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Bioavailable organic matter in surface sediments of the Nazaré canyon and adjacent slope (Western Iberian Margin)

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Abstract

The distribution of bioavailable organic matter in surface sediments of the Nazaré submarine canyon and adjacent open slope was investigated. The concentration of chlorophyll *a* (chl *a*), phaeopigments (phaeo), chloroplastic pigment equivalents (CPE) and total hydrolyzable amino acids (THAA) decreased with increasing water depth, and were in general higher within the canyon (specially in the upper regions) than on the open slope. The concentrations were low on the canyon walls, increasing towards the canyon axis. The chl *a*:phaeo ratio, degradation index (DI), asp:β-ala and glu:γ-aba ratios were highest in the upper canyon, and similarly low in the deeper canyon and along the open slope. On the canyon axis and walls these lability indices were similar. chl *a*: OM ratio indicated that the quality of the bulk organic matter in the upper canyon was higher than on the slope and deeper canyon regions. Bioavailable organic matter enters the canyon through the upper region; it is transported down canyon by the tide circulation, where it is dispersed across a bigger area under a more refractory state. Flume experiments demonstrate that arborescent foraminifera and polychaete pellet mounds, as found in the head of the canyon; increase deposition of phytodetritus under critical shear velocities by a 50%.

Keywords: Nazaré canyon; Surface sediments; Phytodetritus; Amino acids; Lability; Biodeposition

1. Introduction

Over the past 10–20 years, understanding the exchange of energy and matter between the shelves and the open ocean has been the core subject of several multidisciplinary programs such as SEEP (Biscaye et al., 1988; Biscaye et al., 1994), OMEX (Van Weering et al., 1998; Schmidt et al., 2001; Epping et al., 2002; Van Weering et al., 2002; Van Weering and McCave, 2002), ECOMARGE (Monaco et al., 1999; Durrieu de Madron et al., 2000). In several of these studies, submarine canyons have been identified as locally important conduits for particulate matter from the shelf to the deep ocean (Monaco et al., 1999; Durrieu de Madron et al., 2000; Schmidt et al., 2001; Epping et al., 2002; Van Weering et al., 2002). The transport of sediments through canyons to the abyssal plains is induced by processes such as the formation of nepheloid layers, internal tide circulation, intermittent gravity flows, down slope currents, or the cascading of dense water (Puig et al., 2004; Canals et al., 2006; De Stigter et al., 2007).

The nutritional value of the organic matter reaching the sea floor is most important for deep-sea benthic communities (Gage and Tyler, 1991), thus benthic fauna

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may play an important role in the transport and accumulation of the fresh suspended organic matter. Especially suspension feeders can influence the particle transport by actively capturing particles from the water column and depositing them in or at the sediment surface (Graf and Rosenberg, 1997), thus making organic matter available to benthic communities. In addition, feeding pits, faecal pellet mounds and tubes can locally change the flow, resulting in passive biodeposition of particles (Jumars and Nowell, 1984; Graf and Rosenberg, 1997). In the laboratory, with natural macrofaunal communities from the Oslofjord, the concentration of phytodetritus and POC in the BBL decreased by 50% and 60% faster in the presence of benthic fauna (Thomsen and Flach, 1997). In situ studies on the continental slope of the Barents Sea have shown that suspension-feeding communities increased the vertical carbon flux by a factor of 2 to 3.7 (Thomsen et al., 1995).

The upper Nazaré canyon (Western Iberian Margin) traps suspended organic matter transported in nepheloid layers from the adjacent upper slope and shelf (Van Weering et al., 2002). Higher organic carbon contents and sedimentation rates characterise the canyon compared to slope areas, specially the upper region (Epping et al., 2002; Van Weering et al., 2002; De Stigter et al., 2007). Internal tide circulation within the canyon produces the formation of bottom nepheloid layers, and transports the suspended material up canyon and down canyon with a net down particle flux (De Stigter et al., 2007). The bulk organic matter throughout the Nazaré canyon is mainly derived from terrestrial sources, whereas that found on Iberian Margin slope areas is dominated by marine sources (Epping et al., 2002). Thus, the focusing of bulk organic matter in the canyon is mainly due to lateral transport of coastal terrigenous material rather than vertical deposition of material from the euphotic zone. The bioavailable organic matter in the Nazaré canyon and the adjacent open slopes has not been addressed specifically. As part of the EUROSTRATAFORM program and ongoing HERMES program, we investigate whether the Nazaré canyon focuses higher concentrations of bioavailable organic matter than adjacent slope areas, and which processes drive the focusing of bioavailable material in the canyon. We also assess whether small biogenic structures present on the floor are important in the accumulation of fresh phytodetritus under the high hydrodynamic conditions characterising the upper canyon. To assess accumulation of bioavailable organic matter in the canyon, concentrations of chlorophyll *a* and phaeopigments in surface sediments, and concentrations of total hydrolysable amino acids in sediment aggregates were measured along a depth gradient in the Nazaré canyon and slope areas. Ratios of chlorophyll *a* to phaeopigment (Soltwedel et al., 2000; Levin et al., 2002) and the amino acid based degradation index (DI), the ratios glutamic acid to β-alanine and aspartic acid to γ-amino butyric acid (Dauwe and Middelburg, 1998; Dauwe et al., 1999) were computed. Mesocosm flume experiments allowed assessing the importance of canyon biogenic structures in the accumulation of suspended fresh phytodetritus.

2. Materials and methods

2.1. Study area

The hydrography of the Iberian Margin is dominated by a poleward current in winter favouring downwelling, and an equatorward current during summer favouring coastal upwelling, which triggers high primary production along the Iberian Margin (Vitorino et al., 2002; Coelho et al., 2003). The Iberian Margin is a productive area that exports high amounts of terrestrial and marine carbon to the open ocean (Thomsen et al., 2002). The Western Iberian Margin is characterised by a narrow shelf with a steep irregular slope and is dissected by several deep gullies and canyons. The Nazaré canyon is the largest canyon on this margin and in Europe, and it is not directly fuelled by river discharge. The Nazaré canyon can be divided into three main sections (De Stigter et al., 2007): a) the upper part of the canyon characterised by a sharp V-shaped valley deeply incised into the shelf and steep upper slope, which begins at ~50 m depths and descends to ~2700 m depth over a length of 70 km measured along the thalweg, b) the middle part of the canyon is a broad meandering valley, with terraced slopes and V-shaped axial channel. It is incised into the middle slope and descends from ~2700 m to ~4000 m depth over 50 km, and c) the lower canyon is a flat floored valley incised into the lower continental slope. It very gently descends from ~4000 m to ~5000 m depth over 100 km. While descending, the valley gradually increases in width from 3 km to 15 km at the mouth of the canyon. Much of the sediment being carried over the shelf and upper slope enters this canyon and is transported to the deep ocean by internal tide circulation and intermittent turbidity flows (Van Weering et al., 2002; De Stigter et al., 2007).

2.2. Sampling

Surface sediment cores were collected during cruises 64PE225 and 64PE236 of RV Pelagia of Royal NIOZ in