SUBMARINE CANYONS: PATHWAYS OF PARTICULATE MATTER TRANSPORT TO THE DEEP SEA.

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Submarine canyons are important transport routes for the transfer of particulate matter from the coastal ocean to the deep sea. Accumulations of sedimentary material originating from land and shallow seas, now found at the foot of the continental slope around the lower end of submarine canyons, form clear evidence of activity of these submarine valleys. But are canyons active at present? What is their role, and which processes force the transport of organic matter and sediment from the shelf to the deep sea? How do these contribute towards sediment accumulation on the continental margin? The EUROSTRATAFORM project puts observations on present-day sediment dynamics in a geological perspective.

Submarine canyons are a common feature on most continental margins. Ranging from relatively shallow systems to deeply incised sinuous valleys of huge dimensions, submarine canyons show a great morphological similarity with erosional landforms found on land. This similarity, in combination with the character, composition and structure of sediments at the lower end of submarine canyons, argue that erosive turbidity currents descending over the continental slope were responsible for the formation of these submarine valleys. However, submarine canyons are presently mostly sites of sediment accumulation, rather than of erosion. It is therefore often assumed that canyons were mainly active in the past during periods of low sea level, when large volumes of sediment were directly delivered at the continental slope. In the framework of the EU-funded EUROSTRATAFORM project (2002-2005), this hypothesis was tested in submarine canyons of the European Atlantic and Mediterranean continental margin. The wider scope of the project was to assess the presently active processes forcing particulate matter transport on the European margins in relation to the formation of sedimentary strata, and to define amounts of sediment involved.

MCG research focused on canyons off Portugal and in the Gulf of Lions. On the Portuguese continental margin, very active sediment transport was found in the Nazaré Canyon. The presence of terrigenous mud of recent age

BOBO lander (right) and vibrocorer (left) on deck of RV Pelagia.

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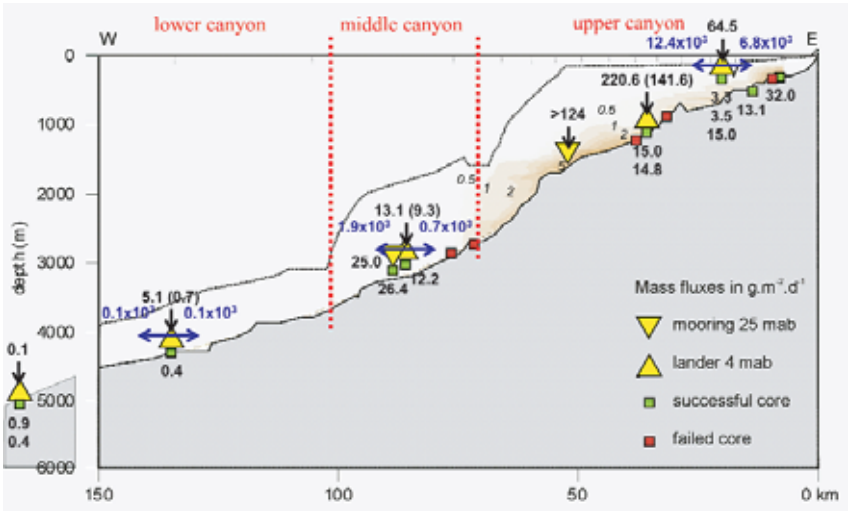
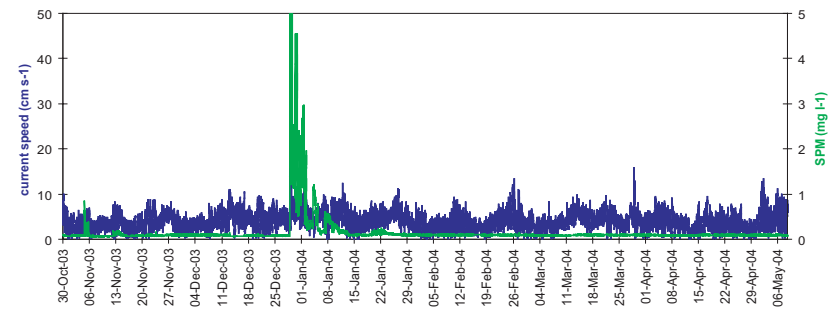


Axial section of the Nazaré Canyon, showing concentrations of particulate matter in the water (small font), and average mass fluxes of horizontal suspended particulate matter transport up- and down-canyon (blue font), depositional flux in sediment traps (bold black font) and accumulation rate in sediment cores (bold black font). Trap fluxes between brackets are averages excluding episodic sedimentation events. Sediment trap moorings of Eurostrataform partners CSIC-ICM (Barcelona) and IH (Lisbon) are indicated by downward pointing yellow triangle. A section of the adjacent shelf and slope N of the canyon is indicated by the dashed line.

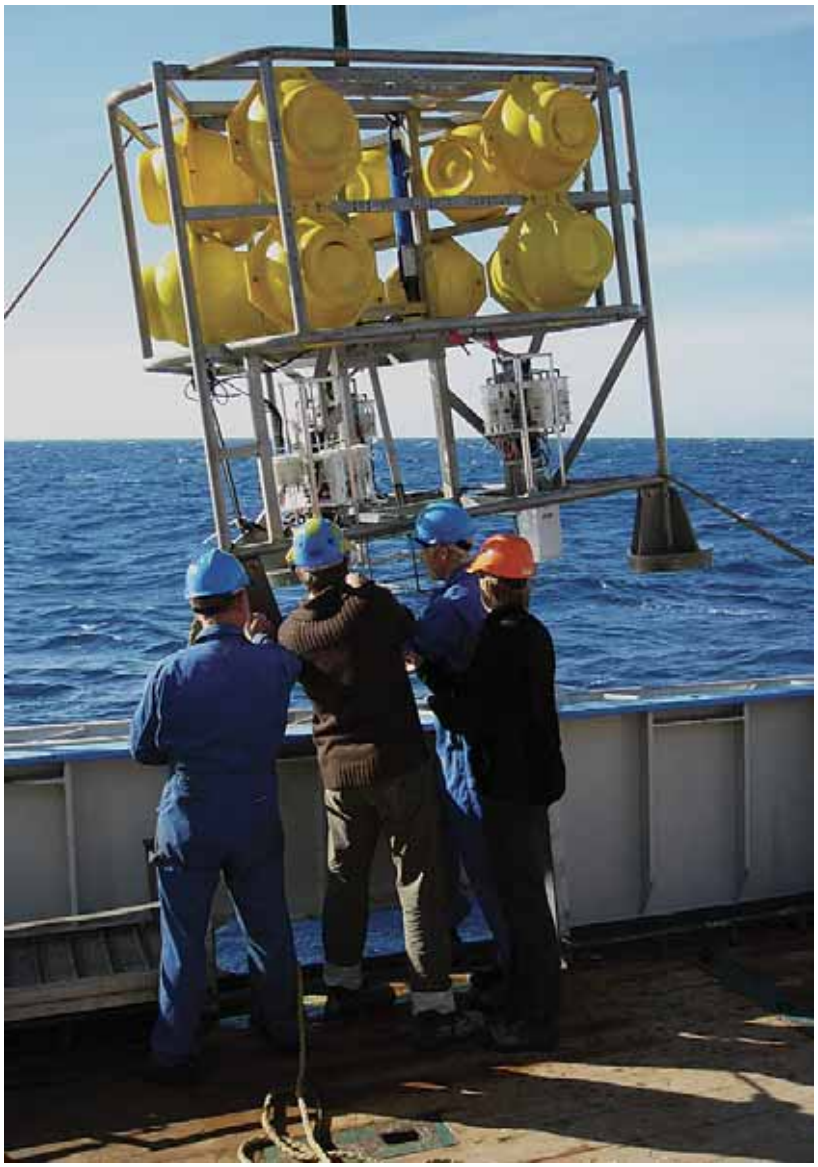
from the head of the canyon down to 5000 m depth clearly shows that this canyon forms an active conduit for transport of particulate matter between the coastal seas and the deep ocean. Processes responsible for this transport were identified by means of multiple long-term (up to 1 year) deployments of BOBO landers, which recorded near-bed currents and particle transport at depths down to 5000 m, as well as salinity and temperature. These data were complemented with CTD water column observations and sediment sampling by multi-, box- and pistoncorer.

At depths between 100 and 2700 m in the canyon, tidal currents frequently exceeding 30 cm.s^{-1} resuspend the muddy sediment from the seabed and subsequently transport suspended sediment along the axis of the canyon. Suspended particle concentrations near the bottom of the upper canyon typically range from 1 to 10 mg.l^{-1}. Net down-canyon flux of suspended sediment through a section of the upper canyon accounted for several kilograms m^{-2}.d^{-1}. Sediment deposition flux measured in sediment traps was several tens to hundreds of grams m^{-2}.d^{-1}. Permanent deposition on the canyon floor was in the order of a few grams to tens of grams m^{-2}.d^{-1}, two orders of magnitude higher than normally found at corresponding depths outside the canyon.

A drastic decrease in hydrodynamic energy in the middle part of the canyon around 3000 m leads to massive settling of suspended sediments and very high rates of sediment accumulation on the canyon floor of up to 25 grams m^{-2}.d^{-1}. Beyond this depth, bottom currents of 5-10 cm.s^{-1} are insufficient to resuspend and transport sediments



BOBO lander record of near-bed current speed and concentration of suspended particulate matter at 4300 m depth in the Nazaré Canyon with corresponding sediment trap samples, showing turbidity current event.



Recovery of the TROL lander.

further down the canyon. The sediment flux of less than 1 gram $m^{-2}.d^{-1}$ consists for a large part of skeletal carbonate produced by pelagic organisms that lived in the surface water. On longer timescales, however, sediment supply to the lower canyon appears to be dominated by episodic occurrence of fast turbidity currents carrying sediments from the upper canyon. These events, possibly triggered by winter storms on the shelf, are usually only recorded in long time-series observations with bottom landers. One event occurring in December 2003 was recorded by a BOBO lander deployed at 4300 m depth.

On a geological timescale, particulate matter transport through the canyon is an active and relatively fast process, but from the perspective of deep-sea biota most of the metabolizable organic material is degraded during transit through the upper half of the canyon. This was demonstrated by in-situ measurements of geochemical reactivity of canyon sediments with the TROL lander, and by assessment of meio- and macrofauna distribution in the canyon.

Future research in the canyons by the MCG group will be directed at the dispersal of anthropogenic contaminants in the Portuguese canyons, and characteristics of canyon biota in relation to the physical and biogeochemical environment.

Stalked crinoid and soft corals attached to a rocky wall of Nazaré Canyon, 2700 m. Width of the image is about 3 m.