Stability and dynamics of Proterozoic oceanic euxinia

K. OZAKI[1*] AND E. TAJIKA[2]

[1]Atmosphere and Ocean Research Institute, The University of Tokyo, Chiba 277-8564, Japan (*corresondence: ozaki@aori.u-tokyo.ac.jp)

[2]Department of Complexity Science and Engineering, The University of Tokyo, Chiba 277-8564, Japan

The spatiotemporal variation of strongly sulfidic oceanic waters (euxinia) have played a crucial role in Proterozoic biological and geochemical evolution not only because of the inhibitory effect of hydrogen sulfide on mitochondrial respiration at the level of cytochrome c oxidase, but because of its fundamental role on the availability of bioessential trace metals, such as Zn, Mo, and Ni, in the oceans. On the other hand, accumulated geological and geochemical evidence demonstrates that the oxidation state of Earth's biosphere was marked by fundamental changes at both ends of the Proterozoic eon and that a broad oxygenation history of Earth surface environments has seen more dynamic trajectory than originally envisioned [1]. This intepretation is also supported by a recent geochemical modeling study. If so, such waxing and waning of the oxidation state of Earth's surface would have caused substantial changes in oceanic euxinicity and, in turn, would surely have impacted the biosphere. From this perspective, the evidence for euxinic environments in the aftermath of the Lomagundi-Jatuli Event (LJE) (~2.08-2.05 billion years ago) is notable because molybdenum and sulfur isotopic data imply a widespread euxinia at that time [2].

To forge a quantitative understanding of how oceanic euxinicity have evolved through most of Earth's history, we have improved upon the CANOPS model [3] by including open-system marine sulfur and methane cycling. This ocean biogeochemical cycle model enables us to both explore the mechanistic processes at play in the mid-Proterozoic ocean-atmosphere system and apply model predictions to the empirical geochemical record. Based on a series of sensitivity experiments and available geochemical data, we show that new production during the mid-Proterozoic was at least a factor of two below the modern Earth, and perhaps much lower, and that anoxic/non-euxinic conditions are an reasonable consequence under such conditions. We also show that a transient expansion of euxinia ("euxinia overshoot") would occurred when a well-oxygenated atmosphere goes into a less oxygenated state, providing a theoretical explanation for geological records at the LJE aftermath.

[1] Lyons et al., (2014) *Nature* **506**, 307-315 [2] Canfield et al. (2013) *PNAS* **110**, 16736-16741 [3] Ozaki and Tajika (2013) *EPSL* **373**, 129-139