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Unveiling the provenance of dust in the EPICA Dronning Maud Land Ice Core (Antarctica) throughout the Last Deglaciation (7–27 kyr BP): A Quantitative Record Using a Novel Rare Earth Element Mixing Model

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Antarctic ice cores have provided valuable insights into the intricate interplay between dust and climate dynamics in the Southern Hemisphere. However, until now, a continuous and quantitative record detailing the origin of dust during the last deglaciation is lacking. In this study, we utilized a novel database comprising 207 Rare Earth Element (REE) patterns obtained from dust and fine sediment/soil fractions collected from well-known potential source areas (PSA) in the Southern Hemisphere. By combining this comprehensive dataset of REE patterns, we developed a robust statistical model to best match the REE patterns measured in the Epica Dronning Maud Land (EDML) ice core in East Antarctica. Among the 398 samples analyzed in the EDML core, 386 have been un-mixed with statistical significance. When coupled with data on total atmospheric deposition, our findings enable the first quantification of the dust flux from the various PSA reaching the EDML region between 7,000 and 27,000 years before present (kyr BP). Our results unveil that, despite a substantial decrease in atmospheric deposition at the onset of deglaciation around 18,000 years ago, the dust composition remained relatively uniform throughout the Last Glacial Maximum (LGM, 18-27 kyr BP) and Heinrich Stadial 1 (HS1, between 14.7-18 kyr BP). During this period, approximately 68% of the total dust deposition was coming from Patagonian sources, with the remaining contributions originating from Australia (14-15%), Southern Africa (~9%), New Zealand (~3-4%), and Puna-Altiplano (~2-3%). A significant shift in dust provenance occurred around 14.5 kyr BP, marked by a drop in Patagonian contribution to below 50%, while low-latitude PSAs increased their contributions, accounting for 21-23% from Southern Africa, 13-21% from Australia, and ~4-10% from Puna-Altiplano. We propose that this shift is linked to enduring alterations in the hydrology of Patagonian rivers, including Atlantic-Pacific drainage reversals and the decline of braided planform, along with the sudden submersion of the Patagonian shelf.

Indeed, between 15 and 14.0 kyr BP, the PAT shelf surface area was halved and by □13 kyr BP, it had shrunk by 70% from to its former maximum glacial expansion, with most of the PAT shelf south of 40°S submerged. The drastic reduction of the area subjected to aeolian deflation coupled with the reduction of fine sediment supply of eastern plains in PAT induced an overall decline in dust emission from Patagonian sources. Our finding emphasizes an important feedback between dust composition in Southern Hemisphere and eustatic sea level during the Last Glacial-Interglacial Transition. The early Holocene dust composition reveals heightened variability, with a prevalent contribution from Patagonia at ~50%. Post 11.5 kyr BP, as Puna-Altiplano experienced persistent aridity, our records demonstrate a noticeable increase in dust contribution. Leveraging a comprehensive coverage of both local and distal PSA, our statistical model, based on REE patterns, provides a straightforward and cost-effective method for tracing dust sources in ice cores.