HIGH RESOLUTION CHEMOSTRATIGRAPHY OF THE EDIACARAN DOUSHANTUO FORMATION, SOUTH CHINA: IMPLICATIONS FOR OXIDATION OF THE EDIACARAN OCEAN

MCFADDEN, Kathleen A., Dept. of Geosciences, Virginia Tech, Blacksburg, VA 24061

Evolution has long been thought to be intimately linked with the oxygenation of the global atmosphere and oceans. However, the geochemical evidence for oxygen rise and its relationship to biological innovation in the Ediacaran Period remain unclear.

Two case studies based on geochemical data from Ediacaran successions in Oman and the Death Valley proposed variant models of geochemical responses to the Ediacaran rise of atmospheric oxygen. One model suggests the Ediacaran oxygenation event occurred in three stages: (1) oceanic sulfate concentration crossed a threshold of 200 μm in early Ediacaran, as denoted by an increase in $\Delta\delta^{34}S$ from <16‰ to ~30‰; (2) the oxidation of a large, deep ocean reservoir of dissolved organic carbon in middle Ediacaran, as denoted by a 15‰ negative carbon isotopic shift (Shuram anomaly); and (3) the continuing growth of the oceanic sulfate reservoir in the late Ediacaran, as evidenced by oxidative sulfur recycling by sulfur disproportionation bacteria and sulfide oxidizing bacteria. Another model proposes that the Ediacaran oxygenation event resulted in increased weathering of fossil organic matter and pyrite in pre-existing sediments. The influx of ^{13}C-depleted carbon and ^{34}S-depleted sulfur would have resulted in an increase in oceanic sulfate concentration, decrease in oceanic $\delta^{13}C$, and decrease in oceanic $\delta^{34}S$.

Neither model fully addresses the extent to which the rise in oxygen during the Ediacaran might have influenced biological evolution. This is largely due to a lack of a complete fossil record along side the presented chemostratigraphy, leaving considerable gaps for global correlation. The Doushantuo Formation in South China, radiometrically constrained between 635 and 551 Ma, has the potential to clarify the global picture of Ediacaran biological and geochemical events. The formation spans 84 million years of the Ediacaran, exhibits large isotopic anomalies, and contains a rich biota of complex microfossils, macroscopic algae, and animal embryos. Here, we present integrated high-resolution chemostratigraphic data from the Doushantuo Formation, Yangtze Gorges area, South China.

The Doushantuo Formation was deposited in an intrashelf basin and comprises of four members, including a cap carbonate overlain by cherty black shale, a dolomitic limestone, and an upper shale. The lower shale originated during rapid transgression associated with the Marinoan deglaciation (663-635 Ma). The most organic rich sediments (total organic carbon, or TOC, up to 4%) likely occurred during pulses in productivity and/or anoxia, based on extreme positive carbonate isotopic values ($\delta^{13}C_{carb}$ = +6‰). The upper shale is thinner, yet lithologically comparable with TOC up to 8%, implying similar depositional conditions. However, the upper shale is characterized by strongly negative carbonate isotope values ($\delta^{13}C_{carb}$ = -10‰) similar in magnitude to the Shuram anomaly observed elsewhere. No glacial deposit is preserved beneath the upper shale, although the ~580 Ma Gaskiers glaciation might be coeval with the upper Doushantuo Formation. Organic carbon isotopes are remarkably stable in the lower shale ($\delta^{13}C_{org}$ = ~ -30‰), but gradually decrease in the upper Doushantuo Formation to ~ -37‰. The $\Delta\delta^{13}C$ throughout this excursion appears to stay the same, which suggests that oxidation of a large dissolved organic carbon reservoir is unlikely, at least on a local scale.

Bulk pyrite concentrations are variable from 0 to 12%, and are particularly high within the black shale successions. This implies that the depositional setting for both the black shales were likely anoxic at and below the sediment water interface. Even so, the $\delta^{34}S_{py}$ is positive (average $\delta^{34}S_{py}$ = +13‰) near the base of the section and has an overall negative trend into the upper shale (average $\delta^{34}S_{py}$ = -7‰). This trend is suggestive of an overall increase in oceanic sulfate concentration, but could also represent a transition from a regionally restricted basin to open marine conditions. Future work will focus on $\delta^{34}S_{SO4}$ analysis and integrating geochemical data with a growing biostratigraphic framework to better understand the role of oxygen on the radiation of complex microfossils during a critical time in earth history.

Advisor: Dr. S. Xiao