



Provenance and fate of organic carbon in three submarine canyons from the Portuguese Margin: Implications for transport processes of material in continental margins

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Submarine canyons are key environments on the continental margin that are affected by unique and dynamic but often episodic and complex processes, and are difficult to study. Canyons are considered hotspots of biodiversity and enhancement of primary productivity at canyon heads has often been postulated to support this, although the evidence is sparse. Additionally canyons are considered to be fast-track corridors for material transported from the land to the deep sea and they are considered major pathways for the transportation and burial of organic carbon, acting as buffers for sediment and carbon storage. Organic geochemical and isotopic markers are often used as reliable indicators for the supply, quality and fate of organic matter in marine systems. In this study they have been used to test the above hypotheses in three contrasting submarine canyons (Nazaré, Setubal/Lisbon and Cascais) of the Portuguese Margin. The elemental and lipid biomarker composition of suspended particulate organic matter of surface waters close to the studied canyon heads had a fresh phytoplankton signal, however there was no clear evidence for enhanced primary productivity by comparison to the neighbouring open slope. By contrast, mid-depth waters (700-1600 m), that are dominated by the northward flowing Mediterranean Outflow Water, had high lipid content and abundant mesozooplankton biomarkers, perhaps reflecting zooplankton activity focused at the boundaries of distinct water masses. In the waters close to the floor of the Nazaré Canyon the presence of elemental sulphur (a product of sediment diagenesis) and high molecular weight hydrocarbons (recalcitrant, terrestrial markers) indicated high levels of resuspended material, particularly at the Upper section (<2000m depth) of the canyon. Resuspension was less evident in other locations suggesting that Nazaré Canyon is the most “active” channel. Nazaré Canyon sediments (0-10 cm) had significantly higher total organic carbon concentrations than the other canyons and the neighbouring open slope, whereas the opposite was observed for carbonate contents. Increased organic terrestrial contributions in Nazaré are also supported by the high molar C/N ratios and low carbon stable isotopic values of the surface (0-1cm) sediment sections. This suggests that the Nazaré Canyon receives more terrestrial, organic-rich material than the other locations, despite the lack of riverine output at the canyon head. By contrast sedimentary organic matter from Setubal/Lisbon and Cascais Canyons had lower C/N ratios suggesting that they received less terrestrial material, despite their proximity to major river systems (Duro, Sado). There is an apparent increasing trend of terrestrial contributions with depth within Nazaré Canyon. This is attributed to the preferential removal of labile, marine OM from the surficial sediments, leaving them “enriched” in more recalcitrant terrestrial material with increasing depth and distance from the shore. However, OM in the Nazaré Canyon surficial sediments is the least altered as a whole. This is supported by the nitrogen stable isotopes and the Oxygen Index (OI; a proxy of OM oxidation state) of surficial sediments. In Nazaré Canyon these are low compared to the other canyons and the open slope. The presence of elemental sulphur in the surficial sediments of Nazaré canyon (absent in all other sediments), is consistent with a shallow (few mm) boundary of bacterial sulphate reduction/sulphide oxidation. This is probably related to the high sedimentation rates that have been measured in Nazaré canyon (but not in any other locations in this study) that limit oxygen exposure time (and hence extensive oxidation) of the sediments. The above observations suggest that Nazaré Canyon is both an important depocentre of organic carbon and the main channel for transporting material from the Portuguese Margin to the deep ocean. However the absence of major river systems close to the canyon head implies that there are important and as yet unclear redistribution processes, that are probably related to the complex oceanographic regime of the region.