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Calcareous nodules for sea floor paleothermometry

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Paleothermometry is one of the most important proxies for paleoceanographers. Benthic foraminifers have been used for reconstructing paleotemperature on the bottom of the sea. They are excellent materials for calcareous ooze, while mudstone sequences shows lots of difficulty to apply this technique for terrigenous sediments distributed around Pacific. Calcareous nodules are commonly observed in mudstone sequences, however, no study discussed potential paleothermometry based on calcareous nodules. It might supplements the role of benthic foraminifers. We described occurrences at outcrops, general configurations including their cut sections, analyzed carbon content, total organic carbon, and carbon and oxygen isotopes of nodules collected from Cretaceous starata of several regions in Hokkaido including the Haboro area.

Structure suggesting consolidation just below the sea floor includes burrows that eject calcareous material from nodule. Nodules consolidated associated with anaerobic oxidation of methane with sulfate reduction appear to be just-below-the-sea-bottom origin. Such nodules show the exactly same oxygen isotope values with that of benthic foraminifers. A bivalve fossil found on one of the methane seep nodules preserved aragonite of the shell and yielded close oxygen isotope temperature with that of host nodule.

Carbonate content and oxygen isotope values had positive relation suggesting carbonate content was controlled by the depth of nodule production. Nodules with lower carbonate content ($<$50%) exclusively show low oxygen isotope values and inappropriate for the sea bottom paleothermometry.

Study on nodules from the Haboro area showed that selections in front of outcrops and at laboratory enable us to select ”high quality nodules” for oxygen isotope paleothermometry. As it is simple procedure, large numbers of analyses are available. The cross-plot of these data can emerge ”upper limit line” of oxygen isotope values. The paleotemperature based on that value could provide reliable temperature for the sea bottom. On the other hand, nodules with similar condition from the Oyubari area appeared to be recrystalized and inappropriate for paleothermometry. It might be derived from the difference of burial depth between sediments of the Haboro and Oyubari areas. Even if it was originally consolidated near the bottom of the sea, strong compaction during burial would have caused permeation of pore water into the nodule. Carbon dioxide or bicarbonate ions derived from decomposed organic matter would have caused recrystallization of calcite with oxygen isotopes as low as -10 permil in the nodule.

Keywords: nodules, paleothermometry, oxygen isotope