論文の内容の要旨

Reassessment of paleotemperature proxies using modern foraminifera based on the specimens derived from controlled laboratory culture and field surveys

（飼育・野外試料に基づく現生有孔虫を用いた古水温代替指標の再検討）

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The knowledge about paleoenvironmental conditions depend on proxy data recording hydrological properties. The analysis of the foraminiferal assemblages, oxygen isotope ratios ($\delta^{18}O$) and Mg/Ca of tests have been well established to quantify the seawater temperature. However, the various proxy studies for foraminifers were based on containing much error and assumptions, which provided a mismatch between actual and reconstructed environments by limitation of calibration sets including temperature calibrated equations and neglecting the variations in foraminiferal seasonal occurrences and calcification depth at regional scale. To reduce the errors which affects more in the region with little available foraminiferal data, fresh modern samples should be investigated in detail.

From the analyses of assemblages of planktic foraminifers in sediment-trap samples collected in the southwestern Bay of Bengal, the seven dominant species were identified as follows; *Globigerinoides ruber*, *Trilobatus sacculifer*, *Globigerinella siphonifera*, *Globigerina bulloides*, *Globigerinita glutinata*, *Neogloboquadrina dutertrei*, and *Globorotalia menardii*. Foraminiferal flux peaks occurred during the

southwest monsoon (SWM) and northeast monsoon (NEM) seasons, following the increased phytoplankton production and food-web development induced by the hydrological seasonality, whereas foraminiferal fluxes were low during spring. The recuring seasonal trend of planktic foraminifers was observed in all three observation periods; thus, this pattern may characterize foraminiferal assemblages in the southwestern bay over an even longer time scale. Despite the clear interannual variation of foraminiferal assemblages and flux patterns, the flux peaks in the NEM or SWM implies that the average assemblage in seafloor sediments may not reflect a seasonal bias. Moreover, the $\delta^{18}O$ and Mg/Ca ratios of *G. ruber*, *N. dutertrei* and *T. sacculifer* in sediment trap samples revealed the apparent calcification depth (ACD). Species-specific ACD; *G. ruber* in the mixed layer, *T. sacculifer* between lower mixed layer and upper thermocline, and *N. dutertrei* in the upper thermocline were indicated. The low light level in the Bay of Bengal constrained the ACD for each species. The difference of $\delta^{18}O$ between surface dwelling *G. ruber* and subsurface dwelling *N. dutertrei* ($\Delta^{18}O_{r\text{-}d}$) may not be appropriate for the proxy of surface stratification in the bay. The flux-weighted $\delta^{18}O$ of each species agreed with the annual mean $\delta^{18}O$ values and the interannual variation in seasonal trends in fluxes and assemblages of planktic foraminifers can be averaged out as predicted from the flux and assemblage results.

Mg/Ca ratios and oxygen isotope ratios ($\delta^{18}O$) in biogenic high-magnesium calcite tests precipitated by reef-dwelling large benthic foraminifers can be used as paleotemperature proxies because they correlated well with the temperature of seawater. The preliminary culture experiments with reef-dwelling large benthic foraminifers, *Calcarina gaudichaudii* and *Amphisorus kudakajimensis* under six temperature conditions (21–30°C) indicated significant correlation of Mg/Ca ratios (*C. gaudichaudii* and *A. kudakajimensis*) and $\delta^{18}O$ (*C. gaudichaudii*) with temperature. The second laboratory cultures for *C. gaudichaudii*, *A. kudakajimensis*,

Neorotalia. calcar, and *Baculogypsina sphaerulata* suggest that similar correlations of Mg/Ca and temperature among the same wall type in cultured species at the optimum temperature even though there is a different relationship between $\delta^{18}O$ and temperature. The Mg/Ca and $\delta^{18}O$ at 31°C for three species deviates from the linear relation with temperature and can be used as temperature proxies between 21°C and 30°C. Although different calcification processes are used in perforate and imperforate LBFs, they have similar ranges of Mg/Ca (133–157 mmol mol^{-1}) and which suggests that the similar controlling mechanism for Mg/Ca is adopted at a similar optimal temperature. The temperature relation of $\delta^{18}O$ is different even among perforate species. There is a $\delta^{18}O$ offset between imperforate and perforate LBFs and temperature estimations differ with a maximum error of 2°C even among perforate species. Species-specific calibrations are necessary for more valuable temperature estimation. The future works require careful assessments of biases between modern and sediment assemblages of planktic foraminifers and applicability of new temperature equations of LBFs for field samples, which leads to better results using only proxies based on sediment foraminiferal specimens.