Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.12439

Co-evolving Redox and Ecosystem Structures in the Early Oceans: Probing the Earliest Environmental Controls and Consequences of Complex Life

CHENYI TU[1], MOHAMED GHNAHALLA[2], ABDERRAZAK EL ALBANI[2] AND TIMOTHY W. LYONS[1]

[1]University of California, Riverside

[2]University of Poitiers

Presenting Author: ctu017@ucr.edu

Co-evolving marine redox and ecosystem dynamics have acted synergistically to regulate long-term habitability over much of Earth history. To shed light on this relationship, we will focus on a critical window in the mid-Proterozoic 1.1 billion years ago (Ga) when eukaryotes—as the first complex life—continued their advance from minor to major contributors to the biosphere. Their preceding evolutionary stasis was, in large part, due to persistently widespread anoxic conditions and coupled limitations in nutrients. Importantly, however, a growing body of evidence suggests dynamic ocean redox conditions over the mid-Proterozoic characterized by multiple pulses of oxygenation, including one at ~1.1 Ga. Despite this possibility, seemingly inconsistent arguments demand that we explore this relationship further. Here, we take the first steps toward this goal by discussing best practices in delineating ancient environments archived in old and often altered fine-grained siliciclastic rocks.

In this study, we are interrogating a set of well-preserved shale records (Atar/El Mreiti Group) from the Taoudeni Basin, Mauritania. Our preliminary results for iron (Fe) speciation and trace metal concentration data suggest that the local redox state was dynamic, shifting between oxic, ferruginous, and euxinic. To further illuminate the redox landscape of global oceans, we are exploring molybdenum and thallium isotope systematics—targeting specific samples tied to low-oxygen local deposition. Also of interest, one of our cores was intruded by a 30-m-thick Mesozoic dolerite sill, which enables us to assess the potential impacts of thermal alteration on various redox-relevant proxies when compared to unaltered materials of the same depositional setting. Delivery of Fe from the hydrothermal fluids associated with the sill intrusion led to the production of pyrrhotite converted from pyrite, which complicates the use of Fe speciation approach. Further, elevated sulfur contents along with the increasing isotopic values of pyrite/pyrrhotite indicate additional supply of sulfur, which is likely derived from thermochemical reduction of sulfate in the hydrothermal systems. Additionally, the coupled increases in C_{org}/N ratios and nitrogen isotopes of our samples imply the selective loss of isotopically light nitrogen during contact metamorphism. Our study demonstrates, in very specific terms, the caution required when applying paleoenvironmental proxies to highly altered rocks.