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Oxygen isotopic composition of the Bering Sea bottom water during the Last Glacial Maximum: constraints from pore water

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1.Introduction

North Pacific Intermediate Water (NPIW) is defined as the salinity minimum water at depths of 300-800 m in the North Pacific Ocean. Today, the main origin of NPIW is thought to be Okhotsk intermediate water, which is formed by brine rejection during the sea-ice formation on the continental shelf in the Okhotsk Sea in winter (Yasuda, 1997). Studies of microfossil assemblages such as foraminifera and radiolaria suggest that during the Last Glacial Maximum (LGM) NPIW was derived from the Bering Sea (Ohokushi et al., 2003; Tanaka and Takahashi, 2005). However to date, no quantitative evidence (for example, salinity, temperature, or isotopic composition data for water) directly indicates past changes in NPIW sources.

In this study, we reconstructed the distribution of oxygen isotopic compositions of bottom water between 1008 m and 3173 m water depth at the Bering Sea shelf break and Bowers Ridge during the LGM on the basis of the vertical profiles of oxygen isotopic composition in pore waters from International Ocean Drilling Program (IODP) Sites U1339, U1341, U1343, U1344, and U1345. We expect that the reconstructed distribution of oxygen isotopic compositions is a clue to discuss the past changes in NPIW sources.

2. Method

For oxygen isotopic composition measurements, pore water was analyzed by using a stable isotope ratio mass spectrometer (IRMS) (GV IsoPrime, UK) with an automated CO2-H2O equilibration system. Each analysis was performed on a 200-ml water sample. The results for each sample are averages of duplicate analyses.

3. Model

We used a model approach reported from that of Schrag and DePaolo (1993) and following studies (Schrag et al., 1996; 2002; Paul et al., 2001; Adkins et al., 2002; Malone et al., 2004) estimating the glacial-interglacial change in oxygen isotopic composition (delta value) by fitting the numerically simulated depth profile of pore water oxygen isotopic composition to the observed oxygen isotopic composition peak of pore water at 25-45 meters below the seafloor (mbsf), associated with the last deglaciation.

We modeled the oxygen isotopic composition of pore water profiles above 200 mbsf in 50-cm increments by using the one-dimensional diffusion/advection tracer equation. The absolute magnitude of changes in the oxygen isotopic composition of bottom water to input into the model is set as a function of the spliced the benthic foraminiferal oxygen isotopic composition records fixed relative to the magnitude of the oxygen isotopic composition since the LGM.

4. Results

The pore water profiles from all sites showed the expected pattern of isotopic peak left from the LGM bottom water. The oxygen isotopic compositions increased over the first 25-50 m below sea floor (mbsf), followed by a decrease. The oxygen isotopic compositions deeper than 150 mbsf from the Sites U1343 and U1344 increased with increasing depth. The increase of the oxygen isotopic compositions deeper than 150 mbsf may reflect the interaction with clay mineral or advection of fluid from deeper sedimentary column.

Our fit to the data yields the delta values of 0.9-1.0 per mil at Site 1139 (water depth: 1868 m), 1.2-1.3 per mil at Site U1341 (water depth: 2140 m), 0.6-0.7 per mil at Site U1343 (water depth: 1953 m), 0.7-0.8 per mil at Site U1344 (3177 m), and 0.6-0.7 at Site U1345 (water depth: 1008). The globally averaged delta value due to ice volume change since the LGM was estimated as 1.0-1.2 per mil (e.g. Schrag et al., 1996; 2002; Clark and Mix, 2002). The small delta value in the Sites U1343, U1344, and U1345 from the Bering shelf break compared to the globally averaged delta value would reflect the locally decreased oxygen isotopic composition probably due to the low salinity bottom water at the shelf break during the LGM. Thus our result highly suggests that low salinity water sank into deeper depth at the shelf break during the LGM in the Bering Sea.

Keywords: Bering Sea, Last Glacial Maximum, NPIW, oxygen isotopic composition, pore water