Oceanic sulfate increase events in the Ediacaran ocean

*Fumihiro Matsuura[1], Masafumi Saitoh[2], Yusuke Sawaki[3], Yuichiro Ueno[1,2,4]

1. EARTH-LIFE SCIENCE INSTITUTE, Tokyo Institute of Technology, 2. Japan Agency for Marine-Earth Science & Technology (JAMSTEC), 3. Graduate School of Arts and Sciences, College of Arts and Sciences, The University of Tokyo, 4. Department of Earth & Planetary Sciences, Tokyo Institute of Technology

It is thought that the development of life was closely linked to seawater chemistry, especially redox conditions. Since metazoans diversified in the Ediacaran, revealing redox condition in Ediacaran ocean is crucial for evolution of life. Recent sulfur isotopic values ($\delta^{34}S$) of carbonate associated sulfate (CAS) and chromium reducible sulfur (CRS) of Ediacaran sediments indicate that the ocean-atmosphere system was progressively oxidized during the Neoproterozoic. Those data further suggest that sulfur cycle was closely related to Shuram excursion, the largest carbon isotope anomaly in the Ediacaran. Ediacaran sediments in South China are ideal to unravel possible linkages between oceanic redox conditions and biological activity, because various proxies have been provided by a number of works. A previous work reported both $\delta^{34}S_{CAS}$ and $\delta^{34}S_{CRS}$ from Ediacaran Doushantuo Formation at Three Gorges, South China. Their $\delta^{34}S_{CAS}$ data were highly scattered, and this is possibly attributed to contamination from CRS during separation processes. Therefore stratigraphic profile of the $\delta^{34}S_{CAS}$ has not been fully determined, which leaves ambiguity in reconstruction of the oceanic redox nature.
We carried out sulfur isotope analyses of CAS and CRS of Ediacaran drill core samples collected from the Three Gorges. To reduce contamination from CRS fraction into CAS fraction, we employed an improved method to extract the pure CAS. The newly obtained $\delta^{34}S_{CAS}$ values display a smooth curve above the lower part of Member 2 of the Doushantuo Formation and range from +18.7‰ to +46.4‰, except for a datum of -3.7‰. The $\delta^{34}S_{CRS}$ values also display a smooth curve, and range from -18.6 to +42.8‰. The differences between $\delta^{34}S_{CAS}$ and $\delta^{34}S_{CRS}$ values are negatively correlated with $\delta^{34}S_{CRS}$ values, suggesting that the $\delta^{34}S_{CRS}$ values likely reflect degree of isotopic fractionation during sulfate reduction. The $\delta^{34}S_{CAS}$ data in sediments deposited before Shuram excursion are unsynchronized among South China, USA, Mexico, and Oman. The heterogeneous $\delta^{34}S_{CAS}$ data possibly arose from low oceanic sulfate concentration, because residence time of oceanic sulfate fell below a mixing time of the various ocean basins when sulfate concentration was low.
The stratigraphic profile of $\delta^{34}S_{CRS}$ exhibits two negative excursions, and we firstly found that the both excursions coincide with the positive excursions of the $^{87}Sr/^{86}Sr$ ratio and the negative excursions of the $\delta^{13}C$ value of the carbonate ($\delta^{13}C_{carb}$). These correlations indicate that enhanced oxidative weathering increased oceanic sulfate concentration and accelerated release of isotopically light carbon through sulfate reduction of organic matter. Furthermore, the $\delta^{34}S_{CAS}$ decreases from +23.5‰ to +18.7‰ parallel with the Shuram excursion. This decreasing trend during the Shuram excursion is comparable to those in Mexico, USA, and Oman. Therefore decrease of $\delta^{34}S_{CAS}$ concomitant with the Shuram excursion was a global trend, and this fact further suggests increase of oceanic sulfate concentration during this period. During the Shuram excursion, $\delta^{13}C_{carb}$ values started to co-vary with $\delta^{13}C$ values of the organic carbon, which indicates that a large oceanic organic carbon pool was exhausted owing to elevated oceanic sulfate level and extensive sulfate reduction. Our new results indicate that enhanced oxidative weathering supplied sulfate into ocean and induced high oceanic sulfate level and subsequent Shuram excursion during the late Ediacaran.

