk S isotope analyses and models to understand modern euxinic sulfur cycle in the Black-Sea

MR. VIRGIL PASQUIER, PHD[1], DAVID A. FIKE[2], ITAY HALEVY[3] AND JOHANNA MARIN-CARBONNE[4]

[1]University of Lausanne
[2]Washington University
[3]Weizmann Institute of Science
[4]UNIL Institute of Earth Sciences

Euxinic conditions (anoxic and sulfidic water bodies) are thought to characterize much of mid-Earth's history and were a recurring feature of the Phanerozoic. However, euxinia is rare on modern Earth, with most insights derived from unique settings like fjords, lakes, and the Black Sea—the largest present-day euxinic basin.

The Black Sea features a well-defined redoxcline, with persistent sulfidic conditions enabling framboidal pyrite formation in the water column. Due to high sulfate reduction rates and iron limitation, pyrite precipitation is thought to occur primarily in the water column with minimal post-depositional isotopic overprint. Consequently, in plaeo-environmental studies sedimentary $\delta^{34}S_{PYR}$ values have been widely used to infer past euxinic conditions (extents and dynamics). However, advances in microscale S-isotope analysis and modeling now suggest that local depositional and diagenetic factors may significantly alter the isotopic record, prompting us to reassess the Black Sea model.

Using microscale S isotope techniques, we analyzed pyrite grains from the water column and sediments. Our results indicate that while framboidal grains initially reflect the local water column sulfide pool, they do not survive early diagenesis. We observe a rapid in-sediment recrystallization creating a bimodal $\delta^{34}S_{PYR}$ distribution in surface sediments (0–2 cm), where the low $\delta^{34}S_{PYR}$ mode represents water column sulfide, while the higher mode reflects local diagenetic conditions driven by diffusion and burial. With depth, framboidal grains decrease in favor of diagenetic pyrite, ultimately causing bulk $\delta^{34}S_{PYR}$ values to reflect local depositional conditions rather than the original water column signature. Comparing our data to existing literature, we find that most dissimilatory sulfate reduction (DSR) and pyrite precipitation occur in sediments. Due to iron limitation, high DSR activity at the sediment-water interface outpace pyrite formation, causing diffusion of DSR-derived sulfide into the water column, thereby sustaining euxinia.

Our findings refine understanding of euxinic settings by challenging the assumption that pyrite S-isotopes strictly record water column conditions. Instead, local diagenetic processes play a significant role, necessitating a revised conceptual framework for paleoenvironmental reconstructions.