Multi-stage Ediacaran ocean oxidation and its impact on evolutionary radiation

D. A FIKE[1], J. P. GROTZINGER[2], L. M. PRATT[3], AND R. E. SUMMONS[1]

[1] Dept. of Earth, Atmospheric & Planetary Sciences, MIT; dfike@mit.edu; rsummons@mit.edu;
[2] Division of Geological and Planetary Sciences, Caltech; grotz@gps.caltech.edu
[3] Dept. of Geological Sciences, Indiana University, Bloomington; prattl@indiana.edu

High-resolution paired carbon ($\delta^{13}C_{carb}$ and $\delta^{13}C_{org}$) and sulfur ($\delta^{34}S_{SO4}$ and $\delta^{34}S_{pyrite}$) isotope records of the Ediacaran strata of the Huqf Supergroup, Sultanate of Oman record a three-stage oxidation of the Ediacaran ocean. Following the Marinoan glaciation, stage I oxidation lasts from ~ 635 – 610 million years ago (Myr) and records an increase in marine sulfate concentrations above ~ 200μM, likely due to a rise in atmospheric oxygen. Stage II oxidation, from ~ 575 – 550 Myr, coincides with the Shuram excursion, a > 13‰ negative excursion in $\delta^{13}C_{carb}$ [1] created by the oxidation of a large reservoir of deep ocean dissolved organic carbon (DOC). The onset of stage II oxidation coincides with the evolution of acanthomorph acritarchs in Australia and China [2], and the appearance of the first Ediacaran metazoa, *Charnia*-type segmented fronds [3], while the first motile macroscopic metazoa (e.g., *Kimberella*) appear at ~555 Myr [3] as the Shuram excursion draws to a close. Stage III oxidation, from ~550 – 547 Myr, is marked by presence of sulfur disproportionating metabolisms and the onset of co-variation in $\delta^{13}C_{carb}$ and $\delta^{13}C_{org}$, which is absent in older strata. Coincident with the onset of stage III oxidation, we see the evolution of macroscopic multicellular algae [4], an increase in the diversity of the acanthomorph acritarchs [1], and the appearance of the weakly calcifying metazoa *Cloudina* and *Namacalathus* [3]. Following stage III oxidation, there is a period of quiescence characterized by little perturbation in the carbon cycle and an absence of significant evolutionary events. At ~542 Myr, anoxia at the Ediacaran-Cambrian boundary causes the extinction of many Ediacaran organisms, setting the stage for the Cambrian radiation.

References

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