

Decoding surface environmental change and biological evolution by multi-chemostratigraphies of drill core samples

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The Ediacaran is the one of the most exciting period where the oldest animals appeared through geologic time. However, it is very difficult to constrain the age because a key fossil to determine the age lacks in the Ediacaran and because the occurrence of fossils is restricted in only few areas such as South China and Siberia. Generally speaking, U-Pb dating of zircons in tuff layers is often performed to estimate the depositional ages in the Ediacaran. But, the geochronology in the Ediacaran is still poorly known because the occurrence of tuff layers is also restricted to only a few layers. As a result, comparison of carbon isotope chemostratigraphies of carbonate rocks is only a useful method. However, the geochronology based on the comparison among only the carbon isotope chemostratigraphies is still ambiguous because there are many large negative carbon isotope excursions in the Ediacaran and because previous works used a composite chemostratigraphy from some fragmental chemostratigraphies over the world. Therefore, we try to reconstruct the standard of multi-elemental and multi-isotope chemostratigraphies of carbonate rocks in the Ediacaran.

The Ediacaran strata in South China are almost continuously exposed, comprise mainly carbonate rocks with subordinate black shales and sandstones, and they contain many fossils, suitable for study of environmental and biological changes. We conducted drilling of the sections from the Ediacaran to the early Cambrian at four sites in the Three Gorges area and at three sites in Shiduping area to obtain continuous, fresh samples without surface alteration and oxidation. The drill core samples in Three Gorges area comprise from the Marinoan-aged Nantuo tillite through Doushantuo, Dengying, and Yanjiahe, Shuijintuo to the early Cambrian Shipai Formations in ascending order. The Shiduping area comprises the Nantuo tillite, through Doushantuo and Dengying Formations in the Ediacaran to the early Cambrian Niutitang Formations. We performed the drilling from the Nantuo tillite to Dengying Formation. The paleogeography of the Three Gorges area is shallow marine continental shelf whereas that of the Shiduping is the edge of the shelf or continental slope.

We analyzed $\delta^{13}\text{C}$, $\delta^{18}\text{O}$, and $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of the fresh carbonate rocks of drill core samples. The $\delta^{13}\text{C}$ chemostratigraphy shows five negative and positive excursions. Especially, there are two large negative excursions. The lower negative excursion corresponds to the 580 Ma Gaskiers glaciation and the upper is the Shuram excursion from ca. 570 to 550 Ma. The negative $\delta^{13}\text{C}$ excursion at the Gaskiers glaciation is accompanied with positive excursions of $^{87}\text{Sr}/^{86}\text{Sr}$ and $\delta^{18}\text{O}$ values. The Shuram excursion is accompanied with negative $\delta^{18}\text{O}$ and positive $^{87}\text{Sr}/^{86}\text{Sr}$ excursions. The $^{87}\text{Sr}/^{86}\text{Sr}$ ratios before and after the Gaskiers glaciation are smaller than 0.708 whereas those before and after the Shuram excursion are larger than 0.7085. Therefore, we can discriminate the two large negative $\delta^{13}\text{C}$ excursions by combination of $\delta^{13}\text{C}$ values and $^{87}\text{Sr}/^{86}\text{Sr}$ ratios.

The two large negative $\delta^{13}\text{C}$ excursions are accompanied with large positive $^{87}\text{Sr}/^{86}\text{Sr}$ excursions. The positive Sr isotope excursion indicates high continental flux, and possibly high nutrient fluxes from the continent because the main source of nutrients such as phosphorus, sulfate and iron is continent. Therefore, the large negative $\delta^{13}\text{C}$ excursions are caused by enhanced

remineralization of dissolved organic carbon because higher continental fluxes of nutrients promoted the bioactivity of photosynthesis and heterotrophs. The emergence of Ediacara biota after the Gaskiers glaciation and the prosperity of the latest Ediacaran is concomitant with the high $^{87}\text{Sr}/^{86}\text{Sr}$ values, suggesting that enhanced continental weathering, and the consequent higher influx of nutrients, played an important role in biological evolution.