Dynamics of Proterozoic ocean euxinia

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

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

[2]University of Tokyo, Chiba 277-8564, Japan (tajika@k.u-tokyo.ac.jp)

There is now a great interest in understanding paleoredox conditions of Earth's atmosphere and oceans because it is essential for investigating links between biospheric oxygenation and major biological innovation and extinction. Accumulating geochemical records, such as abundances and speciation of redox sensitive elements and their isotopes, reveal large spatial heterogeneity of Proterozoic ocean redox chemistry; anoxic and non-sulfidic conditions had been prevailed throughout much of the Proterozoic eon, and sulfidic conditions might had covered only a small portion of the seafloor. It remains, however, unclear exactly what biogeochemical conditions are necessary to explain these redox structure in the ocean interior.

Here we show that the conditions for pervasive euxinia in the ocean are very limited, and widespread non-sulfidic condition is an inevitable consequence of both low atmospheric oxygen concentration and high pyrite burial efficiency, with the aid of a newly developed oceanic biogeochemical cycle model. Sulfidic waters would have been restricted to near-shore regions where nutrient and sulfate availabilities were sufficient for an increase in biological productivity and following sulfate reduction.

We also found that widespread euxinia can be sustained for tens of millions of years only when oxygenated ocean goes into anoxic condition; as anoxia appears in the ocean, sulfate reduction increases to produce transitional peak of ΣH_2S until ocean reaches its new steady state. Such "euxinia overshooting" will occur as long as ~20 Myrs, of which timescale is determined by a massive sulfate reservoir size of the initial oxic oceans. Therefore, large-scale euxinia can be achieved if a well-oxygenated ocean goes into anoxic condition, underpinning a theoretical explanation for the expansions of euxinia in the aftermath of Lomagundi-Jatuli event (LJE) which may have produced vast amount of oxygen to the atmosphere at 2.22–2.06 Ga.