Composition of Saharan dust and its possible source regions – a review

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The Sahara is the strongest source on earth for mineral dust, supplying up to 10^9 t per year of material to the atmosphere (about 50 % of the total mineral dust burden). Saharan dust is subject to long-range transport and may be transported over thousands of kilometers (e.g., across the Atlantic Ocean). The exact consequences of Saharan dust input into the atmosphere are still a matter of debate (Heintzenberg, 2009), but it is generally accepted, that the introduction of mineral matter into the atmosphere has large impacts on the global radiation balance (direct and indirect forcing), thus influencing the climate system from a global to a local scale. Furthermore, the uplift, transport and settling of Saharan and Sahelian dust significantly changes the terrestrial and oceanic systems in the regions of dust entrainment and settling. Hence, a better knowledge of the potential source areas in the northern part of Africa may lead to an improvement of (paleo)climate models. We have compiled the available bulk analysis data (mineralogy, elemental and isotope composition) of Saharan and Sahelian aerosols and soils in order to distinguish source regions with specific compositional characteristics.

Region 1: Atlas region

The bulk mineralogical data of dusts that originated in the Atlas region clearly shows a general high amount of carbonates (with calcite > dolomite) in good agreement with the geology and the outcropping soils. Dusts from the Atlas region are also characterized by the highest illite/kaolinite ratios in northern Africa (> 2.0). Furthermore, palygorskite has been detected in many soil samples in this area and may be also present as an additional marker in the uplifted dust. The high carbonate content and the low content of Fe-bearing minerals (hematite, goethite) of the potential source sediments leads to very low Fe/Ca ratios in the dust. Based on the available isotopic data (Grousset *et al.*, 2005), a further sub-division into a northern Atlas source region with lower $^{87}Sr/^{86}Sr$ ratios (< 0.725) and higher $\varepsilon_{Nd}(0)$ values (> -15) and a southern Atlas source region with relatively high $^{87}Sr/^{86}Sr$ ratios (> 0.725) and low $\varepsilon_{Nd}(0)$ values (< -15) is possible.

Region 2: Libya, Egypt

Compared to the Atlas region, dusts that originated in Libya or Egypt are characterized by a lower but still significant carbonate content and a scarcity of palygorskite. Illite/kaolinite ratios show a general decrease from west to east and hence are relatively low in NE Africa (< 1.0). $\varepsilon_{Nd}(0)$ values of potential source sediments in Libya and Egypt are of the same order as the $\varepsilon_{Nd}(0)$ values of source sediments from the northern Atlas source region, but show increasing values from western Libya (< -15) towards Egypt (> -11). More diagnostic are the low $^{87}Sr/^{86}Sr$ ratios (< 0.720) that are characteristic for source sediments from Tunisia, Egypt and Libya.

Region 3: Sahelian region (Chad, Niger, central Mali, Mauritania)

The most characteristic criteria for the Sahelian (or Sub-Saharan) region are the general absence of carbonates and palygorskite in the analyzed soil and dust samples and the very low illite/kaolinite ratios of < 0.5. Again, on the basis of the isotope data this very large potential source region can be sub-divided into an eastern sector with lower $^{87}Sr/^{86}Sr$ ratios (< 0.720) and higher $\varepsilon_{Nd}(0)$ values (around -12) and a western area with higher $^{87}Sr/^{86}Sr$ ratios and lower $\varepsilon_{Nd}(0)$ values (around -15).

Region 4: southern Algeria, northern Mali

This area is located in an intermediate position between the Sahelian and Atlas region. Dust and soil samples from this area exhibit relatively low illite/kaolinite ratios (c. 0.5), clearly discriminating it from samples from the Atlas region. Calcite contents are variable, probably depending on the exact location of dust entrainment. Palygorskite is generally rare. Isotope data is scarce, but $^{87}Sr/^{86}Sr$ ratios are probably higher than 0.720 and extrapolated $\varepsilon_{Nd}(0)$ values fall in the range between -15.0 and -12.0.

Our review of the available compositional data of Saharan and Sahelian dusts and soils reveals that a combination of different methods leads to an improved characterization of potential source areas. However, it has to be claimed that the areal density of the data is still far from satisfactory.

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