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Water column euxinia in Panthalassa at the Permian/Triassic boundary and its relationship with the mass extinction

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The largest mass extinction event in the Phanerozoic occurred at the Permian/Triassic (P/T) boundary. Several studies suggest that photic zone anoxia in the shallow-water and long-lasting anoxia in the deep-water should have been closely related to the mass extinction. Despite efforts of intensive studies, previous works inferred the bottom water oxygenation condition of the pelagic deep-sea based on the compilation of discontinuous and fragmented lithologic sequences from several different regions. In order to examine the extent, duration, periodicity and stability of the anoxic condition, and their relationship with the mass extinction, continuous and high-resolution reconstruction of the P/T boundary pelagic sequence within the Jurassic accretionary complex in central to southwest Japan was conducted based on the detailed geologic mapping and lithostratigraphic correlation of the sequence. Carbon isotopic analysis of total organic carbon was also carried out to reconstruct high-resolution carbon isotopic record of the sequence, which was compared with inorganic carbon isotopic records from Tethys.
The reconstructed P/T boundary pelagic sequence is approximately 1.5 m thick in Ubara area, southwestern Japan, and 9.5 m thick in Inuyma area, central Japan. In Ubara area, age diagnostic conodont and radiolarian fossils of the Late Permian (Changxingian) were previously reported from the lower to middle part of the sequence, and the conodont fossil (Hindeodus parvus) corresponding to the earliest Triassic was discovered from the black shale interval composing the upper part of the sequence. Carbon isotopic data show the negative shift of approximately 5 permil across the P/T boundary. In Inuyama area, age diagnostic conodont and radiolarian fossils of the late Early Triassic (Smithian) to the early Middle Triassic (Anisian) were previously reported from the middle to upper part of the sequence. Based on age constraints of diagnostic fossils and carbon isotope stratigraphy, the lowermost part of the sequence in Inuyama area is considered to be correlated near the Dienerian/Smithian boundary.
Using the reconstructed sequences, we examined changes in the bottom-water oxygenation condition in the deep-sea environment based on the degree of lamina preservation observed on soft X-ray radiographs. The observation revealed that anoxic condition characterized by preservation of fine laminations periodically occurred in 104 year-scale around the P/T boundary in Ubara area and the Smithian interval in Inuyma area. The size frequency distribution of pyrite framboids was also examined using polished samples under a scanning electron microscope to identify the occurrence of small-sized (approximately 5 micrometer in general) pyrite framboids indicative of water column euxinia. In Ubara area, small-sized pyrite framboids occurred repeatedly within intervals both of anoxic and oxic conditions in the bottom-water based on the degree of lamina preservation. We conducted the correlation of Ubara section with Meishan section of South China, which was deposited in the shallow-water of Tethys (Xie et al., 2007), using carbon isotope stratigraphy. The result suggests that the horizon with small pyrite framboids and bioturbation, which is immediately above the laminated interval in the uppermost Permian in Ubara seems to be correlated with the horizon interpreted as photic zone anoxia and mass extinction around the P/T

boundary in Meishan. Whereas the horizon with small pyrite framboids and well-preserved lamination in the lowermost Triassic in Ubara seems to be correlated with the horizon interpreted as cyanobacterial expansion in Meishan. These results suggest that the upwelling of anoxic deep-water could have caused the photic zone anoxia and mass extinction in the shallow-water at the P/T boundary, while cyanobacterial expansion in the shallow-water possibly contributed to euxinic condition in deep-water following the photic zone anoxia event.