

Formation of stratiform manganese deposits during the Carnian (Late Triassic) “pluvial event” in the pelagic Panthalassa

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Stratiform manganese deposits have been reported from the Triassic bedded chert sequences in the Japanese accretionary complexes, which are considered to have accumulated in a mid-oceanic basin of the Panthalassa Ocean. However, their precise mineralization age and depositional environment remain poorly understood. In the present study, we investigated lithostratigraphy, conodont and radiolarian ages, and geochemistry of bedded cherts and chert-hosted manganese deposits from the Jurassic accretionary complexes (Chichibu, Mino-Tamba, and Northern Kitakami Belts) in Japan.

The studied sequences are classified into three to four lithostratigraphical units; lower bedded chert, massive chert, manganese ore (30-150 cm thick), and upper bedded chert units in ascending order. Radiolarian fossils from the lower bedded chert unit indicate the Early Carnian age, based on the occurrence of *Capnuchosphaera deweveri* and *C. triassica*, whereas the upper bedded chert unit contains Late Carnian radiolarian species, including *Poulpus carcharus* and *Trialatus megacornutus*. Conodonts extracted from the upper bedded chert unit also include Late Carnian species, such as *Paragondolella praelindae* and *Metapolygnathus praecommunisti*. These occurrences of microfossils suggest that the sedimentary age of the manganese ores can be constrained from the late Early Carnian to early Late Carnian. Chemical compositions of the manganese ore are characterized by the enrichments in Mn and low concentrations of Co, Ni, and Zn. These geochemical features are similar to those in modern submarine hydrothermal manganese deposits. On the other hand, highly enrichments in V, Ni, Zn, U, and high U/Th ratio were recognized in the massive chert unit below the manganese ores, which indicate deposition under a reducing depositional environment.

Our biostratigraphic and geochemical analyses indicate that a redox state change from anoxic to oxic environments occurred in a pelagic deep seafloor in the late Early to early Late Carnian. This interval is known as a period of increased rainfall, named the Carnian Pluvial Event (CPE) in the western Tethys. CPE is characterized by the increased continental weathering which led to the increased nutrient flux and triggered the development of anoxia. It is likely that the Upper Triassic manganese deposits may have been formed during recovery from the reducing environment associated with the CPE.

Keywords: Stratiform manganese deposit, Triassic, Carnian Pluvial Event, Jurassic accretionary complex, Microfossil, Geochemistry