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Single-particle characterization of insoluble particles in an ice core by the combined use of SEM/EDX and Raman microspectrometry

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Ice cores preserve valuable information on past changes in atmospheric conditions involving variability in airborne mineral dust, which plays a critical role in regulating Earth's climate system by affecting the radiative balance through absorption and scattering of both solar and infrared radiations, particularly in polar regions due to its polar-amplification effect. However, the uncertainties in radiative effects of dust in past climate conditions stem partly from ignorance of mineral dust composition. In this study, we performed a single-particle analysis of insoluble microparticles in two discrete samples, corresponding to Bølling/Allerød (B/A) period and the Last Glacial Maximum (LGM), from the Greenland NEEM ice core. Only very small amounts of samples (15–30 μL) were applied for the analysis, which is a great advantage in the ice core research field. The single-particle analysis performed by scanning electron microscopy coupled with energy dispersive X-ray spectrometry (SEM/EDX) and Raman microspectrometry (RMS) can provide detailed information on the morphology, size, elemental composition, and molecular species of individual microparticles. Our results highlight that chemical species of mineral dust in both samples mainly include quartz, plagioclase (Na-, K-, and Ca-feldspars), illite/smectite, muscovite, montmorillonite, and kaolinite with a dominant size distribution of 1–2 μm (> 85%). The prominent difference is the relative abundances in quartz (25% and 20.5% for the B/A sample and the LGM sample, respectively), illite/smectite (48.5% and 44.5%), k-feldspar (1% and 4%), and high-intensity particles (> 40%) in carbon (24% and 26.5%). It might be attributed to variability in Greenland dust sources and the associated atmospheric residence time of each mineral between the periods of interest. Further study is required to understand the mechanisms linked with the climate-related changes in the variance in particle mineralogy and dust provenances between the B/A and LGM samples.