End-Triassic Mass Extinction: Causes and Consequences

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The biodiversity crisis across the Triassic-Jurassic boundary (TJB; *ca.* 201 Ma) is characterized by one of the largest mass extinctions in the Phanerozoic. Significant increases in the extinction rate of marine fauna, and major turnovers in terrestrial vegetation and vertebrate groups, have been well documented across the TJB. In addition to the extinction, several unique geological episodes around the TJB were recognized; i.e., the emplacement of the Central Atlantic Magmatic Provinces (CAMP) which is associated with the breakup of Pangea, carbon cycle perturbations, and widespread ocean anoxia and associated deficits of nutrients. In the last decade, based on of the numerous data-set obtained from the shallow-marine shelf sequences around the Pangea, major advances have been made in our understanding of the TJB biotic crisis, related environmental changes, and the CAMP volcanism. However, the casual relationships between the CAMP volcanism and extinction-related environmental changes of global context still remain unclear. Therefore, the deep mid-Panthalassa, which occupied major portion of the global ocean during the Triassic-Jurassic transition, is indispensable for reconstructing the global environmental changes related to the TJB biotic crisis.

Deep-sea bedded cherts in the Mino-Tanba belt in SW Japan provide critical constraints for reconstructing paleo-environmental changes because they preserve extinction-related intervals from the Middle Permian to the Early Jurassic deposited in the deep mid-Panthalassa. Most recently, the stratigraphic $\delta^{13}C_{org}$ variation using Rhaetian (Late Triassic) to Hettangian (Early Jurassic) shales interbedded within deep-sea cherts was established in the Katsuyama section in the Mino-Tanba belt. By obtaining high-resolution Rhaetian to Hettangian $\delta^{13}C_{org}$ values, three negative carbon isotopic excursions (NCIEs) were newly detected before and across the TJB. The mid-Panthalassic NCIEs are well correlated with those in many shallow-marine regions including the base Jurassic GSSP of TJB at Kuhjoch in Austria, suggesting that three NCIEs in the Tethys and mid-Panthalassa likely reflected global perturbations of the carbon cycle, rather than local phenomena. Based on the Os isotopic records correlated with $\delta^{13}C_{org}$ stratigraphic profiles, the mid-Panthalassic NCIEs can be interpreted as the consequences of the multiple emplacements of CAMP volcanism.

On the other hand, despite the oxic deep mid-Panthalassa, widespread ocean anoxia and associated deficits of nutrients around the TJB were recently identified in the Eastern Panthalassa. Since the redox conditions were quite different between shallow-marine regions and mid-Panthalassic sites, information regarding nutrient concentrations in the mid-Panthalassa is required. Oceanic fixed nitrogen is a bio-limiting component in the modern ocean, and total nitrogen isotopic composition ($\delta^{15}N_{TN}$) of sedimentary rocks is a useful tool for the reconstruction of ancient nitrogen cycles. To advance our understanding on the global nitrogen cycle, this study for the first time provides Rhaetian to Hettangian $\delta^{15}N_{TN}$ records in combined with Mo and U concentrations from the shales in the Katsuyama section. Based on the newly obtained data-set, I comprehensively discuss relative concentrations of biologically available nitrogen compounds in the mid-Panthalassa, their possible association with the redox condition, and biodiversity during the Triassic-Jurassic transition.

Keywords: Central Atlantic Magmatic Provinces (CAMP), Panthalassic ocean, Nitrogen isotopes, Redox sensitive elements, Bedded cherts, Japan