Particulate fluxes and sediment dynamics on the Northwest Iberian margin

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1. **Introduction**

The aim of the IH contribution to WP III is the understanding of the processes affecting the particulate matter in oceanic systems. This main purpose is achieved by two tasks: 1) the identification of sediment main sources; 2) the recognition and quantification of processes acting in the suspended particle matter and in bottom sediments.

This study has been developed in the north Portuguese margin (north of parallel 41ºN). This sector of the Iberian margin shows the following peculiarities: a lengthy continental shelf, which is very narrow (with an average of 35 km wide); several rocky outcrops; the steepness of the slope with the Porto Submarine Canyon; and finally it is strongly affected by continental inputs due to high river activity (the five major rivers are the Minho, the Lima, the Cávado, the Ave and the Douro).

2. **Methodology**

2.1. **Data acquisition**

To meet these objectives two cruises were promoted by IH covering the study area: the CORVET 96 and the CLIMA 97 (Fig. 1).

CORVET 96:
vessel: NRP "Almeida Carvalho"
dates: November 1996 (1 to 22)
data collected: CTD + nephelometric profiles
SPM sampling (water sampling and filtration) in the nepheloid layers
surface sediment sampling (grab and multi-corer from Univ. Bordeaux I) in fine deposits located in the middle continental shelf
meteorological conditions: winter with a storm event interromping the cruise for a few days.

CLIMA 97:
vessel: NRP "Almeida Carvalho"
dates: December 1997 (6 to 15)
data collected: CTD + nephelometric profiles
SPM sampling (water sampling and filtration) in the nepheloid layers
meteorological conditions: typical winter conditions.

The area was covered by a E-W transepts, perpendicular to bathymetric contours (7 transepts in CORVET 96 and 10 in the CLIMA 97).

Surface SPM samples were collected by direct filtration while other layers were sampled using Niskin bottles (12 bottles in the CTD rosette), filtered on board by the classic vacuum system. All the SPM samples were immediately dried after collection.

Used filters had the following characteristics: *ester cellulose* filters with 0.45 μm porosity and diameter of 47 mm (for mineralogical studies) and 142 mm (for grain-size analysis) and *glass fibre* filters with 0.7 μm porosity and diameter of 47 mm (for POC analysis).

2.2. **Laboratory studies**

Samples collected during CORVET 96 were analysed in order to obtain:

- SPM distribution (concentration in mg/l) in the main nephelometric layers (at surface and near bottom) and filter optical observation with a microscopic and a SEM;
- SPM grain size analysis using the MALVERN equipment;
- Clay mineralogy of SPM using a X-ray difractometer;
- Particulate Organic Carbon distribution (POC in µg/l units) in the main nephelometric layers;
- Characterisation of bottom sediments (granulometry, POC and CaCO3 contents,).

Samples collected during CLIMA 97 are still being analysed.

These results will be integrated with physical parameters and with results from others WP3 partners in OMEX II-II area.

3. **Results and Discussion**

3.1. **Amount, Character, Distribution and Composition of Suspended Particulate in nepheloid and Clear Water Layers (Task III.1.1)**

The study of SPM in the north Portuguese margin collected in both cruises will allow an interannual variability approach. General interpretation allow us to present the following preliminary results:

a. The spatial analysis of SPM through the North Portuguese margin, during winter time, shows the impact of river run-off. The nephelometry values increase from the surface to the bottom, but when the water column is deeper than ≈30m, turbid waters differentiates in two layers separated by a clear water mass, as it is clearly identified in nephelometric profiles.

b. SPM concentrations are higher near bottom and in the river mouth proximity (Fig. 2). At surface values range between 0.13 up to 3 mg/l (in 1996) and 4 mg/l (in 1997). Near bottom, the observed SPM concentrations becomes much higher, between 0.3 and 19 mg/l (in both years).

c. In the shelf domain, the main composition of the surface nepheloid layer away from river influence is mainly biogenic, while bottom nepheloid layer has a terrigenous composition.

d. The rate between biogenic and terrigenous components in the SPM can also be determined by the POC distribution (Fig.3). In the inner shelf the lower values of POC indicate both the proximity to river mouth and energetic ressuspension of bottom sediments due to wave action and tidal currents. In middle and outer shelf the input of fresh continental water is clear in the surficial distribution of POC content. Westward the POC increases as the terrigenous components of SPM decrease. This was observed in both nepheloid layers. Optical observations suggests an organic (plankton) rich SPM.

e. The grain-size distribution (at surface), is dominated by a general oceanic westward increase from less than 9µm, near rivers, to more than 14µm offshore. The coarser mean diameter occurs over the outer shelf were the major terrigenous river input is minimal and the plankton debris prevails (essentially siliceous and carbonated skeletal fragments).

f. Concerning composition of SPM, terrigenous particles are plate-like clay minerals with other grains present namely quartz, feldspar, mica and charcoal. Biogenic remains are essentially phytoplankton (diatoms, dinoflagellats, silicoflagellates and coccolitophores) and zooplankton is not frequent (dominated by copepods). Foraminifera were absent or rare.
   The fine fraction (silt+clay) mineralogy is still being analysed but the clay fraction reveal, as expected, an homogeneous assemblage of ilite, chlorites, kaolinite and smectite.

g. During CORVET 96, one of the transepts was repeated immediately after a storm event. This allowed us to give an estimation of the impact of such an event in the general water column and bottom sediments characteristics. It was observed that after the storm, the benthic nepheloid layer increased three times its thickness, and became much more terrigenous (Fig.4). This is an evidence of ressuspension events in the muddy deposits induced by storm waves. The benthic nepheloid

layer, more developed, extend westward, nourishing intermediate nepheloid layers after the shelfbreak. Differences were also detected in the spatial distribution of the surface nepheloid layer, which becomes restricted to the inner shelf, as a direct consequence of the Westward strong winds.

3.2. **Sediment Distribution, Properties and Composition along Selected Transepts (Task III.1.4)**

In the OMEX II.II framework it is intended to realise a more accurate study and cartography of sedimentary deposits, with special attention to the first centimetres. This is essential to identify depositional areas of suspended particles in the continental shelf and slope.

From previous works it is known that the sedimentary cover in the continental shelf is mainly sandy. Other peculiarities are the presence of rocky outcrops in the outer and inner shelf and also two main finer deposits with muddy characteristics (DIAS, 1987; MAGALHÃES, 1993; RODRIGUES *et al*., 1991): Douro Muddy deposit and the Minho Muddy deposit. These two deposits were the first target of sediment sampling in CORVET 96. In this cruise 43 grab samples and 13 multi-corers were collected. Preliminary analyses were addressed to water content, mean grain-size, POC and $CaCO_3$ content in the first centimetre(Fig. 5). The following results were obtained:

a. The water content give us an approach to sediment consolidation and grain-size. In areas were the sediment is coarser the water content is less than <30%. In the middle shelf were sediments are finer the water content can be more than 60%.
b. The first centimetre of bottom sediments has less than 25% of particles with a diameter <15 μm. In fact, the collected sediments were classified as muddy silt. Spatially the finer samples were collected in Minho Muddy Deposit and west of the Douro Muddy Deposit. The coarser sample (fine sand) was collected in the head of the Porto Submarine canyon. In general it seems that deposits have a NE-SW banded geometry. Its origin was not established but it might be related to the predominant wave regime (from the NW).
c. The POC contents have a very good correlation with sedimentary grain-size. In the first centimetre it ranges between 0.2% and 1.8 % (mean value 0.5%). Maximum POC areas are the Minho muddy deposit and the west boundary of the Douro Muddy deposit, where sediments are also very fine.
d. In general the 1st centimetre of the bottom sedimentary cover presents low values of $CaCO_3$ (ranging from 1.7 to 38%) with a mean value of 7%. The $CaCO_3$ distribution pattern is not yet fully understood. It seems that higher values are present in the outer shelf far away from terrigenous sources. Also the presence of carbonate outcrops in the outer shelf can explain some of this content.

3.3. **Dominant sediment Transport Processes at Contrasting Margins (Task III.1.5)**

The work carried out in this first year does not allow any conclusive result in what concerns transport processes at contrasting margins or in different seasonal conditions. Nevertheless, the results achieved during this period show that:

1. This is a very energetic continental margin: during winter conditions ressuspension processes must be considered as SPM sources to the benthic nepheloid layer;
2. The river run-off definitely contributes to the SPM character and dynamic in water column;
3. SPM with a continental origin can, especially in storm events, reach the shelfbreak and enrich the intermediate nepheloid layers in the continental slope;
4. Sedimentary characterisation (in muddy deposits) seems to indicate that particles can settle in the middle and outer shelf. Nevertheless, in severe winter conditions (with high SW waves), sediments can be ressuspended and transported to deeper domains.

3.4. **Carbon Sources, Cycling and Fates (Task IV.2)**

Preliminary results on POC content in the water column (especially in nepheloid layers) allow us, together with the characterisation of water masses, to give an estimation of Carbon sources. So, in the continental shelf and upper slope of the Portuguese margin, POC content of SPM have the following pattern:

a. A roughness analysis of POC distribution over the continental shelf shows an inverted trend of the SPM concentration.
b. Higher values of POC, 29% of total SPM, were found in the surface nepheloid layer in the northern part of the studied area (off the Minho river), while the lower POC content, 3% of total SPM, was located in the middle and inner shelf off Douro river (southern limit of the studied area).
c. The bottom nepheloid layer in the continental shelf, always present low POC content, between 3 and 12%. When compared with the surface spatial gradient this distribution is more homogeneous.
d. In the outer shelf and upper slope (depth > 200 m), the POC content in the SPM does not show any difference between the surface layer and the deeper one (≈ 500 m). Values range between 13 and 19 % of total SPM.

Results obtained so far are related only to the 1996 cruise. Samples collected in 1997 are still being analysed.

4. **Dissemination of results**

the above described results, total or partially, have been object presented in formal and informal meetings. Abstract and paper are attached to this report.

4.1. **Meetings**

Oliveira, A.; Rodrigues, A.; Jouanneau, J.M.; Weber, O.; Dias, J.A.; Vitorino, J. - "The suspended particulate matter distribution and composition in the northern Portuguese margin", *"2nd symposium Iberian-Atlantic continental margin"* Cadiz, 17-20 September 1997

Oliveira, Anabela -"SPM dynamics on the northern Portuguese Shelf during winter 96 and 97". *OMEX II.II WPIII workshop*, Faro, 5-7 April 1998

Rodrigues, Aurora -"POC distribution on shelf muddy deposits between 41ºN and 42ºN". *OMEX II.II WPIII workshop*, Faro, 5-7 April 1998

Vitorino, João - "Winter conditions off the NW Portuguese coast (a compared view based on IH 96 and 97 cruises)". *OMEX II.II WPIII workshop*, Faro, 5-7 April 1998

4.2. **Papers**

Oliveira, A.; Rodrigues, A.; Jouanneau, J.M.; Weber, O.; Dias, J.A.; Vitorino, J. (1998)- "The suspended particulate matter distribution and composition in the northern Portuguese margin" *Special issue of IEO "2nd symposium Iberian-Atlantic continental margin"* (*in press).*

5. **Future activities**

a) Integration of results that were not included thus far, namely the 1997 SPM samples.
b) Integration and discussion of results with other WP III partners;
c) A 1998 summer cruise is planned (dates not yet available), to be carried out in the north Portuguese margin. SPM samples and surface bottom sediments will be collected in the continental shelf and slope. Station will be extended further more to West in order to integrate observations with other WPIII partners.
   Plans are being made to promote a Portuguese cruise that will cover some Spanish continental shelf stations.
d) participation on OMEX II-II workshops and meetings to present and integrate results and discuss future activities.

6. **References**

DIAS, 1987 - DIAS, J.M.A. (1987) - "*Dinâmica Sedimentar e Evolução Recente da Plataforma Continental Portuguesa Setentrional*". Dissertação de Doutoramento, Universidade de Lisboa. 384 pp. (*unpublished).*

MAGALHÃES, F. (1993) - "*A cobertura sedimentar da plataforma e da vertente continental superior a norte de Espinho*" Dissertação de mestrado, Univ. Lisboa. 191 pp. (*unpublished*).

RODRIGUES, A.; MAGALHÃES, F.; DIAS, J.M.A. (1991) - "Evolution of the north Portuguese coast in the last 18,000 years". Quaternary International, 9:67-74.

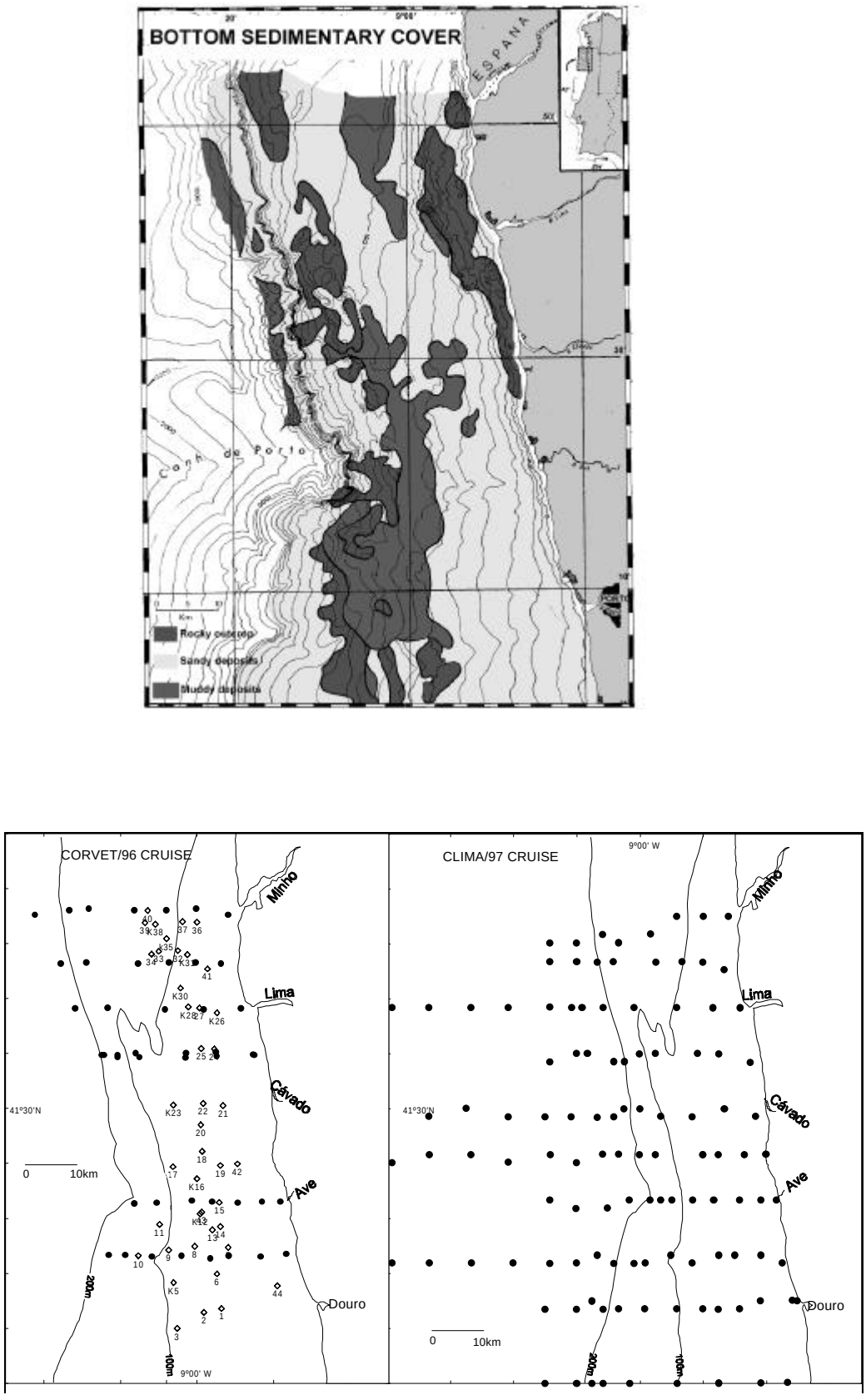

Figure 1. Study area and location of collected samples during CORVET 96 and CLIMA 97. Dots-CTD+Nephelometer profiles; losangs-Sediments samples (K -multi-corer).

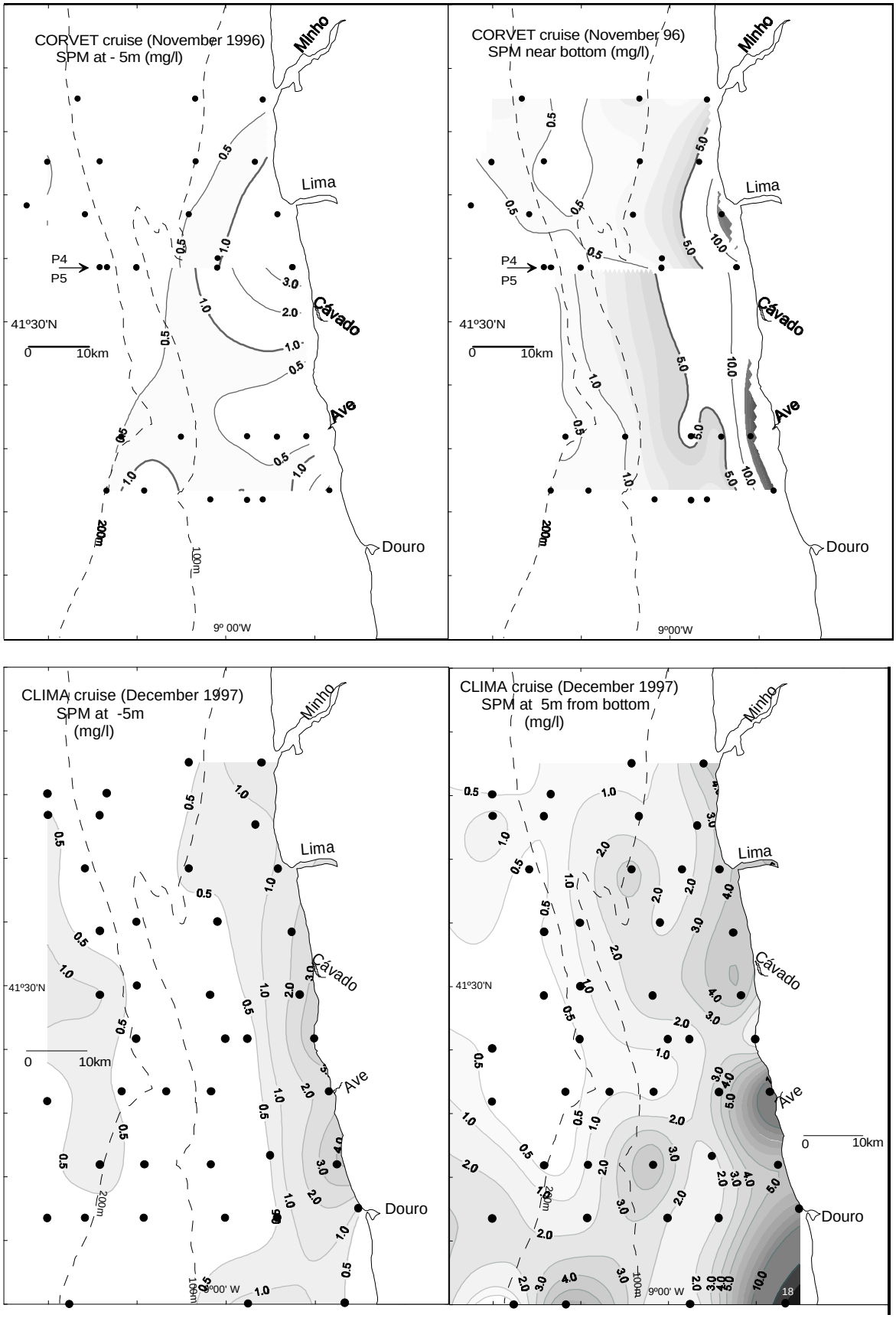

Fig. 2. SPM distribution in the surface nepheloid layer (-5m) and in the bottom nepheloid layer. a) CORVET 96 cruise; b) CLIMA 97cruise .

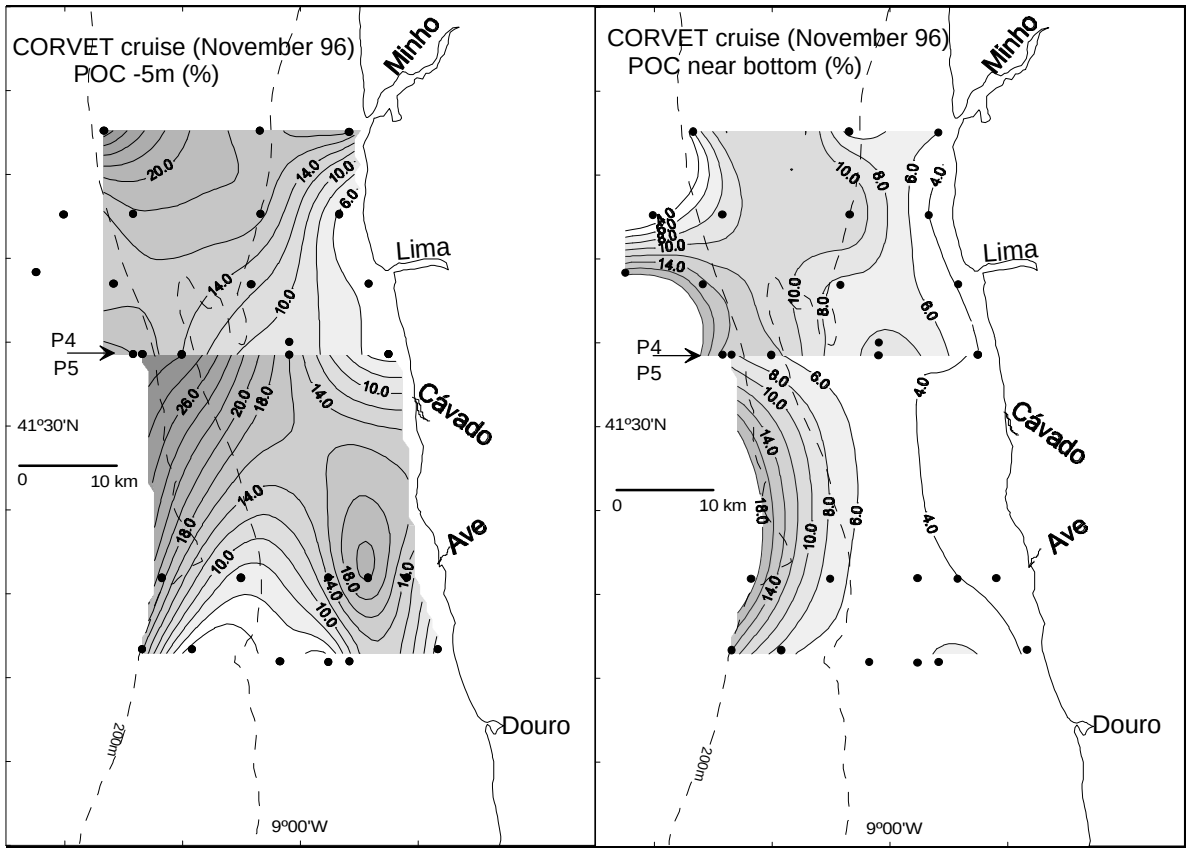

Fig. 3. POC distribution in the surface nepheloid layer (-5m) and in the bottom nepheloid layer during CORVET 96 cruise.

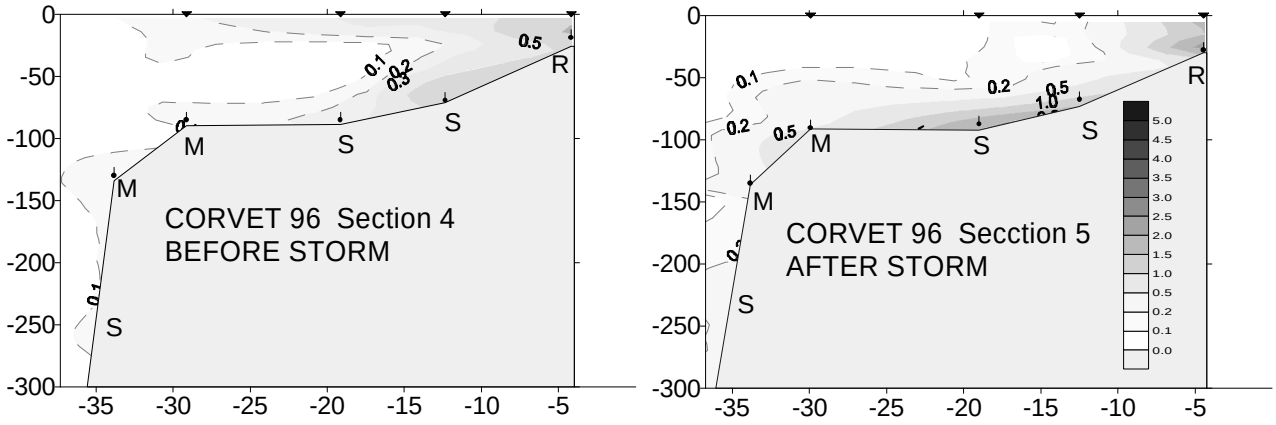

Fig. 4. Cross shelf nephelometric profiles (in f.t.u. units) before and after the 19 November storm. (1 f.t.u.≈ 1.6 mg/l).

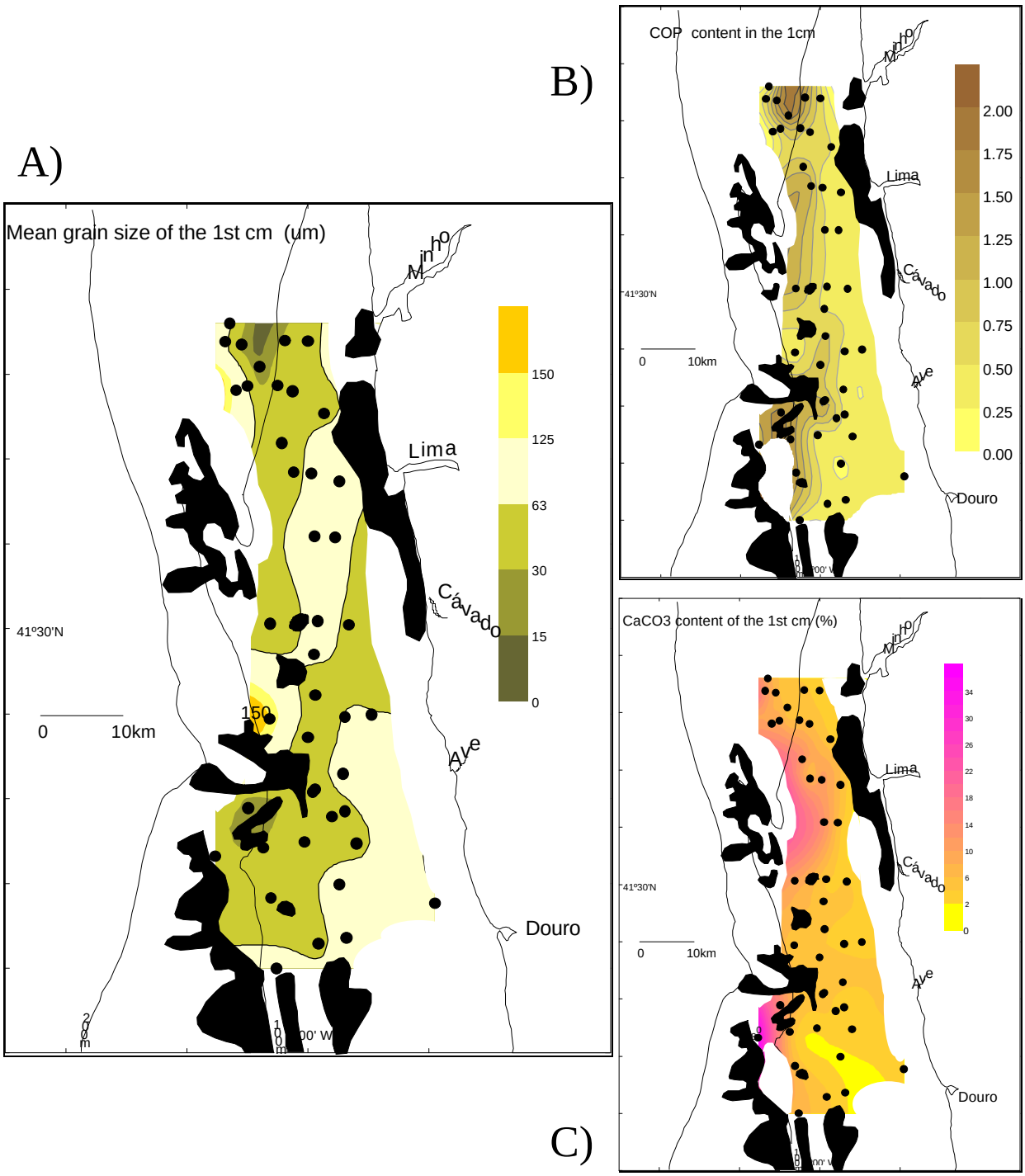

Fig. 5. Bottom sediments (1st centimetre) characteristics: A)-mean grain-size; B)-COP content (%); C)-$CaCO_3$ content (%).