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In-situ analyses strontium isotope and rare earth of phosphorite in the Ediacaran in Weng'an area, South China

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The Ediacaran is one of the most important ages through the history of the life. It is because the multicellular animal appeared for the first time in this age. Especially, the Ediacaran sections in South China are relatively continuous without large unconformity, and contain various fossils like the oldest animal embryo fossil and multicellular algae fossil [Xiao et al., 1998]. So, the sections in South china are one of suitable regions for researching the surface environment change and evolution of life at the time.
The strontium in the ocean is derived from the hydrothermal and continental sources, and the former has a low Sr isotope ratio and the latter has the high ratio [Richter et al., 1992]. The Sr isotope ratio of the ocean is balanced between them. The elucidation of Sr isotope variation of seawater through the time allows us to estimate variation in the continental influx. At present, the thermohaline circulation of the whole ocean is efficiently operated, and it takes thousands of years to circulate the whole ocean. On the other hands, the residence time of strontium is longer than the thermohaline circulation because seawater contains much amount of strontium, thus the isotope ratio is homogeneous in the ocean. Therefore, the reconstruction of Sr isotope changes, preserved in sediments precipitated from seawater, leads us to decode change in the continental influxes. Sawaki et al., 2010 (Precambrian Research) showed the change in strontium isotope ratios from the Ediacaran to early Cambrian, estimated from the isotope variation of the carbonate rocks in Three Gorges area, South China. However, generally speaking, the whole rock composition of carbonate rocks is susceptible to secondary alteration and involvement of detrital materials. This study presents the in-situ Sr isotope analyses of phosphate and carbonate minerals in the phosphorite with nano-SIMS at University of Tokyo to evaluate the Sr isotope signatures in the Ediacaran, estimated from the whole rock composition of carbonate rocks as well as in-situ rare earth element (REE) analyses of phosphate and carbonate minerals with LA-ICP-MS at Kyoto University to estimate the redox condition during the precipitation of the phosphate minerals
The Ediacaran sections in Wengan region, South China comprise the Nantuo Tillite, corresponding to the Cryogenian Marinoan Snowball Earth, Doushantuo formation and Dengying formation in ascending order. The Doushantuo formation consists of six members: Cap Carbonate, Black shale, Lower Carbonate rock, Lower Phosphorite, Middle Carbonate Rock, and Upper phosphorite in ascending order. And, various fossils of the oldest animal embryos, cnidarian, sponge and multicellular algae appear in the Upper Phosphorite Member.
The Sr isotope values of phosphate minerals are consistent with those of the whole rock within the errors. The REE patterns of the phosphate minerals display that the phosphate minerals in the Upper Phosphorite Member, where the animal and multicellular algal fossils occur, have different REE patterns from those in the Lower Phosphorite Member. The former has a faint negative Ce anomaly whereas the anomaly lacks in the latter. The results of in-situ Sr isotope analyses of phosphate and carbonate minerals confirm the reconstruction of Sr isotope change of seawater through the Ediacaran by Sawaki et al., 2010. The appearance of the Ce anomaly in the upper Phosphorite Member indicates that the phosphate deposition occurred under the oxic condition.

The evidence suggests that the phosphate minerals precipitated from the water column. In addition, the change from lack of Ce anomaly in the Lower Phosphorite Member to its appearance in the Upper Phosphorite, concomitant with the first occurrence of multicellular algae and metazoans, implies oxygenation of seawater due to more active photosynthetic activity by algae, and foundation of a new niche for the multicellular animals.

Keywords: strontium, isotope, south china, phosphorite