

Trace element cycling in ferruginous waters: Modern constraints on generalizable v. local signals

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Ferruginous (Fe(II)-rich) aquatic environments are a dominant geochemical regime throughout Earth's history [e.g., 1]. Modern ferruginous settings, restricted to anoxic deep waters in certain sulfur-poor redox-stratified lakes, can serve as valuable analogs to constrain biogeochemical cycling in Earth's past [2]. However, it is important to differentiate which aspects of physico-biogeochemical cycling can be attributed to universal processes and which may reflect lake-specific controls. Here, new trace element data are presented from ferruginous Lake Poso (Indonesia) [3] and Lake La Cruz (Spain), and comparisons are made between these and other modern ferruginous lakes. We focus on Ni, Cr, and U, which are critical for anaerobic metabolism (e.g., Ni for methanogenesis) and widely used for reconstructing redox through time (e.g., Cr, U).

Among available data, Lake Pavin shows fundamental differences in element distributions, indicating it may not serve well for generalizing biogeochemical cycling. In other systems, dissolved Cr is removed near the oxic-anoxic interface, consistent with reduction and scavenging onto Fe oxides. Dissolved Cr accumulates in anoxic deep waters and oxic-anoxic transition zone removal is incomplete, indicating potential for stable isotope fractionation, in contrast to common assumptions in Cr-based paleoredox reconstructions. Dissolved U concentrations decrease in anoxic zones, but water column data overall are difficult to reconcile with classical interpretations of U removal occurring in sediment pore waters. Instead, dissolved U distributions in some lakes are more consistent with water column removal near the oxic-anoxic interface. In most settings, Ni is partially removed at the oxic-anoxic transition, before increasing in upper anoxic waters. Decreasing Ni concentrations near the sediment-water interface suggest diffusive removal of Ni into ferruginous lake sediments, though this is not apparent in all settings. Overall, the varied distributions of trace metals within modern ferruginous lakes indicate a need for additional modern data to refine mechanistic understandings of the cycles of these elements through time.

References

- [1] Poulton, S.W. & Canfield, D.E. (2011). *Elements*. **7**(2), 107-112. doi: 10.2113/gselements.7.2.107.
- [2] Swanner et al. (2020). *Earth Sci. Rev.* **211**, 103430. doi: