

Formational process of Manganese oxides in the Hokuroku District, northeastern Japan

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Several Mn ore deposits are present in the Hokuroku district in Akita. Origin of Mn ore deposits and their relationship to Kuroko ore deposits are completely unknown. Therefore, in the present study, geological, mineralogical and geochemical studies are performed on Mn ores and associated rocks in the Hokuroku district.

Our geological survey revealed that Mn ore deposits and/or Mn enriched rocks appear above “R2-Rhyolite” horizon, which age is approximately 12 Ma. Mn ores mostly appear in tuff as disseminated or massive ores, and some ores appear in mud stone. Major Mn mineral is MnOOH, and more than 10 kinds of Mn minerals are found. Electron-microprobe and Raman spectroscopic analyses on the examined samples identified todorokite, hausmannite and so on as Mn minerals

Those Mn minerals are spatially associated with dolerite intrusions. In addition, Fe-enrichments (by forming hematite) are often found around dolerite. By detailed geological survey, we were able to reconstruct sub-seafloor hydrothermal circulation pathways, which were initiated by R2 rhyolite and then followed by dolerite intrusions, in the studied sections.

Chlorite geothermometer and general mineral assemblages suggest the temperature of the hydrothermal fluids were not high enough to generate sulfidic “black smoker.” Multiple submarine hydrothermal circulation mobilized and locally enriched Mn in tuff. Those are remobilized when dolerite intruded into tuff.

Then large quantity of Mn oxides precipitated in tuff or seafloor with significant amounts of Fe²⁺ derived from dolerite and the reaction with oxygenic seawater at the subsurface area.

These result suggest that submarine hydrothermal activities with relatively low temperature can potentially form the high Mn concentration. Such low temperature hydrothermal processes are common in the modern ocean and Mn ores similar to the Hokuroku may be present on the modern ocean floor or sub-seafloor rocks. The process found in the present study is different from previous model based on “black smoker” type hydrothermal activities. In addition, age and stratigraphy of Mn ores indicate no relationship to Kuroko ores, but bimodal activities, which succeeded from Kuroko age, are important to form Mn ores in the Hokuroku district.

Keywords: Manganese, low temperature hydrothermal activity