North-south oscillation of surface frontal system and climate change in the Southern Ocean : Latitudinal transect of marine cores

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1. Introduction

The Southern Ocean plays a very important role in the global climate system on a present and geologic past Earth. The Southern Ocean has also become a region of paleoceanographic focus because of the key role it plays in global deep-water circulation and its potential significance for the global carbon. For example, it has been proposed that new production was higher and utilization of preformed nutrients in surface waters was more efficient in the glacial Southern Ocean than today, effectively lowering the glacial atmospheric CO_2 concentration. To resolve causes and processes of a CO_2 change, it is important to understand a mechanisms and processes of sub-systems in the Antarctic Cryosphere such as a change of biological productivity, sea surface temperature, surface water frontal system, sea-ice distribution, and East Antarctic ice sheet during the glacial-interglacial climate cycle.

2. Sample and methods

Surface sediments were collected from a latitudinal transect (from 47.5 deg. S to 65.5 deg. S) in the Australian sector of the Southern Ocean during the two cruises KH94-4 and KH01-3 by R/V Hakuho-Maru. In addition, we used two piston cores (SIR-1PC and AMR-2PC). Core site of SIR-1PC is located just under the modern Antarctic Polar Front (APF). We analyzed for these sediments by the X-ray CT scan, ice-rafted debris (IRD) counts, grain size analysis, organic carbon contents, and biomarkers.

3. Latitudinal distribution of paleoceanographic proxies

The amount of dropstones and IRD preserved in the latitudinal surface sediments were decreased toward the northern sites, and apparent northern edge of the observed IRD was located at 60 deg. S. These results indicate that the modern iceberg reaches up to about 60 deg. S in the Australian sector of the Southern Ocean. Grain size distributions of non-biogenic particles in the surface sediments near Antarctica are clearly larger than those of pelagic sites at about 60 deg. S. These results suggest that the ice-rafting process and gravity flow from the Antarctic ice sheet contributes largely to the deposition of the Wilkes Land margin sediments.

Concentration of carbonate in the surface sediments were enhanced in the north of the modern APF, whereas these are extremely low in the south of APF. Alkenone concentrations also show a similar distribution pattern in the Southern Ocean. Therefore, the production of carbonate-test plankton is remarkably limited in the south of the APF, whereas the biological productions are mainly composed of silicate-test plankton in the area.

4. North-south oscillation of surface frontal system in the Southern Ocean

At the SIR-1PC site, carbonate % was increased in the interglacials and decreased in the glacials. Variation pattern of carbonate % shows a change of typical saw-tooth pattern, and extremely corresponds to the air temperature change in the Vostok ice core (e.g., Jouzel et al., 1996). These results indicate that the surface water system and deep water chemistry in the Southern Ocean have closely interacted with climate changes on the Antarctica. According to the analytical results of latitudinal transect of surface sediments, carbonate sediments are enhanced in the north of the modern APF, whereas these are extremely low in the south of APF. Therefore, a saw-tooth variation of carbonate contents in SIR-1PC may be caused by the north-south migration of the APF during the glacial to interglacial climate changes. If so, it is thought that the position of the APF was repeatedly changed with the air temperature variation on the Antarctica.