High-resolution carbon and oxygen isotope analyses of the Ediacaran carbonate rocks

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The Ediacaran is one of the most important periods in the history of life when multicellular fauna appeared on the earth. However, it is still controversial about the relationship among the abrupt biological evolution and environmental change during the time. Therefore, it is necessary to decode the environmental change through the Ediacaran using some proxies. This work presents carbon and oxygen isotopic compositions of carbonate rocks of drill core samples from the ca. 630 Ma Cap carbonate of the bottom of the Doushantuo Formation through the Hamajing Member to Shibantan Member of the Dengying Formation, possible corresponding to a sequence from the Cap carbonate on the 630 Ma Marinoan Glaciation through the 580 Ma Gaskiers Glaciation to the 550 Ma Shuram excursion, in the Three Gorge area, South China, in order to decode the surface environment.

We made rock powders from the drill core samples using a micro-drill to avoid any altered portions and to do multi-isotopic and elemental analyses including carbon, oxygen and strontium isotopes and some trace elements. The delta 13C analyses displays a smooth variation with five positive and five negative anomalies, respectively. They are named as PI-1to 5, and NI-1 to 5, respectively. The NI-1 anomaly of the Cap carbonate has -7.5 parmil at the minimum, and is followed by the PI-1 anomaly with +2.4 parmil in delta 13C through an abrupt positive excursion. NI-2, 3, 4 and 5 have -5, -1, -5 and -9 parmil in delta 13C, respectively. On the other hand, PI-2, 3, 4, and 5 posses high delta 13C values of +5, +3 to +5, +0 to +5, +0 to +5 and +0 to +6 parmil, respectively. However, the modes of the negative excursions are varied each other, and PI-2 is characterized by the abrupt change, whereas PI-3 is gradual increase of delta 13C.

Although oxygen isotopic compositions is easily altered by secondary influence, the oxygen isotopic compositions possibly exhibit that they still preserve the primary signatures. Especially, at the NI-4 anomaly, the chemostratigraphy of oxygen and carbon isotopic compositions clearly shows the oxygen isotopic excursions are conversely correlated with the carbon isotopic compositions. In addition, it is considered that the Gaskiers glaciation occurred at the time, evident form the negative isotopic composition and presence of unconformity. The line of evidence indicates that the oxygen isotopic positive excursion is reasonably explained by global cooling and the Gaskiers glaciation at 580 Ma. In this case, the global cooling resulted in negative excursion of delta 13C through reduction of primary productivity and in the regression due to formation of extensive ice sheets. The NI-1 anomaly corresponds to the Cap carbonate on the Marinoan glaciation, along with the extremely low delta 13C values, characteristics to the Cap carbonate on the Marinoan Glaciation over the world. Generally speaking, it is considered that the Cap carbonate was derived from very hot seawater with high CO2 contents (Hoffman et al., 1998). We calculated the temperature as about 40 degree Celsius assuming the ice-free condition, consistent with the geological evidence.

In summary, we analyzed carbon and oxygen isotopic compositions of drill core samples in Three Gorge area, south China, from the Cap carbonate on the 630 Ma Marinoan Glaciation through the 550 Ma dolomitic carbonate to the late Ediacaran limestone. We found the five negative and positive excursions of delta 13C and delat 18O values, respectively. Especially, the oxygen isotope compositions are the first report for the primary oxygen isotopic variation through the Ediacaran, clearly exhibits positive excursions with negative carbon isotope compositions, possibly corresponding to the Gaskiers Glaciation at 580 Ma.