Dynamics of Nepheloid layers associated with internal wave activity off Figueira da Foz

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Abstract: Fixed station CTD/nephelometry and water sampling data, obtained during the HABWAVE cruise (07 to 19 September 2019) in the continental shelf off Figueira da Foz, are used to describe nepheloid layer dynamics (INL and BNL) in the presence of intense Internal Wave (IW) activity. During this cruise, the vertical displacement of the intermediate nepheloid layer (INL) is in the order of ±20m and bottom nepheloid layer (BNL) mimic the passage of IW, increasing in height with wave crest (43m) and decreasing in wave pit (21m), in the same order as INL. The suspended sediment BNL composition, obtained through X ray diffraction, confirms the detrital mineral source of suspended particles, with some punctual increases of organic matter, possibly due to bottom sediment resuspension and near bottom transport.

Key words: internal waves, nepheloid layers, NW Iberia, shelf.

1. INTRODUÇÃO

Previous studies have shown that nepheloid layers (intermediate and bottom) are present in the water column worldwide and are considered important for the transport of matter and energy (Eisma, 1993). In the Portuguese continental shelf Quaresma *et al*., (2007) observed the remobilization of mid-shelf bottom sediment by the action of large amplitude internal solitons that can force strong bottom current pulses during summer forcing conditions, resulting in a well-defined bottom nepheloid layer (BNL).

The action of internal waves in sediment dynamic was investigated in the Portuguese continental shelf off Figueira da Foz (fig.1) as part of HabWAVE project. In this area, sands and gravel with limited fine fraction (silt + clay) dominate the sedimentary cover. The silty sand sediments are only present near the shelf edge and normally associated with rocky outcrops (IH 2010).

In this study, we present and discuss results obtained during late summer, from fixed station CTD/nephelometrical profiles, characterizing nepheloid layer dynamics in the presence of intense Internal Wave activity (IW).

2. DATA AND METHODS

During the multidisciplinary IH-HABWAVE cruise (09-20 September 2019) two periods of fixed station (YoYo) with CTD/nephelometer and water sampling were surveyed covering two semi-diurnal low tides (33 yoyos on September 16th and 15 yoyos on September 18th, corresponding to, approximately, a 09 h and 06 h period, respectively). The yoyos covered a ~100m depth water column near a mooring position where two ADCP´s were previously deployed (more details in Oliveira *et al., this issue*). Collected grab samples (fig.1) show that a bottom silty sand sediment characterize this spot.

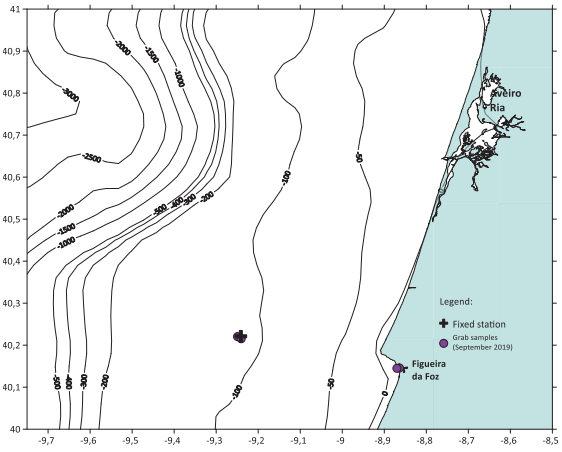

Fig. 1. Fixed station and grab samples location (HabWave cruise in September 2019).

Particulate matter concentration (PMC) was determined by filtration on 0.45µm acetate cellulose membranes. The water samples were collected with a rosette sampler containing 11 Niskin bottles (8 of 5.0 liters and 3 of 2.5 liters) in the bottom nepheloid layer (BNL).

The obtained nephelometrical profiles in Formazine turbidity units (FTU) were used as a semi-quantitative but reproducible measurement of PMC. In this cruise the following calibration equation was obtained; *FTU=0.997667xPMC(mg/l)* with n=31 and R^2=0.93227.

The mineralogy of the PM was also studied in selected samples from BNL. This analysis was carried out in an X-Pert diffractometer, with CuKα radiation. Scans were run between 2º and 35º 2θ directly on filters containing the PM samples .

3. RESULTS AND DISCUSSION

The observations conducted in September 2019 are representative of conditions found during the upwelling season. The surface wave regime was weakly energetic, without wind (fog). The water column structure shows the development of a well-defined thermocline, variable in depth, along the tidal cycle (fig. 1). The nephelometry data, gathered during the cruise showed that the study area is generally characterized by low values (<2.5 FTU), indicating that concentration of PM are normally low (Fig.2).

On September 16th the thermocline extends between 05-30 m and 17-55 m water depth (between 11:50 and 16:06) (fig. 1) showing depth-temporal variability. Relatively high PM concentrations were observed near the seabed (>0.5 FTU) but also in two small INL's (15 and 35 water depth) whose position is associated with the thermocline. BNL, also shows temporal variability associated with the moving thermocline. Higher PM values are associated with the IW's passage. During this cruise, the vertical displacement of the intermediate nepheloid layer (INL) is in the order of ±20m and bottom nepheloid layer (BNL) mimic the passage of IW, increasing in height with wave crest (43m) and decreasing in wave pit (21m), in the same order as INL

The effect of the IW's in the water column is also evident on September 18th (fig.3). During the observation period, INL´s seems thinner, but BNL was again intense and well defined with ~20-30m height.

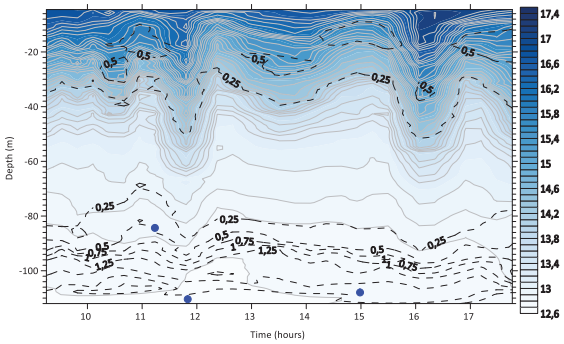

Fig. 2. Temperature (in blue) and resultant nephelometry/PMC (mg/l) dotted black lines, in fixed station (16/09/2019). Blue dots represent the PMC samples.

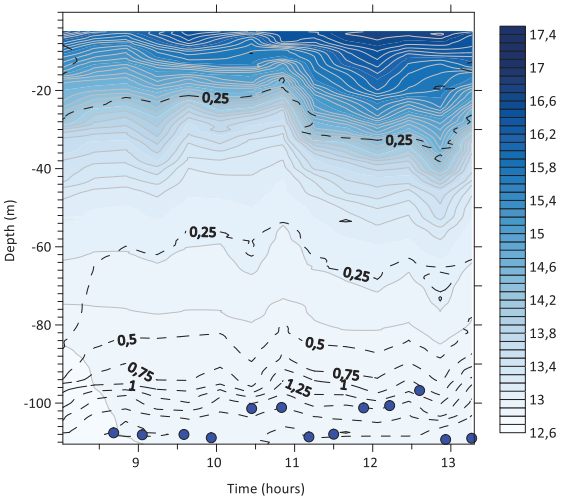

Fig. 3. Temperature (in blue) and resultant nephelometry/PMC (mg/l) dotted black lines, in fixed station (18/09/2019). Blue dots represent the PMC samples.

PM mineralogical results made in 3 BNL samples in the first sampling period and in 12 samples in the second day (location in fig.2 and fig.3), show that the prevailing minerals in suspension were phyllosilicates, mainly mica/illite > chlorite > kaolinite with the presence of calcite and quartz (fig.4). These results were influenced by the presence of organic matter (OM) in the filters, that can shift the characteristic mineral's peaks position (hkl) and increase the background around the 20º 2θ (*see* fig.4a station ADCP20 and 4b stations ADCP36, 38, 41 and 42).

Observations showed that on September 16th, OM increased at the BNL's top layer (~80m depth), but on the 18th this tendency was not so evident, because the samples were collected at one single depth. The increase of OM seems related with the different IW's energy (action) near bottom that can promote irregularly the preferential transport of OM in the BNL, or the remobilization and transport of the mineral fraction, namely quartz and phyllosilicates.

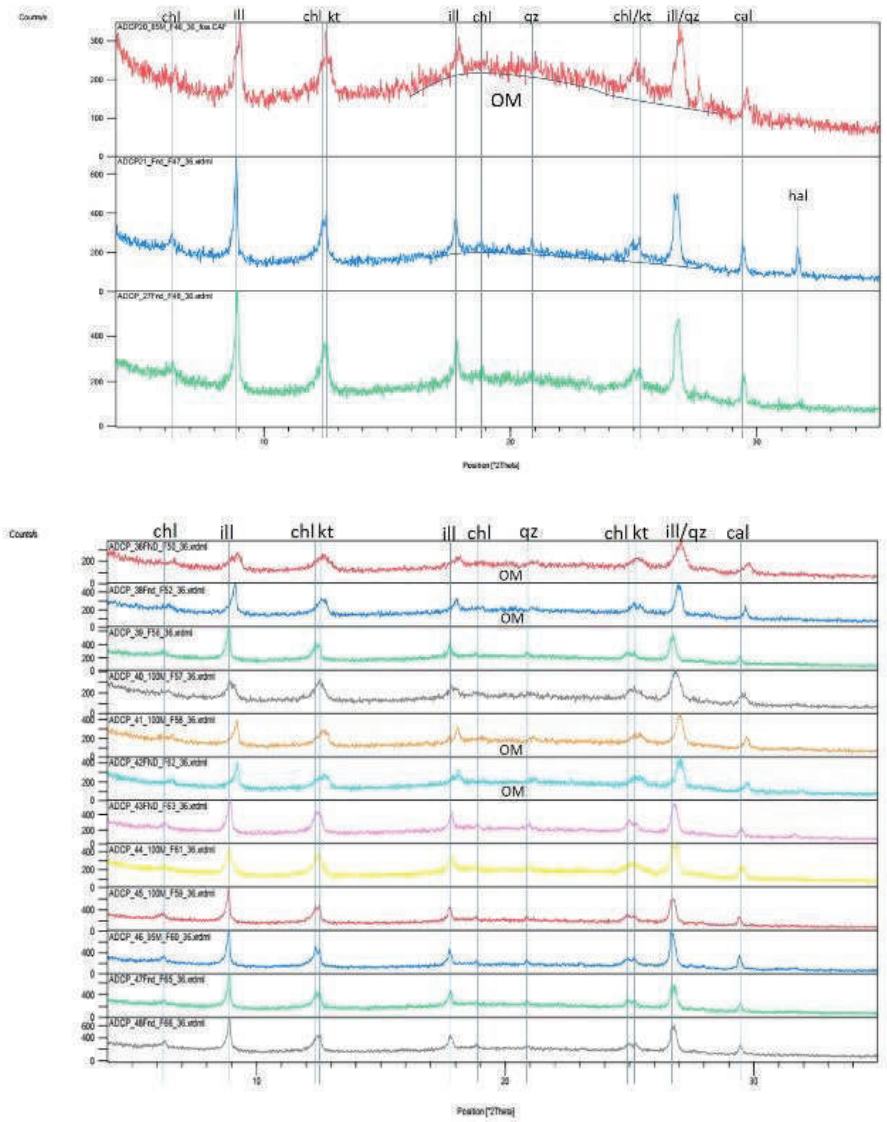

Fig. 4. PM DRX analyses; Top figure correspond to 16 September samples and bottom figure corresponds to 18 September samples (OM- organic matter; chl-chlorite; ill-illite; kt-kaolinite; qz-quartz; cal- calcite; hal-halite). Note in graphics, vertical axis scale is variable.

FINAL CONSIDERATIONS

The data obtained in this study show that effectively IW's are transporting and resuspending both OM and mineral grains in the BNL (mostly phyllosilicates).

Future work, includes the relation of BNL with forcing agents (IW's pulses/energy, directions, currents velocity), and also the relation of resuspension periods with harmful algal blooms and the presence of phytoplankton resting stages in the water column.

AKNOWLEDGEMENTS

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