Deep-Sea Research II 58 (2011) 2321–2344

Contents lists available at ScienceDirect

Deep-Sea Research II

journal homepage: www.elsevier.com/locate/dsr2

Recent sediment transport and deposition in the Lisbon–Setúbal and Cascais submarine canyons, Portuguese continental margin

Henko C. de Stigter [a,*], Carlos César Jesus [b,1], Wim Boer [a], Thomas O. Richter [a], Ana Costa [c], Tjeerd C.E. van Weering [a,d]

[a] NIOZ – Royal Netherlands Institute for Sea Research, P.O. Box 59, 1790 AB Den Burg, Texel, The Netherlands
[b] GeoBioTec, Department of Geosciences, University of Aveiro, Portugal
[c] Laboratório Nacional de Energia e Geologia, I.P., Alfragide, Portugal
[d] Faculty of Earth Sciences, Free University of Amsterdam, The Netherlands

ARTICLE INFO

Available online 15 April 2011

Keywords:
Submarine canyon
Suspended sediment transport
Internal tide

ABSTRACT

Recent sediment transport and deposition in the Lisbon–Setúbal and Cascais submarine canyons, Portuguese continental margin, were investigated on the basis of water column profiles of suspended particulate matter, records of near-bottom currents and settling fluxes of particulate matter obtained with benthic landers, and analysis of surface sediments. The results show that fine-grained predominantly lithogenic sediment derived from adjacent shelf areas accumulates in the upper reaches of the canyons. Sediment deposited further down in the middle and lower reaches of the canyons is essentially similar to the hemipelagic sediment found on the adjacent continental slope, indicating that down-canyon transport of sediment from the upper to the lower canyon is limited. Tidal currents measured at various depths in the Lisbon–Setúbal Canyon appear sufficiently strong to resuspend and transport sediment, but net up-canyon flow of the bottom water may retain shelf-derived lithogenic sediment in the upper canyon. Sediment gravity flows, which in the nearby Nazaré Canyon are an effective mechanism for down-canyon sediment transport, appear rare in the Lisbon–Setúbal Canyon and probably also in the Cascais Canyon. Turbidity current events recorded in the sedimentary record of the canyons may correspond to seismic events of 1969 and 1755 AD.

1. Introduction

Submarine canyons are a common feature of continental margins around the world. They show many morphological similarities with drainage systems on land, and are generally believed to have an analogous function as conduits for transport of material from shallow coastal seas to the deep ocean basins, extending laterally and deepening by the sustained erosive force of focussed down-slope sediment transport (e.g. Shepard, 1963; Weaver et al., 2000). Because they function as traps for fresh organic material washed in from the coastal zone and settling out from surface water layers (e.g. Vetter and Dayton, 1998), submarine canyons may be sites of enhanced biological productivity, although intense sediment dynamics in some cases appear to restrict development of a stable benthic community (e.g. García et al., 2007; Koho et al., 2007; Tyler et al., 2009; Van Oevelen et al., 2011). It would be an oversimplification, however, to assume that the particular sedimentary and biological characteristics observed in certain canyons in the world would apply to canyons in general. Against a few conspicuously active canyons, there are probably a much larger number of canyons that are presently virtually inactive, at least in terms of bulk sediment transport. The apparently dormant systems which are numerous along the edges of the present continental shelves were active conduits during past periods of lowered sea level, when they connected continental drainage networks with sediment depocenters on the continental rise (e.g. Reid and Hamilton, 1990; Zaragosi et al., 2000). Flooding of the shelves during subsequent sea-level rise disconnected these systems from continental sediment sources. Although focussing of internal tides in the upper reaches of these canyons may represent a potentially powerful mechanism of sediment transport (e.g. Gardner, 1989), disconnection from major sources of sediment input seems to limit the effective net sediment transport coming down through these canyons. In addition, as observed in the Nazaré Canyon on the Portuguese margin, tidal energy may strongly diminish towards the lower reaches of the canyon and prove insufficient to mobilise and transport sediment (De Stigter et al., 2007).

Cases where seemingly dormant canyons fringing the shelf edge are periodically turned into active conduits of sediment transport have been recently described from the northwestern

* Corresponding author. Tel.: +31 222 369401; fax: +31 222 319674.
E-mail address: henko.de.stigter@nioz.nl (H.C. de Stigter).
[1] Present address: Nemus, Lda., Campus do LUMIAR – Edifício D, 1649-038 Lisbon, Portugal.

0967-0645/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.dsr2.2011.04.001

and central Mediterranean Sea (Canals et al., 2006; Palanques et al., 2006a; Trincardi et al., 2007). Here, dense water formed by excessive winter cooling over the shelf was observed to spill over the shelf edge and cascade down the slope through submarine canyons, entraining suspended sediments and organic material stirred up from the inner shelf by winter storms. This mechanism, so far only documented from canyons in the Mediterranean Sea, may be more widespread in view of the relatively common occurrence of dense shelf water cascading on ocean margins in other parts of the world (e.g. Ivanov et al., 2004). However, canyons known for substantial present-day sediment transport activity commonly head close to the shore, thereby capturing sediment from nearby rivers or long-shore sediment transport cells. The other common characteristic is that sediment transport in these systems is dominated by sediment gravity flows, including the entire spectrum from mass-wasting of canyon slopes to low-density turbidity currents. Examples are the Var Canyon (Mulder et al., 1998; Khripounoff et al., 2009), the Monterey

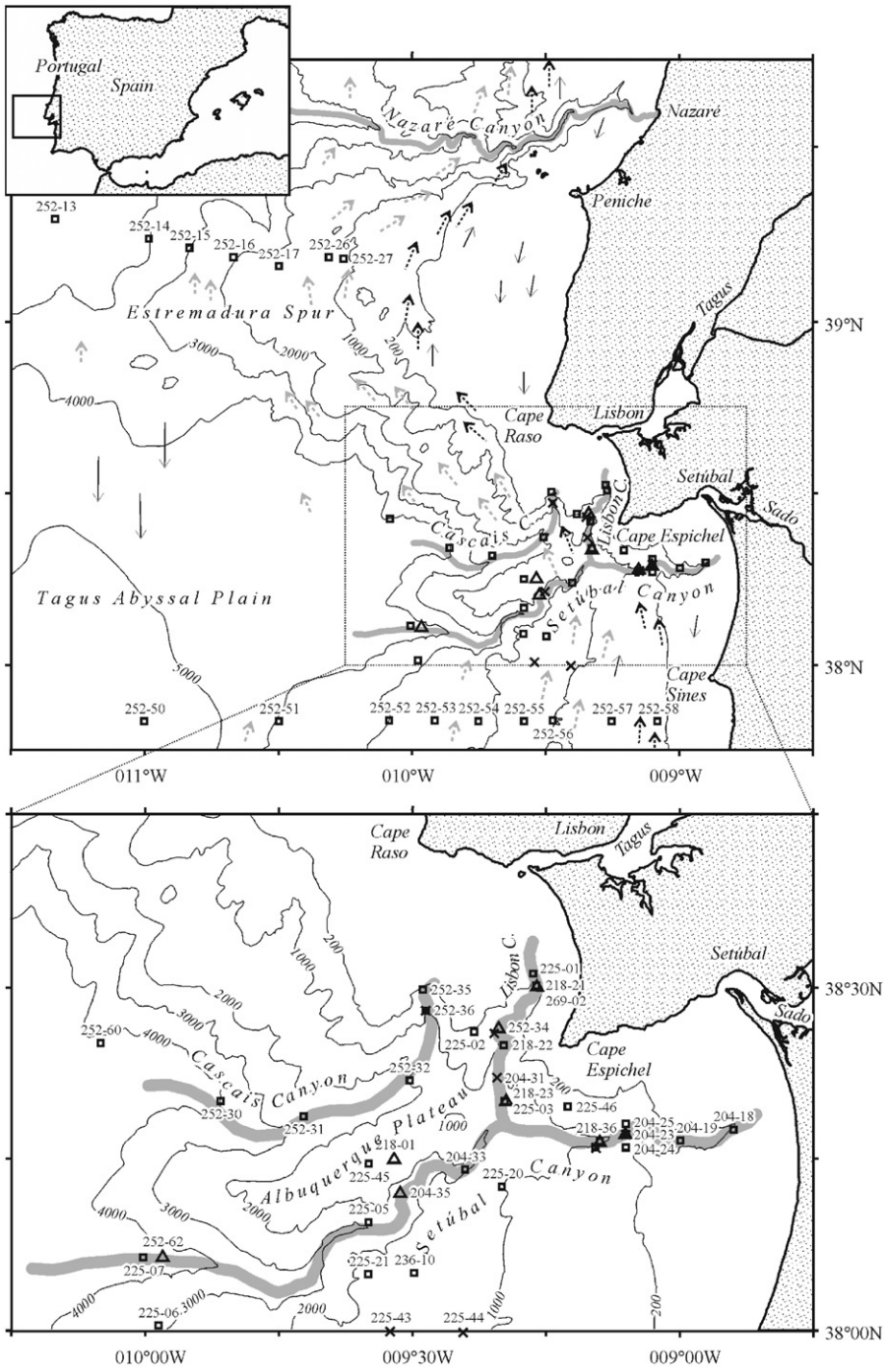

Fig. 1. Schematic map of the central Portuguese continental margin, showing topographic features mentioned in the text, surface and deep currents, and position of sampling stations. Inset shows location of the study area relative to the Iberian Peninsula. The lower panel shows enlargement of the Lisbon–Setúbal and Cascais Canyon area. Depth contours in metres according to GEBCO Digital Atlas (IOC, IHO and BODC, 2003). The axis of the canyons is outlined in grey. Main currents are schematically indicated by arrows: summer equatorward shelf current and winter poleward shelf current (continuous short), Portugal Current (continuous long), ENACW upper slope current (dashed black), MOW slope current (dashed grey long), NEADW and LDW slope current (dashed grey short). Stations are referred to by the last three numerals of the cruise number in combination with station number. Squares: box and multicores; crosses: piston cores; triangles: BOBO landers with attached sediment traps.