TEX_{86} derived temperature record in the Sea of Okhotsk for the past 160,000 years

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The Sea of Okhotsk is characterized by seasonal sea ice (Kimura and Wakatsuchi, 1999), formation of North Pacific Intermediate Water (NPIW) (Talley, 1991; Freeland et al., 1998) and high biological productivity (Honjo, 1997; Honda et al., 1997). Because of the southern boundary region of sea ice and ventilation by NPIW, the Sea of Okhotsk is a region sensitive to climate change. Recent paleoclimatological study based on diatom assemblages and ice rafted debris (IRD) in sediment cores demonstrates that sea-ice extent was enhanced during the glacial period (Shiga and Koizumi, 2000; Sakamoto et al., 2005; Shiga et al., 2001).

The sea surface temperature (SST) in the Sea of Okhotsk provides important information for understanding climate change, especially evaluating the previous sea ice regime in the glacial period. Paleo-SSTs in the Sea of Okhotsk have been previously estimated by alkenone paleothermometry in a sediment core from central and southwestern sites (Seki et al., 2004; Harada et al., 2006). Surprisingly, the alkenone SST records in the both sites showed anomalous warm temperatures during the late glacial period (40-16ka), including the last glacial maximum (LGM). The warm alkenone SSTs during the LGM conflict to the sedimentary records of IRD and diatom assemblage (Shiga and Koizumi, 2000; Sakamoto et al., 2005; Shiga et al., 2001).

In this study, we employed newly developed paleotemperature TEX_{86}, which is based on the number of cyclopentane moieties in the glycerol dialkyl glycerol tetraether (GDGT) lipids of the membranes of marine Crenarchaeota (Schouten et al., 2002) in order to test whether the glacial SST in the Sea of Okhotsk has been extremely warm or not.

Piston core PC07B was collected at the central Sea of Okhotsk in summer 2006. Age models of PC7B are based on correlation of magnetic susceptibility to SPECMAP oxygen isotope record. Total lipids were extracted by ultrasonication and saponification with 0.3 M KOH. The extracts were separated into two fractions by silica gel column chromatography (23-400 mesh). Analysis of GDGT lipids was performed using a HP 1100 series liquid chromatography/mass spectrometry equipped with auto-injector (2.1 x 150 mm, 3 mm; Alltech, Deerfield, IL, USA). Detection was achieved using atmospheric pressure positive ion chemical ionization mass spectrometry (APCI-MS) of the eluent. TEX_{86} indices were converted into growth temperatures using the calibration equations of Schouten et al. (2002).

The TEX_{86} derived temperatures in PC07B ranges from 2 to 8.3 degree C over the last 160 kyrs. Core top TEX_{86} temperature (7 degree C) is slightly (1 degree C) lower than alkenone derived temperature (Seki et al., 2004) and coincides with surface temperature in July and October. In contrast to the previous alkenone SST record (Seki et al., 2004), glacial-interglacial variation pattern of TEX_{86} temperature is very similar to benthic oxygen isotope record of high latitude climate signal with colder during the glacials and warmer during the interglacials. Cold temperatures (2-4 degree C) in the glacial maxima (Marine isotope stage 2 and 6) are consistent with previous interpretation that sea ice has expanded during the glacial period (Shiga and Koizumi, 2000; Sakamoto et al., 2005; Shiga et al., 2001). Our result indicates that TEX_{86} paleothermometry could be applicable to paleotemperature reconstruction in the Sea of Okhotsk during the late Quaternary.