Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37626

The sulfur cycle of an Eocene saline lacustrine system

HAO YUAN[1], PETER E SAUER[2], ANNA SZYNKIEWICZ[3] AND **SIMON C BRASSELL**[2]

[1]Indiana University Bloomington
[2]Indiana University
[3]University of Tennessee

The sulfur isotopic composition of sedimentary sulfates, combined with geochemical modeling, helps assess and quantify microbial pathways, abiotic reactions, and depositional processes governing the biogeochemical sulfur cycle [1-3]. Prior studies have focused on marine systems, leading to a paucity of data for hypersaline lacustrine settings despite estimates that the sulfate reservoir in evaporitic rocks far exceeds the ocean reservoir [4]. Thus, there is a crucial gap in understanding how temporal variations in hypersaline systems influence the balance of sources and sinks within the biogeochemical sulfur cycle. Here, we report wide ranges of $\delta^{34}S_{sulfate}$ and $\delta^{18}O_{sulfate}$ values for evaporitic minerals from sediments (+8.3 to +37.5 ‰ and -0.6 to +22.6 ‰, respectively) within the Qianjiang Formation. These data enable reconstruction of microbial activity, depositional conditions, chemical weathering, and isotopic fractionation in an Eocene hypersaline lake. Chronological controls allow assessment of orbital forcing controls on the hydrological cycle using quantitative modeling of key environmental parameters, including sulfate sources and sinks, and water level fluctuations. This approach yields evidence for the role of reservoir effects, and how depositional and microbial factors drive pyrite preservation [5]. Temporal variations in inputs and precipitation of sulfate determine whether the lake system operated under sulfate-rich or sulfate-limited conditions, while sulfate fluxes associated with chemical weathering further modulated pyrite preservation. The Qianjiang saline lake was not permanently stratified, unlike other systems, and alternated between stratified and mixed stages. During stratification, enhanced evaporative weathering favored sulfide preservation and greater $\Delta^{34}S$ (up to ~43 ‰) under anoxic conditions. Under dysoxic conditions, elevated sulfide weathering and nutrient recycling promoted sulfide oxidation resulting in decreasing $\Delta^{34}S$ (min. 9.6 ‰). These alternating redox states were periodically disrupted by clastic starvation events, when intense chemical weathering and sediment reworking strengthened connectivity between sulfur in the water column and sediments. Collectively, the Qianjiang record characterizes the sulfur cycle in saline lacustrine environments and serves as a potential analog for similar environments on Mars.

References:

[1] Fike *et al*., 2015. *doi:10.1146/annurev-earth-060313-054802*

[2] Gomes & Hurtgen, 2015. *doi:10.1016/j.gca.2015.02.031*

[3] Wang *et al*., 2023. *doi:10.1038/s41467-023-39962-9*

[4] Schoonen, 1998. *doi:10.1007/1-4020-4496-8_308*

[5] Yuan et al., 2026. *GSA Bulletin (Accepted)*