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Single particle analysis of dust in the Greenland NEEM ice core for identification of its geographic origin during the Last Glacial Maximum

SEOKHYUN RO[1,2], MR. HANJIN YOO[3], YOOJIN LEE[3], CHANGHEE HAN[2], AHHYUNG LEE[2], YEONGCHEOL HAN[1], CHUL-UN RO[3] AND SUNGMIN HONG[2]

[1]Korea Polar Research Institute

[2]Inha University, Department of Ocean Sciences

[3]Inha University, Department of Chemistry

Presenting Author: rsh@inha.edu

Dust fluxes in Greenland ice exhibit pronounced glacial/interglacial variations with an approximately 20-fold increase during the Last Glacial Maximum (LGM) relative to the Holocene. As understanding and knowledge of dust provenance is of fundamental importance to improve climate model simulations of past atmospheric circulation patterns, many studies have been conducted on isotopic and geochemical properties to identify dust sources of Greenland LGM dust. They pointed to East Asian deserts, the Sahara, and loess deposits in Europe as the main potential source areas (PSAs) for Greenland LGM dust. Despite previous studies, a millennial-scale variability of dust provenance across the LGM is poorly known, mainly due to the low temporal resolution of Greenland ice core analysis with discrete samples. To gain useful insights into the temporal variation of Greenland LGM dust provenance, we investigated the morphological and geochemical characteristics of insoluble microparticles in seven discrete ice samples from the Greenland NEEM deep ice core, covering cold Greenland Stadials (GS)–2.1a to GS–3 (~16.0 to 25.4 kyr ago) in the LGM. It is based on the analysis of single particles using scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM/EDX). The individual dust particles in two selective samples were further examined by Raman micro-spectrometry (RMS) to characterize the mineralogy and carbon contents of the particles. The results of the SEM/EDX analysis suggest that the Gobi Desert and/or European loess were the dominant dust source(s) for Greenland LGM dust during GS–3, while the Sahara was the primary source during GS–2.1. The RMS analysis showed the distinct difference in the abundances of carbon-containing particles between GS–2.1and GS–3, further supporting the systematic change in dust provenance between periods. Our findings may reflect a millennial-scale variability in the mid to high-latitude northern atmospheric circulation during the LGM.