Sulfur and carbon isotope profiles for Guadalupian-Lopingian paleo-atoll carbonates in Japan

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The mass extinction event that occurred around the Guadalupian–Lopingian (or Middle-Late Permian) boundary (G-LB; 260 Ma) followed extremely high carbonate $\delta^{13}C$ values (up to + 6 ‰) [1)]. This carbon isotopic signal was named the "Kamura event," after the Kamura section in Japan[1]. To elucidate the environmental conditions during the G-LB mass extinction, we analyzed the sulfur isotope ratios of carbonate-associated sulfate (CAS) and the carbon isotope ratios of organic carbon in the Middle-Upper Permian carbonates of an accreted mid-oceanic paleo-atoll complex at Kamura in central Kyushu, Japan, which is where the Kamura event was first documented.

Although the extreme carbonate $\delta^{13}C$ values corresponding to the Kamura event were accompanied by high organic matter $\delta^{13}C$ values, the isotope differences between carbonate and organic matter ($\Delta^{13}C$) varied and were correlated with carbonate $\delta^{13}C$ values throughout the Capitanian (late Guadalupian) and Wuchiapingian (early Lopingian). The Capitanian $\delta^{13}C$-$\Delta^{13}C$ correlation can be understood if an unusually large reservoir of dissolved organic carbon (DOC) is assumed[2)]. The decline in carbonate $\delta^{13}C$ after the Kamura event indicates enhanced DOC oxidation. As the deep-sea Panthalassa had been well oxygenated during the Capitanian, the large DOC reservoir likely developed as a result of the expansion of mid-depth oxygen minimum zone (OMZ) in Panthalassa.

The Wuchiapingian $\delta^{13}C$-$\Delta^{13}C$ correlation, the slope of which differs from that of the Capitanian, can be explained by steady-state models in which incoming and outgoing carbon fluxes are balanced. The lower carbonate $\delta^{13}C$ values occurred when the concentrations of atmospheric CO_2 were higher, which likely induced global warming that could have suppressed oceanic circulation and, therefore, the supply of oxygen to the seafloor, which could enhance bacterial sulfate reduction. Therefore, the increased input of volcanic CO_2 can decrease $\delta^{13}C$ in carbonate and increase $\delta^{34}S$ in sulfate, producing a negative $\delta^{13}C$-$\delta^{34}S$ correlation, which was observed for the Wuchiapingian dataset. The intense volcanic activity might be limited to the G-L boundary and the middle Wuchiapingian, based on the lower $\delta^{13}C$ values. As the decline in Middle Permian marine biodiversity began in the earlier half of the Capitanian period, these two volcanic events may not be the cause of the decline in biodiversity. The expansion of the OMZ during the Capitanian could have severely impacted the Middle Permian fauna.

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2) Rothman, D.H., Hayes, J.M., Summons, R.E., *Proc. Natl. Acad. Sci.* 100, 8124-8129 (2003).

Keywords: Guadalupian-Lopingian boundary, mass extinction, carbonate associated sulfate

