

# Variations on the Mineralogical Particle Properties of Atmospheric Saharan Dust from Different Source Regions

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## INTRODUCTION.

The geographical proximity of the Sahara-Sahel dust corridor to the Mediterranean basin and the occurrence of certain meteorological scenarios favour intense dust episodes over the whole basin and strongly affect the surface PM<sub>10</sub> ambient levels (Moreno et al., 2005). In some particular cases such as in the central region of the Iberian Peninsula (IP), African dust storms from long-range transport, jointly with regional recirculation, make of mineral dust the main contributor to the PM<sub>10</sub> mass. The presence of dust, which can act as Cloud Condensation Nuclei (CCN) and Ice Nuclei (IC), is known to affect cloud optical properties and the formation of rain. It also affects the climate system by changing the energy balance of solar and thermal radiation (IPCC, 2007). But mineral dust does not travel alone. Several types of pollen and fungi spores together with several thousand types of microorganisms, very different from the native species, are also transported and can influence ecosystems and human health. In addition, interactions with other species during transport can modify its physicochemical and optical properties and serve as condensation nuclei for species such as organics, sulphates or chlorine. As a positive factor dust can also act as a fertilizer, providing nutrients to both marine and terrestrial ecosystems.

This study focuses on the relationships between the elemental composition and morphology of individual dust particles from intense Saharan dust outbreaks over the Iberian Peninsula. Characteristics of local and regional resuspended mineral dust are also discussed and compared with those of Saharan dust. Morphology seems to be crucial in determining the dust plume characteristics, the variability during

transportation and some physicochemical properties such as CCN activation.

## CCSEM/EDX METHODS.

Single particle analysis of more than 100,000 particles was performed using a fully Computer-Controlled Scanning Electron Microscope coupled to Energy-Dispersive X-ray Spectroscopy (CCSEM/EDS). Clustering from the relative elemental composition amongst 18 different elements and morphological classification from the aspect ratio ( $AR = \text{Length}/\text{Width}$ , Fig.1) were carried out, which allowed the differentiation between episodes linked to diverse origins (Coz et al., 2009). Reproducibility of the samples and details regarding procedure limitations can be found in this reference.

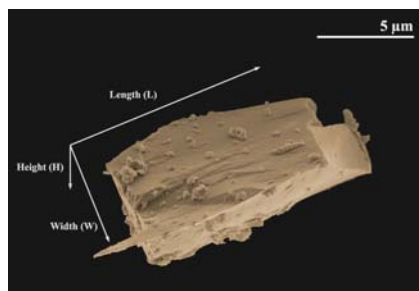


fig 1. Length, width and height measures on an atmospheric dust particle.

## TRANSPORT SEASONALITY & SOURCE REGIONS.

While the Saharan dust transport following Atlantic pathways is a semi-permanent phenomenon associated to the presence of trade winds, a similar transport towards Southern Europe and the Mediterranean basin is less frequent and requires the occurrence of specific synoptic scenarios. Mineral dust transport from North Africa can be observed at any time of the year; however, the frequency of the events is

much greater in certain periods (Escudero et al., 2005; Coz et al., 2009):

### Late winter and early spring period.

Two different synoptic scenarios are characteristic from this period: a low pressure system at low atmospheric levels located to the West of Portugal, with typical associated origin in the Northern African margin (AFR-1); and a transport with a Mediterranean path entering the Iberian Peninsula (IP) with origin over the Morocco-Algeria-Tunisia region (AFR-2).

### Summer and early autumn period.

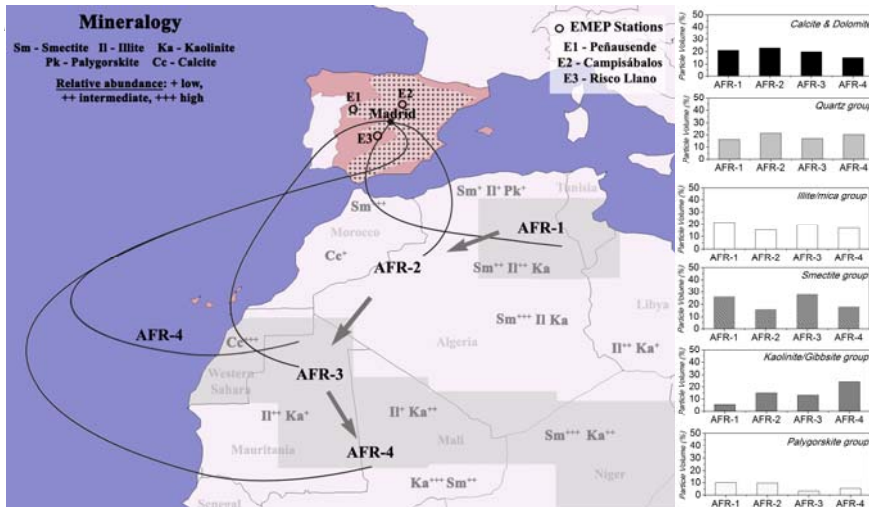
Two other characteristic scenarios can be linked to this period: an anticyclone located to the East or Southeast of the Iberian Peninsula sometimes over Algeria and Tunisia (AFR-3); and a scenario associated to thermal low pressure systems that develop in summer, sometimes overlapping to the previous case study (AFR-4).

## SOIL VERSUS AEROSOL MINERALOGY.

Saharan dust is comprised mostly of calcite-dolomite, quartz, clays, micas, feldspars, gypsum and other minerals in smaller amounts (Avila et al., 1997; Coz et al., 2009). The silicate fraction dominates the total contribution, with a major presence of clays, which contribute to large components of North African topsoil (Moreno et al., 2006). It has been already shown that Saharan incursions contribute to increase the relative abundance of silicates in the atmospheric picture independently of the emplacement of the receptor site in the IP and the associated topsoil composition (Coz et al., 2010). Fig. 2 shows the trajectories and origins of the previously described transports into central Iberian Peninsula and relative abundance of clay minerals at the

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**key words:** Saharan dust, CCSEM/EDX, Mineralogy, Morphology.



**fig 2.** (Left) Map of the most active source regions of mineral dust transported into the Iberian Peninsula (shaded areas) AFR-1, 2, 3, and 4 indicate the source origin and respective air-mass back-trajectories of the episodes discussed in this study and the relative clay topsoil composition. Dotted area in the Iberian Peninsula indicates calcareous enriched topsoil; (Right) Relative atmospheric mineralogical composition for the episodes at Madrid (Coz et al., 2009).

source regions. Fig.2 (right side) shows the relative abundance of clays, quartz and calcite-dolomite in air at the receptor site (Madrid). Both figures correlate with a higher abundance of the clusters associated to kaolinite as the source origin moves to south-western Sahara in both soil and aerosol composition. Smectite content is higher as the source region is located to the East whereas the presence of palygorskite is double in Northern areas.

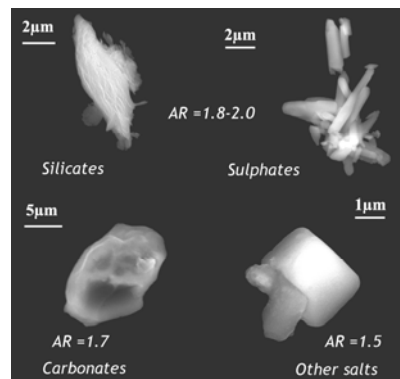
**MINERALOGICAL-DERIVED INDIVIDUAL PROPERTIES.**

Clays are frequently used as a footprint of Saharan incursions, not only for their relative abundance, but also because of their particular aerodynamic properties; a consequence of their specific laminar morphology that favours transport over distances greater than several thousands of kilometres. Coarse African dust particles observed in this study had a median Aspect Ratio (AR) of 1.81. AR median values of  $1.64 < 1.81 < 1.96$  for the Canary Islands, the Spanish Peninsula and Puerto Rico, respectively, would be related to selective aerodynamic processes during the transport. Larger median values seem to suggest the tendency of more elongated laminar particles to persist during the transport, which may be linked to the aforementioned aerodynamic behaviour of clays (Coz et al., 2009). From all the mineralogical groups, the clays and gypsum elongated crystals are always related to the highest AR median values (1.8-2.0), but with an important structural difference (Fig.3). The basic

units of clays are fine layered sheets as thin as 0.7 nm in the case of kaolinite. Salts, such as halite, are associated to AR median values of around 1.5 derived from their cubic crystallization. Calcite and dolomite present intermediate AR median values of 1.7 (Fig.3).

**CONCLUSIONS.**

In general, samples taken during the same transport episode (same day, or different days) are consistent in morphology, but also chemical composition. Mineral dust transported from Africa collected in Madrid was characterised by the presence of silicates ranging from 65-85% (by particle volume), which was consistent with other studies of Saharan dust conducted in continental Europe using a similar methodology. Comparisons with samples collected during the influence of regional and local episodes decreased the silicate abundance down to 34-45%. The opposite trend occurring



**fig 3.** Examples of the main mineral clusters in the study and the associated AR mean values.

within the calcium carbonate cluster, being specially clear in areas of the IP with calcareous lithology (Coz et al., 2010). Variability within the chemical cluster distribution of silicates can be linked to the major topsoil mineralogical composition in the geographical origin of each type of Saharan dust episode. The shape parameters used as morphological descriptors to compare particle morphology between episodes, are characteristic of each chemical cluster (mineralogy), independently of the transport process or origin. These results confirmed that the mineralogical composition of dust is closely related to the lithology at the source origin even after aerodynamic selection during transport has occurred.

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