The linkage between the East Antarctic Ice Sheet fluctuations and global climate changes during the Plio-Pleistocene

Masako Yamane[1, 2] and Yusuke Yokoyama[1, 2]
[1] *Atmosphere and Ocean Research Institute, University of Tokyo*
[2] *Graduate School of Science, University of Tokyo*

Global climate has become progressively cooler with glacial-interglacial cycles becoming evident since the late Cenozoic. This cooling trend has markedly increased after the development of Northern Hemisphere ice sheets (NHIS) approximately 2.7 Ma. This suggests a link between global climate cooling and the development of polar ice sheets. However, a detailed picture of East Antarctic ice sheet (EAIS) fluctuation has yet to appear. Ice-free areas of Antarctica can elucidate past ice sheet fluctuations directly. The aim of this study is to reconstruct EAIS fluctuation during the last 5 Myr using exposure ages in various parts of East Antarctica, and to discuss the relationship between ice sheet fluctuations and global climate changes.

The concentration of *in situ* produced cosmogenic radionuclides (CRN; *e.g.* ^{10}Be, ^{14}C, ^{26}Al, ^{36}Cl) in quartz reflects the cumulative exposure time of the rock. Also, the ratios (*e.g.* $^{26}Al/^{10}Be$ ratio) of two cosmogenic nuclides indicate the nature of the exposure history (simple or complex). In addition, ice sheet basal conditions may be indirectly inferred from exposure history. In the case of warm-based ice sheets, with ice sheet basal temperature above the pressure melting point, the bedrock surface is subject to continuous erosion and exhibits a simple exposure history. In contrast, cold-based ice sheet cannot erode bedrock sufficiently enough to reset the exposure age “clock”. Rocks overridden by this type of ice sheet show complex exposure history, and hence nuclides being contained in the rocks hold previous exposure “memory”. The inheritance of the nuclides described above result in deviation of nuclides content from that predicted by both half-life and present day production rates. Therefore, the ratios of more than two cosmogenic nuclides give us knowledge of ice sheet basal conditions.

The ice-free areas of various parts of East Antarctica have been investigated using this method for the last 5 Myr. First, we reviewed reported exposure ages from six areas in East Antarctica (Coats Land, Droning Maud Land, Mac Robertson Land, Princess Elizabeth Land, Victoria Land and Transantarctic Mountains) and then added newly obtained ^{10}Be and ^{26}Al data for samples collected from Sør-Rondane Mountains, Droning Maud Land. Some of the reported ages applied only standard atmospheric thickness in their age calculations, and therefore we revised them using Stone (2000)’s scaling factor. These ages indicate that the EAIS was thicker by at least 600 m than present, at least once before 3 Ma. The EAIS had then become 500 m thinner from 3 to 1 Ma. Waxing and waning of EAIS has repeatedly occurred with glacial-interglacial cycles during the Pleistocene epoch.

From the compilation of the exposure ages, we determined that the EAIS was a large-scale and unstable ice sheet until 3 Ma, after which it became a stable, small-scale ice sheet coinciding with enhanced global climate cooling. Therefore it is suggested that the transition from a large to small scale ice sheet was due to weaker hydrological cycles after 3 Ma caused by a colder climate that reduced inland moisture transport to Antarctica. The relatively stabilized EAIS was very sensitive to changes in sea level. That is to say, EAIS changes were dictated by NHIS and synchronicity was created via sea-level changes. Overall, close examination of the timing of waxing and waning of the EAIS indicates that ice sheet behavior was strongly related to global climate conditions.

References

Stone, J.O., Air pressure and cosmogenic isotope production, Journal of Geophysical Research, 105, 23753-23759, 2000.