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SEM37-05 Room:413 Time:April 30 10:00-10:15

Rock magnetic study of the North Atlantic sediment during late Pliocene and early Pleistocene

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As the ocean is a major component in the climatic system, it is crucial for palaeoclimatic study to understand the past evolution of the thermohaline circulation. The North Atlantic Ocean is one of the most important sea areas because newly formed deep water mass is redistributed to the global ocean from there (Broecker et al., 1991). In order to recover the past change in deep ocean circulation at the North Atlantic Ocean, a variety of proxies have been studied. However, the change during Pleistocene and Pliocene is still poorly understood.

In this study we conducted rock magnetic measurement of deep-sea sediments recovered from IODP Site U1314 on the Gardar Drift, to investigate the past change in bottom current flows at the North Atlantic Ocean. Since a coercivity of magnetic mineral varies sensitively with its state such as chemical composition, grain size, grain shape, stress, and so on, coercivity spectra can be used as a proxy for the constituent spectra of the sediment.

The samples were collected at 16 - 50 cm resolution from 199.3 to 262.5 mcd of the core, which corresponds to the age between 2.22 and 2.75 Ma according to the age model by Hayashi et al. (2010). Rock magnetic properties were measured for these samples using a MicroMag 2900 Alternating Gradient Magnetometer. The isothermal remanent magnetization (IRM) acquisition curve was obtained by the application of stepwise-increasing uniaxial fields to the sample at 30 steps from 1 mT to 1 T. The ratio of IRM acquired in a back-field of 0.1 T to that in a forward-field of 1 T (S-ratio) was also measured for all samples.

In order to reveal constituents of the sediment, decomposition of coercivity spectra were conducted. The IRM acquisition curve was normalized by the IRM intensity at 1 T and then the first derivative of the curve was calculated with respect to log10 field (hereafter referred to as IRM gradient curve). The least square fit was performed so as to decompose the IRM gradient curve into linear combination of two end-members. Two end-member components were calculated by averaging the IRM gradient curves of selected samples. Samples with low S-ratio (<0.57) and younger than 2.4 Ma were chosen for component 1. Samples with high S-ratio (>0.88) and during MIS100, which were associated with the ice rafted debris, were chosen for component 2. These components were distinctly different from each other; coercivity distribution of component 1 was magnetically harder than that of component 2.

In consequence of the decomposition, the fitting error was significantly small for all samples, indicating that North Atlantic sediments in the Garder Drift during late Pliocene and early Pleistocene are explained by mixing of two end-member components. The fraction of two components periodically changes with time and agrees well with the LR04 $\delta^{18}O_{benthic}$ stack (Lisiecki and Raymo, 2005): the high-coercivity component dominated during interglacial periods, and the low-coercivity component dominated during glacial periods.

On the basis of the elemental ratio of potassium to titanium (K/Ti), Grutzner and Higgins (2010) reported change in proportion of sources of sediment at Site U1314 during the last 1.1 Ma. They demonstrated that Ti-rich basaltic material transported by the Iceland-Scotland Overflow Water and K-rich particle (continental rock like) derived from the other source dominated during interglacial periods and glacial periods, respectively. Our result is consistent with their result because high-coercivity and low-coercivity components are interpreted as the fine-grain titanomagnetite of Icelandic sources and the coarse-grain magnetic mineral of continental sources, respectively. Therefore the change in fraction of two end-member components represents change in fraction of bottom currents, and the bottom current flow patterns similar to those during the last 1.1 Ma might prevail at the North Atlantic Ocean during late Pliocene and early Pleistocene.

Keywords: North Atlantic Ocean, Deep-sea Sediment, IRM acquisition curve, Bottom current flow