Rare earth elements record of the mid-Proterzoic (1.7-1.3 Ga) carbonates from North China: implications for the seawater redox conditions

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The earth environment and biosphere experienced boring billion years in the mid-Proterozoic. The time period from 1.7 Ga to 1.3 Ga is the most boring part due to the stasis of eukaryote evolution as well as the atmosphere and ocean chemical conditions. However, a number of fossil records recently discovered globally including from North China Gaoyuzhuang Formaiton [1] indicate that the eukaryotes have experienced an early evolutionary diversification during this time. We hypothesize that the simplest default reason for this mid-Proterozoic renovation is the oxygenation in earth surface system. However, the knowledge about the oxygen level in the atmosphere and the redox conditions in the ocean during the mid-Proterozoic is still very limited. Geochemical estimates of atmospheric oxygen levels during the Proterozoic range widely over more than three orders of magnitude [2, 3].

In this study, we focused on the well-preserved and low-grade metamorphosed strata in North China spanning a period from 1.7 Ga to 1.3 Ga. On the basis of carbon and strontium isotope stratigraphy, we emphasized analyzing the iron speciations of black rocks and the rare earth elements to reconstruct the deep and shallow water redox conditions, respectively. We use a refined sequential leaching method to aquire the most pristine rare earth elements information of the seawater and use cerium anomaly as effective redox proxy in carbonate-dominated marine settings [4, 5]. Preliminarily cerium anomaly data show an oxic event during the time when upper Gaoyuzhuang Formation strata was deposited.

Chromium and uranium isotopes of carbonates from the Gaoyuzhuang Formation are being analyzed in order to reconstruct the redox conditions by multi-proxy comparisons. By synthesis of different proxies, we are trying to reveal the atmosphere oxygen level and the ocean redox conditions and their evolution through time in the mid-Mesoproterozoic, and discuss the relationship between the atmosphere and ocean redox conditions and the eukaryote evolution.

[1] Zhu *et al*. (2016) *Nature Commun.* **7**, 11500. [2] Planavsky *et al*. (2014) *Science* **346**, 635-638. [3] Zhang *et al*., (2015) *PNAS* **113**, 1731-1736. [4] Zhang et al. (2015) *Chem. Geol*. **412**, 82-91. [5] Tostevin et al. (2016) *Chem. Geol*. **438**, 146-162.