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Isotope analysis of ng-sized Nd samples: toward the isotopic analysis of foraminifera extracted from deep-sea sediments

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Modern seawater has heterogeneous Nd isotopic compositions. The source rocks of Nd in the ocean, continental rocks and igneous rocks derived from the mantle, show wide range of variation in their radiogenic $^{143}Nd/^{144}Nd$ ratios (˜5 permil). The short residence time of Nd in the ocean (300-500 yr: Tachikawa et al., 2003; Amakawa et al., 20004; Arouze et al., 2009) compared with the ocean mixing timescale of 1500 yr (Broecker and Peng, 1982) prevents the homogenization of seawater Nd isotopic compositions. The Nd isotopic variation of the seawater has been used to distinguish different water masses, to trace the ocean circulation and to estimate the flow rate and contribution of Nd from various sources (ca. Piepgras and Wassurburg, 1980; Amakawa et al., 2013).

Calcareous shells of foraminifera are now drawing attention as a proxy of seawater Nd in the past, which can be used to trace the changes of the oceanic Nd isotopic composition related with paleoclimate changes (Tachikawa et al., 2014). One of the difficulties in analyzing Nd isotopic composition of foraminifera comes from the low Nd concentration of the foraminiferal shells. The low Nd concentration (up to several ppm) of foraminiferal shells requires quite large sample sizes (several mg) to meet the minimum sample size required for Nd isotope analysis (Nd amount of 2-5 ng). Lowering the sample size limits for Nd isotope analysis may expand the applicability of the technique to foraminifera-poor sediments derived from oceanic drilling sites.

We have developed a new technique to measure isotope ratios of ng to sub-ng sized Nd samples using total evaporation normalization method (Wakaki et al., 2007) together with the low-blank Nd separation chemistry. Isotope ratios of Nd are measured using thermal ionization mass spectrometer (Thermo TRITON) at Kochi Core Center.

The $^{143}Nd/^{144}Nd$ values of the isotopic reference reagent JNdi-1, measured at sample sizes of 0.5, 1 and 2 ng of Nd, all agreed with the values obtained by large sample measurement (100 ng of Nd) within statistical errors. The reproducibility of 143Nd/144Nd values are 100 ppm (n = 8), 60 ppm (n = 9) and 40 (n = 8) ppm for 0.5, 1 and 2 ng measurements, respectively. The precision and accuracy of the sample analysis, including chemical procedure, is checked by analyses of two GSJ reference rocks, JB-2 (basalt) and JCp-1 (coral). The basalt sample was decomposed by mixed HF-HNO3-HClO4, and the coral sample was decomposed by HNO3. Sample aliquots, containing 0.5 and 1.2 ng of Nd, respectively, were processed by using the low-blank Nd separation chemistry. The measured 143Nd/144Nd ratios of JB-2 (n = 9) and JCp-1 (n = 8) samples all agreed with the values obtained by measurements with large sample sizes within statistical errors. These results demonstrate that our technique gives reliable results even for samples as small as 0.5 ng of Nd. Preliminary results of subsurface-dwelling planktonic foraminifera samples, Globorotalia tumida, collected from a Quaternary sediment core from the West Caroline Basin (western equatorial Pacific Ocean) will be presented.

Keywords: paleoclimate, Nd isotopes, foraminifera