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N.incompta Mg/Ca-paleothermometry in the Japan Sea and its application to Holocene climate reconstruction

HORIKAWA, Keiji[1*] ; KODAIRA, Tomohiro[1] ; IKEHARA, Ken[2] ; MURAYAMA, Masafumi[3] ; ZHANG, Jing[1]

[1]University of Toyama, [2]AIST, [3]The Center for Advance Marine Core Research, Kochi University

We present new core-top calibration for *Neogloboquadorina incompta* Mg/Ca-paleothermometry in the Japan Sea using 15 core-top surface sediments taken from the southern Japan Sea. Using this new Mg/Ca-paleothermometry, we generate the first high-resolution Mg/Ca-derived SST record for the past 7000 years from the sediment core (YK10-7-PC09) taken from 738 m water depth off Niigata. The age model for core YK10-7-PC09 was based on 8 AMS ^{14}C data of mixed planktic foraminifera, and the conventional ^{14}C ages were converted to the calendar ages using Marin13 and delta R of 0±100 yr. Trace metal/Ca ratio of *N.incompta* was measured by a SF-ICP-MS (Thermo Fisher Element II) and the precision (1sigma) of Mg/Ca ratios of the international $CaCO_3$ standard (BAM-RS3) was 0.786±0.008 (n=100).

We have performed paired analyses of δ^{18}Oc and Mg/Ca ratios of *N. incompta* at 15 sites. First, to calculate the mean temperatures of waters in which the foraminiferal shells were formed (i.e., calcification temperature), we have used modern local salinity and temperature data (http://www.jodc.go.jp/) in the following paleotemperature equation; T (℃) = 21.4-4.19×(δ^{18}Oc-δ^{18}Osw) + 0.05×(δ^{18}Oc-δ^{18}Osw)^2 (Oba, 1980). The δ^{18}Osw was calculated from the following salinity-δ^{18}Osw equation in the Japan Sea (δ^{18}Osw (‰ VSMOW) = 0.27×Salinity-8.98; this study). The comparison of the predicted δ^{18}Oc values with the measured δ^{18}Oc shows that *N. incompta* shells were formed at 0-125 m water depths from June to December in the Japan Sea. Given that previous studies show that *N.incompta* dwells in the shallow waters (<100 m) in November to December (Kuroyanagi and Kawahata., 2004; Sagawa et al., 2013), we calculated the calcification temperatures at each site assuming shells were formed in November to December. The cross plot of the calcification temperatures and the Mg/Ca ratios for our core-top samples gives the following equation; Mg/Ca (mmol/mol) = 0.361×exp (0.043×Temp).

Using this new Mg/Ca-paleothermometry, the 7000-years *N.incompta* Mg/Ca records (0.6 to 0.9 mmol/mol, n=127) from core YK10-7-PC09 were converted to the temperature record. Compared to the present winter SST of ca.15 ℃, the 7000-year SSTs varied from 13.5 ℃ to 20.8 ℃. We identified four periods (ca.6000 yr BP, 4000-3500 yr BP, 3000-2300 yr BP, and 800 yr BP) that were warmer than the present and distinct colder periods at ca.4500 yr BP and ca.1500 yr BP than the present. This SST variability for the past 7000 years was almost consistent with the record of relative abundance of F.doliolus, which is the dominant species in the Tsushima Current (Koizumi et al., 2006). This finding indicates that the Tsushima Current influx might have changed with time and altered the heat transport into the Japan Sea, and probably induced significant changes in terrestrial precipitation and vegetation over the northern part of Japan facing the Japan Sea.

Keywords: Japan Sea, Holocene climate change, Mg/Ca-paleothermometry, Tsushima Current, Neogloboquadorina incompta