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Intensity variation in ocean circulation with iceberg surges after intensification of Northern Hemisphere glaciation

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Ice sheets linked with ocean circulation play an important role in global climate change. Here we show millennial-scale rock magnetic records together with ice rafted debris (IRD) counts indicating links between ice sheet collapse and ocean circulation after the intensification of Northern Hemisphere glaciation (NHG). We report an abrupt variation in the activity of water circulation associated with an IRD event in Marine Isotope Stage (MIS) 104 weakened to a similar degree to that occurred in MIS 100, the first pronounced glacial period in which widespread glaciation occurred in the northern hemisphere at the intensification of NHG.

We analyzed a sediment core IODP Site U1314 in the Gardar Drift in the North Atlantic. In this study, we analyzed sediments from 239.5 to 245.5 mcd (m composite depth) at 2 cm resolution, which corresponds to the age between 2.58 and 2.62 Ma according to the age model by Hayashi et al. (2010). This interval includes MIS 104, which is a prior glacial interval to MIS 100. We compare the result in MIS 104 to that in MIS 100 in the preceding study (Ohno et al., 2014, JpGU).

We sieved 0.5 g sediments and counted IRDs larger than 150 μm. As a result, two IRD events were confirmed at about 2.602 Ma and 2.610 Ma. Magnetic hysteresis parameters, S-ratio (Mr_{-100mT}/Mr_{1T}) and IRM (isothermal remanent magnetization) acquisition experiments were done by using an Alternating Gradient Magnetometer (MicroMag 2900, Princeton Measurement Corporation).

Rock magnetic records showed 2 types of variation: a long-term variation with glacial-interglacial cycle and a short-term variation associated with an IRD event. The IRM acquisition curves in all samples were well explained by a mixture of two components (of high and low magnetic coercivity, respectively). The variation in the proportion of two components are interpreted as variation in the content of basaltic sediments transported by North Atlantic Deep Water. Therefore, the variation in the proportion of two components indicates the variation in the intensity of deep water circulation. Increase in the component of high magnetic coercivity indicates active deep water circulation at interglacial period. In contrast, increase of the component of low magnetic coercivity indicates inactive circulation at glacial period.

In addition to the long-term variation in IRM acquisition curve during 2.58-2.61 Ma (for thirty thousand years), short-term variation associated with an IRD event occurred at 2.602 Ma and 2.610 Ma. The component of high magnetic coercivity in IRM acquisition curve decreased by 68% (from 73% to 5%) within about a thousand years at 2.602 Ma. Succeedingly, it increased to the same proportion as before the event within a time interval of 10 thousand years. In addition, another short-term variation occurred without IRD event at Gauss-Matsuyama geomagnetic polarity transition.

In our previous study in MIS 100, we reported repetition of sudden decrease and gradual increase in component of high magnetic coercivity associated with IRD events. It is well known that the continental ice sheets grew much larger in MIS 100 compared to in MIS 104. However, our study suggests that the comparable level of decrease in deep water circulation occurred at not only in MIS 100 but also in MIS 104.

Keywords: ice rafted debris, rock magnetism, ice sheet collapse, deep water circulation, North Atlantic Deep Water