Mass extinctions related to global cooling: A case study of the late Ordovician mass extinction using a multi isotope approach

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Except for the most severe mass extinctions, such as the Permian-Triassic (PT) and Cretaceous-Paleogene (K-Pg) boundary events, most moderate- to minor-class mass extinctions were related to global cooling rather than global warming [1]. The elevated extinction rates for the cooling-related mass extinctions were generally accompanied by a positive carbon isotope excursion, implying that major perturbations of the global carbon cycle might be involved. As it is very difficult to draw conclusions from carbon data alone, a multi-isotope approach is necessary to understanding the paleoenvironmental perturbations in such mass extinctions. Although there are some common characteristics for cooling-related mass extinctions, it is still unclear whether or not all of them were induced by a common trigger event, such as volcanic activity, meteorite impacts, or nearby supernova explosions. In this study, we discuss the environmental perturbations at the late Ordovician mass extinction as an example of a cooling-related mass extinction. Although the late Ordovician mass extinction was one of the "Big Five" mass extinction events in the Phanerozoic, the rate of species extinction was lower than those of the P-T and K-Pg boundary events [2]. The decline of biodiversity coincided with the onset of the Hirnantian glaciation, the inducing mechanisms for which are still unclear. In this study, isotopic ratios and concentrations of carbon and sulfur were analyzed in the Upper Ordovician to Lower Silurian shales from the Langkawi Islands in Malaysia. The results revealed that the weight ratios of organic carbon and pyritic sulfur (C/S) varied periodically from <1 to ~30. These periodic variations were interrupted by the position of the positive $d^{13}C$ excursion. The excursion was accompanied by C/S ratios <0.1, lower than the minimum values during the periodical variations. Although the C/S ratios varied periodically, the minimum values for each C/S variation cycle gradually increased. This implies that the environmental perturbation recorded as very low C/S ratios repeated high and low intensities, but its fluctuation was attenuated overall.

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Keywords: Ordovician-Silurian boundary, Stable isotopes, Global cooling

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