Isotopic characterization of winter time aeolian dust over Cape Verde

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Radiogenic isotope tracers are robust tools for tracking dust provenance and atmospheric transport pathways. Recent studies of African sources have shown spatial isotopic heterogeneity locally and on short time scales. High-temporal-resolution isotopic time series are thus essential for resolving seasonal changes in dust provenance. Here, we report Sr, Nd and Pb isotopic compositions of aeolian dust collected during a campaign in late winter (1-20 February 2012) on the island of São Vicente at the Cape Verde Atmospheric Observatory (16.9°N, 24.9°W).

Total suspended particulate (TSP) and PM10 (particulate matter less than 10 μm aerodynamic diameter) were collected on acid-cleaned cellulose filters on a daily basis (~24 hrs). During the dust storm event, from 6-8 February 2012, samples were collected at shorter time intervals (every 5-8 hrs). About 1-20 cm^2 of filter was leached with ultrapure MilliQ water to remove sea-salt Sr and subsequently leached with 0.5 N HBr to extract the anthropogenic Pb and soluble particulate fraction. The remaining silicate fraction was fully dissolved using $HF\text{-}HNO_3$ acids. Isotopic measurements were obtained on all fractions by TIMS; Pb isotope ratios were corrected for instrumental mass bias using a triple spike.

The silicate fractions show consistently more radiogenic Pb and Sr compared to those of the leachates, while Nd isotopic compositions are nearly uniform in both fractions. A shift towards higher Pb isotope ratios is observed during the dust event, followed by a continual decrease. By comparison, Sr and Nd isotopes record small changes, with a noticeable excursion to low values after the dust event. Lead and Nd isotopic compositions of TSP and PM10 are similar during dusty days, in contrast to less-dusty days, suggesting that grain-size fractionation depends on dust loading. The radiogenic isotope time-series of winter dust at Cape Verde pinpoints Northwest Africa as a persistent source of dust, while an additional emission source, with more radiogenic Pb, was active during the dust storm event. These inferences are entirely consistent with analysis of air-mass back-trajectories.

The ocean's biological pump in deep time

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The importance of biotic processes in the functioning of the Earth system is perhaps nowhere better demonstrated than by the vertical chemical stratification of the ocean. In the face of physical forces of homogenization, life transforms the ocean into a chemically heterogeneous environment, depleted of nutrients, and through fractionation, ^{12}C in surface waters and enriched at depth. This biological pumping of nutrients to depth occurs with the sinking of organic matter and its remineralization in the deep ocean. The "health" of the ocean's biota has been inferred from reconstructed gradients in $\delta^{13}C$, with strong gradients implying a strong biological pump and loss of the gradient, e.g., during the Cretaceous-Paleogene extinction event implying collapse. However, today, the magnitude of the surface-to-deep gradient is inversely related to the rate of export of organic matter to the deep on a regional basis. Rather, it is the efficiency of the biological pump, the ability of organisms to extract nutrients from upwelling waters before those waters mix physically with waters at depth, that is reflected in the gradients, and the most efficient removal occurs in the oligotrophic gyres. The biological pump appears as a robust feature of ocean ecosystems over geologic time, as evidenced through detailed investigations of the carbon isotope gradients inferred from carbonate rocks deposited during the Paleoproterozoic, end Permian, and throughout the Cenozoic.

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