

Temperature changes of shallow waters during the late Pliocene in the Sea of Japan based on Mg/Ca of ostracode shells

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Mg/Ca analysis of ostracode shells were conducted by using genus *Krithe* (intermediate water dweller) and *Cytheropteron* (shallow water dweller) in the Kuwae Formation, central Japan to determine more accurately the paleo-temperatures of intermediate and shallow waters during the late Pliocene in the Sea of Japan. More than 60 sandy mudstone samples were collected from Tainai and Sakai sections where the upper Pliocene Kuwae Formation well exposed. Two to six whole ostracode valves per sample were analyzed by ICP-AES in Kochi Core Center. The regression lines established in the previous studies (e.g. Dwyer et al., 2002) were used for *Krithe*. For *Cytheropteron*, the partition coefficient between water temperature and Mg/Ca ratio of ostracode shells was newly established based on the analysis of recent ostracode shells collected from the Sea of Japan.

Calculated bottom water temperatures located under intermediate waters ranged from 0.5 to 15 degrees C in the Tainai section. Their intervals in each sample ranged from 2.0 to 7.5 degrees C based on seven different regression lines. The intermediate water temperature shifted largely and abruptly with the range more than 5 degrees C in interglacial periods, whereas it changed within the range less than 3 degrees C in the glacial periods. During the MIS G17, lowest temperature (0.5-3 degrees C) was estimated in the interglacial maximum. Moreover, two peaks of higher temperature (6-10 degrees C) were found in the horizons just below and above the interglacial maximum, which correspond to the transitional periods. Therefore bottom water temperatures in the study site increased in the transitional period from glacial to interglacial maximum due to the inflow of the Temperate Intermediate Waters (TIW) though water depth became deeper. Then, the study site was influenced by cold deep waters lying under the TIW due to sea-level rise at the interglacial maximum. Increase and decrease of intermediate water temperatures during the transitional period from interglacial to glacial maximum indicate that the study site was deposited under the TIW again and then was affected by cool intermediate waters after the disappearance of the TIW. Steady temperatures during the glacial periods may attribute to a good balance between temperature decrease due to a climate cooling and its increase induced by sea-level drop. Shallow water temperature calculated by Mg/Ca ratio of valves of *Cytheropteron* ranged between 7 and 14 degrees C in the Tainai section. Relatively higher values (10-15 degrees C) were estimated in the horizons corresponding to glacial and interglacial maximum. Paleo-temperature gradient between shallow and intermediate waters were reconstructed based on our calculated temperatures of Mg/Ca records in the periods of the MIS G19 to G17 and G14 to G13 in the Sea of Japan. The estimated values of intermediate water in the MIS G17 and G13 were within the temperature that *Krithe* can inhabit abundantly in the recent sea around Japan. They are approximately 4-6 degrees C warmer than those at water depths of 150-200 m off the study site today.

Intermediate waters ranged between 0 and 8 degrees C in the Sakai section. Two lower and higher values of intermediate water temperatures were recognized in the horizons corresponding to shallow and deep environments based on ostracode assemblages, respectively. On the other hand, shallow water temperatures shifted more frequently within intervals of 5 degrees C. Thus, difference in shifted patterns of intermediate water temperatures corresponding to glacial and interglacial cycles was appeared between in the Sakai and Tainai sections. Fossil ostracode analysis and sedimentary facies infer that depositional environments in the Sakai section were shallower than those in the Tainai section. This might be caused their distinctions.

Keywords: Sea of Japan, Late Pliocene, Ostracod, Mg/Ca, Paleo-water temperature