# Variability of the lithogenic particle fluxes down through the water column of the north-eastern subtropical Atlantic Ocean. Relations with atmospheric inputs

A. Bory
P. Newton
C. Lambert
F. Dulac
C. Moulin
W. Guelle

Laboratoire des Sciences du Climat, et de l'Environnement, Domaine du CNRS, Avenue de la Terrasse, 91191 Gif-sur-Yvette Cedex, France

Downward lithogenic and biogenic particle fluxes were measured using deep-moored sediment traps deployed in two regions of different primary productivity levels (mesotrophic and oligotrophic) of the north-eastern subtropical Atlantic Ocean. Time series were obtained between 1990 and 1992 for 8 to 16 month periods at several depths (ranging from 1000 to 3200 m) within the Eumeli and BOFS programs (France and UK JGOFS, respectively). Atmospheric mineral dust plumes originating from Africa were characterised for the two oceanic regions using remote sensing data (Meteosat) (Moulin *et al.*, 1997). Estimates of atmospheric dust inputs to the ocean were then made using parameters from a dust transport/deposition model (Schultz *et al.*, 1996).

## Results and Discussion

High (250 $mg.m^{-2}.j^{-1}$) and variable mass fluxes were observed in the water column at the mesotrophic site, consistent with the rather high primary production in the surface waters and the variable influence of the Mauritanian upwelling system on this region. In comparison, the oligotrophic site is characterised by a low (35 $mg.m^{-2}.j^{-1}$) and less variable mass flux, showing no marked seasonal signal, which is consistent with the weak seasonality of the climatological forcing at these low latitudes. The oligotrophic site appears to show a very weak variability in the composition of the settling particulate matter. On the contrary, a significant variability in the composition of the particulate fluxes was observed at the mesotrophic site, with high lithogenic fluxes in winter, and high organic matter fluxes in spring/beginning of summer.

The difference between the average fluxes for the two sites together with previous water column flux measurements and sedimentary records show a decreasing gradient of the lithogenic fluxes from the African coast to the open ocean in relation with the increasing distance from the particle sources (Sahara and Sahel) (Fig. 1).

The mesoscale variability of particle fluxes down through the water column in the mesotrophic region was assessed for a 5 month period by comparing the fluxes collected by two simultaneously deployed sediment traps moored 100 km apart. The comparison shows no significant mesoscale variability of the lithogenic fluxes, despite biogenic flux mesoscale variability. The observations are consistent with rapid and efficient transport of dust in the water column in this region, suggested by the low average lithogenic/organic carbon fluxes ratio together with the non-

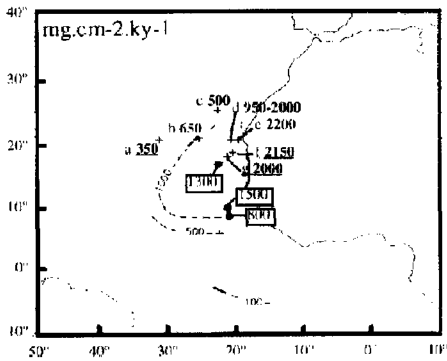


FIG. 1. Lithogenic flux in the water column (bold values; underlined values: this study) and in surface sediment (map and values in box; Rea, 1994). a: Eumeli oligotrophic site, b: Kremling and Strue (1993), c: Jickells *et al.* (1996), d, e,: Fisher *et al.* (1966), f: BOFS mesotrophic site, and g: Eumeli mesotrophic site.

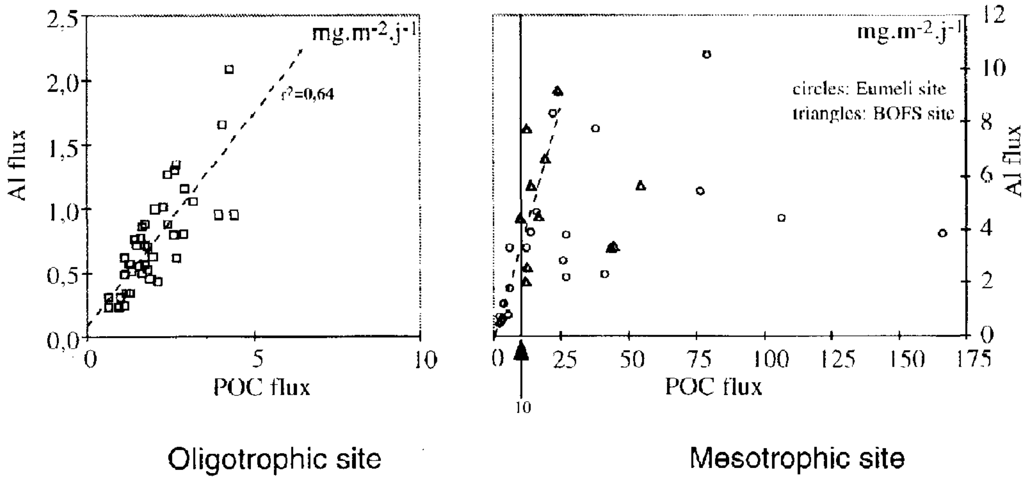


FIG. 2. Aluminium (tracer of the lithogenic fraction) *vs* particulate organic carbon (POC) at 1000 m depth in the water column.

correlation of the two fluxes (Fig. 2). This hypothesis is supported by the covariation of atmospheric dust fluxes onto the surface ocean and lithogenic fluxes down through the water column. In contrast, at the oligotrophic site lithogenic and organic carbon fluxes are linearly correlated at a higher lithogenic/organic carbon. In this region, no simple relationship is apparent between temporal variations of atmospheric dust inputs and lithogenic particle flux in the water column; the latter appears to follow biogenic flux variations.

On an annual basis, estimates of atmospheric dust fluxes onto the ocean surface in both regions were 2–3 times lower than the measured lithogenic fluxes in the water column. This apparent mismatch could be due to the uncertainties of the dust deposition flux calculations, or to lateral advection of lithogenic richer surface water masses from regions closer to the African coast.

## Conclusions

This study shows the complexity of the relationship between atmospheric dust deposition fluxes and lithogenic fluxes in the water column. The link between both fluxes seems to depend on the magnitude of the primary production. For high production (mesotrophic site), the high biogenic fluxes allow an efficient export of lithogenic particles from surface waters to the deep ocean. Therefore, the variations of the lithogenic fluxes reflect mostly that of the atmospheric dust deposition. In regions where primary production is low (oligotrophic site), the removal of the lithogenic particles from surface waters seems to be limited by the weak biogenic export. Therefore, the variation of the lithogenic fluxes follows closely that of the biogenic fluxes in the water column.

Moreover, the significant mesoscale variability of the biogenic fluxes in the water column at the mesotrophic site, up to a factor of two, underlines the importance of such studies for regional carbon export budget estimates in the ocean.

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