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Oceanic Mo isotope change and prosperity of algae in the Late Ediacaran

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The Ediacaran is the one of the most exciting period where the first animals appeared through geologic time, and many and various multicellular algae appeared. However, the driving force of the emergence of the multicellular animals and algae is still controversial: increase in atmospheric oxygen (e.g. Shen et al., 2008 PNAS) and increase in nutrients (Sawaki et al., 2010 Precamb. Res.). Mo is one of the essential elements of life and involved in a nitrogenase enzyme of nitrogen fixation organisms. In the oxic water, Mo is stable as MoO_4^{2-} and has very long residence time (ca. $8x10^5$ yr), whereas it occurs as MoS_4^{2-}, and is scavenged to sulfide-rich sediments in euxinic condition. As a result, oxic seawater is enriched in Mo whereas Mo would be a nutrient in sulfidic and anoxic seawater. During the oxic periods, Mo isotope (delta$^{98/95}$Mo) of seawater is relatively high because the Mo is scavenged through involvement of Mo with the low delta$^{98/95}$Mo value in an iron manganese oxide. In addition, the isotope fractionation is insignificant because the Mo is completely scavenged to the sediment in euxinic condition.
Three Gorges area comprises relatively continuous, low-grade shallow marine sediments from the Ediacaran to early Cambrian. We carried out drilling from the Marinoan-aged Nantuo tillite through Doushantuo, Dengying, and Yanjiahe, Shuijintuo to Shipai Formations in ascending order. The Doushantuo Formation is composed of Cap dolostone, black shale-dominated Member II, dolostone-dominated Member III and Member IV in ascending order. The U-Pb dating shows that the bottom is ca. 635 Ma and the top is ca. 551 Ma (Condon et al., 2005, Science). The Member IV consists of black shale, and contains many algal fossils, the Miaohe Biota.
This work presents Mo isotope variation of black shale in Member IV of the drill core samples. Black shales and carbonate rocks from the Cap carbonate to the Member III are very depleted in Mo content (< 2 ppm), and we could not obtain the accurate Mo isotope values. The depletion in Mo content suggests that the Ediacaran seawater was depleted in Mo because it was sulfidic. On the other hand, Mo contents are very high, 25 to 160 ppm, in the Member IV and the delta$^{98/95}$Mo values increase from ca. 0 to 1.2 permil through the Member IV. The line of evidence indicates that seawater became more oxic and enriched in Mo in the late Ediacaran. Increase of Mo content in seawater favored prosperity of Miaohe biota including algal fossils. And the more active photosynthesis promoted oxygenation of seawater. The multiplicative effect makes enrichment of Mo content in seawater and prosperity of algae in the late Ediacaran.