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Raman spectroscopy, an innovative tool to explore the mineralogy and provenance of dust (1-5 μm): Dome B ice core, East Antarctica

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The polar ice sheets are invaluable archives preserving information about past climate changes and atmosphere composition. Deep ice cores from Greenland and Antarctica provide records of several climate-dependent proxies allowing climate reconstructions at different time scales, among which greenhouse gases, atmospheric aerosol and aeolian dust. In this project, the mineralogy of dust preserved in the Dome B (77°05'S, 94°55'E, 3650 m a.s.l.) ice core was investigated using Raman spectroscopy. The thermal drilled ice core, made during the 1987-1988 Austral season by the 33rd Soviet Antarctic Expedition, covers the last 30 kyr. The record thus encompasses the last glacial period, the Last Glacial Maximum (LGM), the deglaciation and the beginning of the Holocene. Four Dome B ice core samples from the LGM were selected, and the mineralogical fingerprint of dust particles was investigated. Dust in central Antarctic ice cores is clay to finest silt, the volume-size distribution of particles showing modal values around 2-2.6 μm at the Dome B site. Detrital minerals of such a fine grain-size range are exceedingly difficult to determine one by one, a task that to the best of our knowledge has never been accomplished so far. In order to meet this challenge, we have developed a new protocol for the preparation and analysis of particles between 1 and 5 μm in diameter, in a clean room at the EuroCold Lab and at the Laboratory for Provenance Studies of Milano-Bicocca University. Three slides were prepared for each sample, and 962 particles were studied overall. In total, 41 different minerals were recognized, including species derived from granitoid, metamorphic or siliciclastic rocks (e.g., quartz, feldspars and phyllosilicates), from volcanic source rocks (e.g., sanidine, anorthite, pyroxenes, zeolites) associated with biogenic marine aragonite and iron oxides probably derived from erosion of soil profiles. Our observations indicate southern South America as the most likely dominant dust source for Dome B during the LGM. Abundant carbonates found in samples DB620 and DB631 highlights the role of the exposed Argentine continental shelf as a significant additional dust source during the sea-level low-stand period of Marine Isotopic Stage 2. This study demonstrates that dust minerals as small as 1-5 μm can be identified with single-grain method by Raman Spectroscopy, opening up a new frontier in provenance studies of silt-sized sediments down to the size limit of clay.