Millennial-scale variations in Asian winter monsoon and westerly deduced from eolian dust grain size and ESR signal intensity

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Atmospheric circulation in East Asia is characterized with Asian monsoon and westerly. Recently, it is demonstrated that Asian summer monsoon intensity oscillated in association with Dansgaard Oeschger Cycles (e.g., Tada et al., 1999 ; Wang et al., 2001). On the other hand, clear evidence for Asian winter monsoon and westerly variations associated with DOC has not been demonstrated. In order to explore temporal and spatial variations of atmospheric circulation in East Asia, we attempted to reconstruct detailed behavior of Asian winter monsoon and westerly by utilizing eolian dust contained within the sediments of the Japan Sea.

Hemipelagic sediments of the Japan Sea contain significant amount of eolian dust derived from dry areas in inland Asia. The grain size of eolian dust is mainly controlled by the intensity of the transport wind and distance from the source area. There are two possible sources and paths of eolian dust transport to the Japan Sea. One is from the northeast China by means of Asian winter monsoon and the other is from the central China by means of the westerly. Namely, the eolian grain size in the Japan Sea sediments is controlled either by the Asian winter monsoon or by westerly.

To obtain the information on temporal and spatial variations of Asian winter monsoon and westerly, we reconstructed the grain size of eolian dust within the sediment cores recovered from northern (KT94-15-PC5; 150 km west of Akita) and southern (IMAGES MD01-2407; 200 km north of Tottori) parts of the Japan Sea based on grain size distribution measurement of detrital component and peak split analysis of the distribution. The results revealed millennial-scale variability of eolian dust grain sizes in association with the DOC with larger sizes during glacial stadials, and smaller sizes during glacial interstadials at both sites. In addition to these grain size oscillations, grain size difference between the two sites also changes in association with the DOC. Eolian grain size of the northern site is larger than that of the southern site during glacial stadials including Heinrich Events, and vice versa during glacial interstadials. This result may imply switching between two different dust source areas and/or transport wind systems corresponding to the each mode of the DOC.

In order to clarify this point, we investigate source areas of eolian dust based on Electron Spin Resonance (ESR). Since ESR signals of quartz derived from northeast Asian source rocks show higher intensities because of dominantly Pre-Cambrian age of the source rocks, and that of central Asian source rocks show lower ESR intensities because of dominantly Paleozoic-Mesozoic age of the source rocks, the ESR intensity of eolian quartz gives us the information on the source area and transport path of the eolian dust (Naruse et al., 1996, 1997). Based on this idea, we conducted the measurement of ESR intensity on detrital quartz grains in the sediment cores MD01-2407 and PC5 to specify the sources of the eolian dust and its transport paths. The measured ESR signal intensities show lower values for samples from interglacial and glacial interstadial intervals, whereas higher values are observed for samples from the intervals corresponding to glacial maximum and glacial stadials. This result suggests that eolian dust were supplied from central Asia through wesrerly during interglacial and glacial interstadial periods, whereas it was supplied from northeast Asia through winter monsoon during glacial maximum and glacial stadial periods. Because winter monsoon may convey larger eolian dust to the northern site than southern site, reconstructed changes in north to south difference of eolian grain size consistent with this suggestion. Hence we propose that glacial-interglacial and millennial-scale variability of eolian grain size and its north to south difference reflect switches in dust-transport wind system between the westerly and the winter monsoon.