

Short-Timescale Strata Formation on a Canyon-Dominated Margin: Assessing the Link Between Shelf and Slope Systems

Beth Mullenbach
Texas A&M University
Department of Oceanography
College Station, TX 77843-3146
phone: 979 845-8479 fax: 979 845-6331 e-mail: bmullenbach@ocean.tamu.edu

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LONG-TERM GOALS

Prior to recent work, it was commonly thought that sediment did not escape to areas seaward of the shelf break during the present highstand of sea level because of sediment trapping in estuaries and on broad continental shelves. However, recent results (including those from the STRATAFORM Program) have revealed that a significant amount of sediment can accumulate on continental slopes and escape to the deep sea via submarine canyons (e.g., Mullenbach et al., 2004; Puig et al., 2003). These studies reveal the importance of off-shelf sediment exchange during present conditions; however, the factors that control sediment transfer across shelf breaks are not well understood, particularly near canyon heads. The long-term goal of this research is to assess how a bathymetrically complex shelf break (i.e., with many canyons) affects the link between shelf and slope sedimentary systems.

OBJECTIVES

This research (as part of the EuroSTRATAFORM Program) focuses on understanding the link between the shelf and slope sediment dispersal systems on the Gulf of Lions (GOL) margin, an area with many submarine canyons. The seabed study aims to achieve the following objectives: determine the primary pathways of seaward sediment dispersal over the shelf and slope, estimate the timing of sediment delivery to the slope, delineate the deposition/accumulation patterns on the shelf and slope, and estimate the amount of sediment sequestered by the canyons.

APPROACH

Previous research has suggested that the western GOL may be the primary outlet for sediment due to narrowing of the shelf and the general east-to-west circulation pattern. This project has focused on the western GOL, including the western shelf and Cap de Creus and Lacaze-Duthiers Canyons, where seaward escape is expected to be most intense (Fig. 1). Information on the spatial and temporal changes in seabed characteristics was collected (using shipboard coring techniques). Grain sizes, sedimentary structures, radioisotopic signatures and accumulation rates were monitored during different seasons to capture the timing of sediment delivery to the shelf and canyon heads. In addition, cores were collected across the western shelf and canyons to define the spatial patterns of sediment accumulation. Field and laboratory resources were pooled with C. Nittrouer to aid in the collection and analysis of cores.

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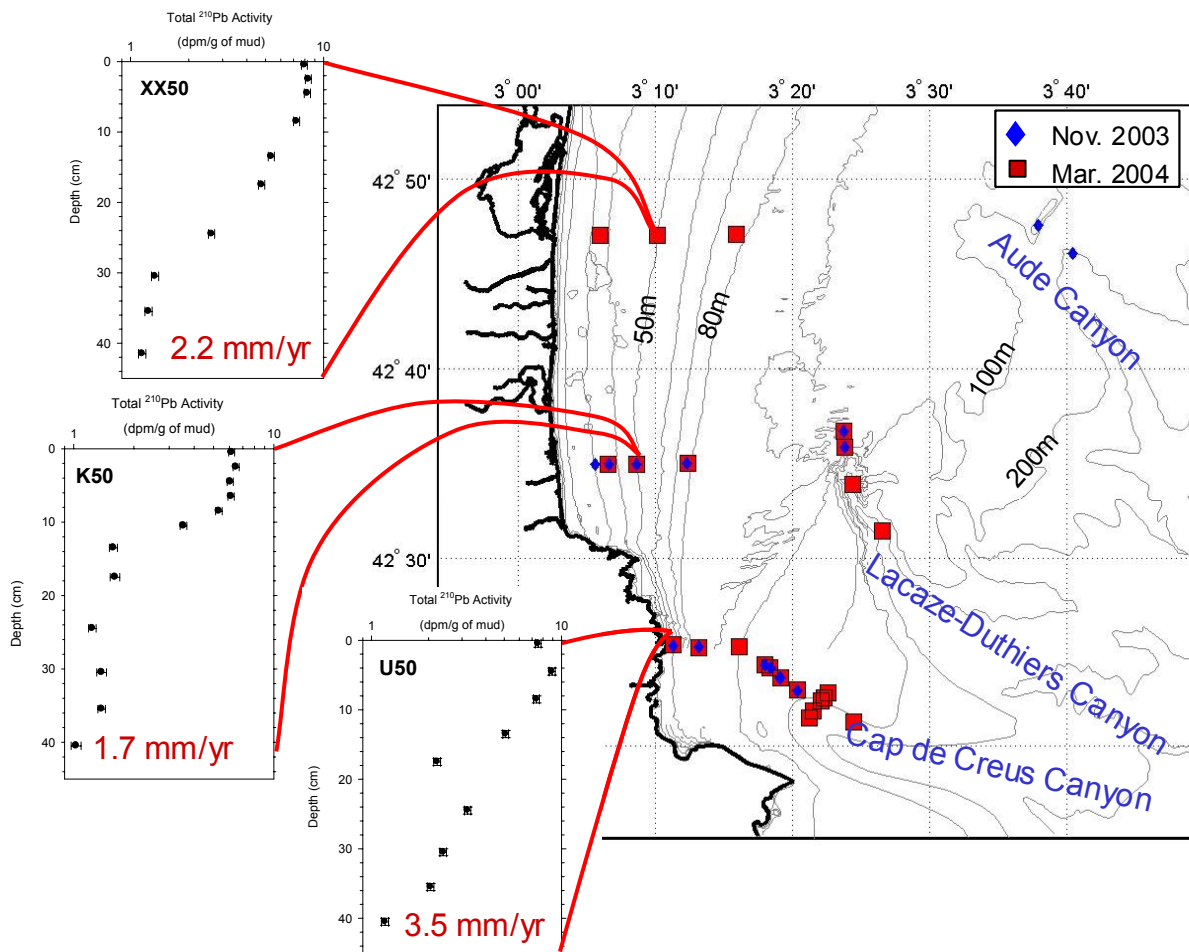


Figure 1. Map of the western Gulf of Lions, showing the core sample locations. [^{210}Pb data indicate that accumulation rates are increasing toward the south (narrowing shelf and near the head of Cap de Creus Canyon)]

WORK COMPLETED

The primary thrust of the FY04 work was to conduct a coarse survey of seabed characteristics across the entire western GOL study area and to use these preliminary data to aid in the future placement of focused coring efforts and deployment of instruments (see “Related Projects”). Box cores were collected in November 2003 and March 2004 on the R/V *Tethys II* in collaboration with EU scientists X. Durrieu de Madron and P. Puig. Cores were collected along 3 across-shelf transects and within the Aude, Lacaze-Duthiers, and Cap de Creus Canyons (Fig. 1). Analyses of sedimentary structures, grain sizes, radioisotopic signatures (^7Be , ^{210}Pb , ^{234}Th) and accumulation rates (^{210}Pb) have been completed for many of these cores and continues for the remaining cores in FY05.

RESULTS

An along-shelf transect of cores collected at 50 m water depth in March shows an increase in accumulation rates (~ 2 to ~ 4 mm/yr) from north to south (Fig. 1). The accumulation rates appear to increase in the direction the large-scale circulation on the shelf and slope (to the Southwest) and

toward the narrowing shelf. These data suggest that sediment input from the Rhone and the many smaller rivers to the west may be funneled toward the narrowing shelf in the western GOL. More detailed sampling across the shelves of the greater GOL are needed to definitely support this hypothesis. However, these shelf data clearly indicate that significant amounts of sediment are reaching the seabed very near the Cap de Creus Canyon head.

Analyses of cores from within the Cap de Creus Canyon indicate that sediment is accumulating in the canyon during the present sea level high-stand (Fig. 2). Cores collected at shallow depths within the canyon (150 m) reveal a distinct sandy layer with detectable excess ^{210}Pb activities (indicating deposition <100 years ago) that unconformably overlies a highly-consolidated mud with only supported levels of ^{210}Pb (deposited >100 years ago). This coarse material was seen in both November and March and appears to extend as deep as 400 m. In addition, the high-resolution multibeam map of Cap de Creus Canyon (collected by D. Orange and others) shows that this core was from what appears to be a wedge of sediment filling in the canyon head. Deeper within the canyon (500 m), core data show a blanket of unconsolidated mud (13 cm thick) that was deposited within the last 100 years; the canyon flanks are also observed to be accumulating at varying rates. These data are significant because they suggest that (1) both coarse and fine grained sediment from the GOL are being intercepted and funneled into the canyon during the present sea level high-stand, and (2) Cap de Creus is an important conduit for the seaward escape of sediment in the GOL.

Sedimentary structures and radioisotopic depth profiles from cores within the canyon suggest that the surface sediments have been emplaced over relatively short timescales. Most cores collected deeper in the canyon reflect a shift from highly consolidated basal muds or coarse material to unconsolidated sediments near the surface, some with very distinct interfaces. One such core (at 500 m in the canyon thalweg) shows similar excess ^{210}Pb activities in both the upper and lower layers down to the base of the core (18 cm), indicating that both were likely emplaced within the last ~20 years (one half-life for ^{210}Pb). The layered nature of these deposits may reflect a deposit formed by (1) two phases of a single transport event, possibly a gravity-driven flow or (2) a shift in sediment source over short timescales (on the order of years). Future core sampling over smaller spatial scales, in conjunction with analysis of the high-resolution bathymetry by D. Orange and others, will aid in the interpretation of the transport mechanisms responsible for these deposits. Regardless of the mechanism, these preliminary data suggest that Cap de Creus is an important outlet of sediment from the continental shelf in the western Gulf of Lions.

IMPACT/APPLICATIONS

Recent studies have shown that voluminous amounts of sediment can be transported from the shelf through present-day canyons in areas where the sediment source is near the canyon head (i.e., a river discharging onto a narrow shelf) (e.g., Kineke et al., 2000). The GOL data support these results showing active sediment escape through a submarine canyon that is adjacent to a narrow shelf. However, these data also offer new insights into other types of canyon systems that may be important during highstand conditions: both coarse and fine grained material are transported off the shelf through a present day canyon, even though it is not adjacent to a major river sediment source. These data suggest that the shelf break morphology exerts strong controls on the link between shelf and slope systems.

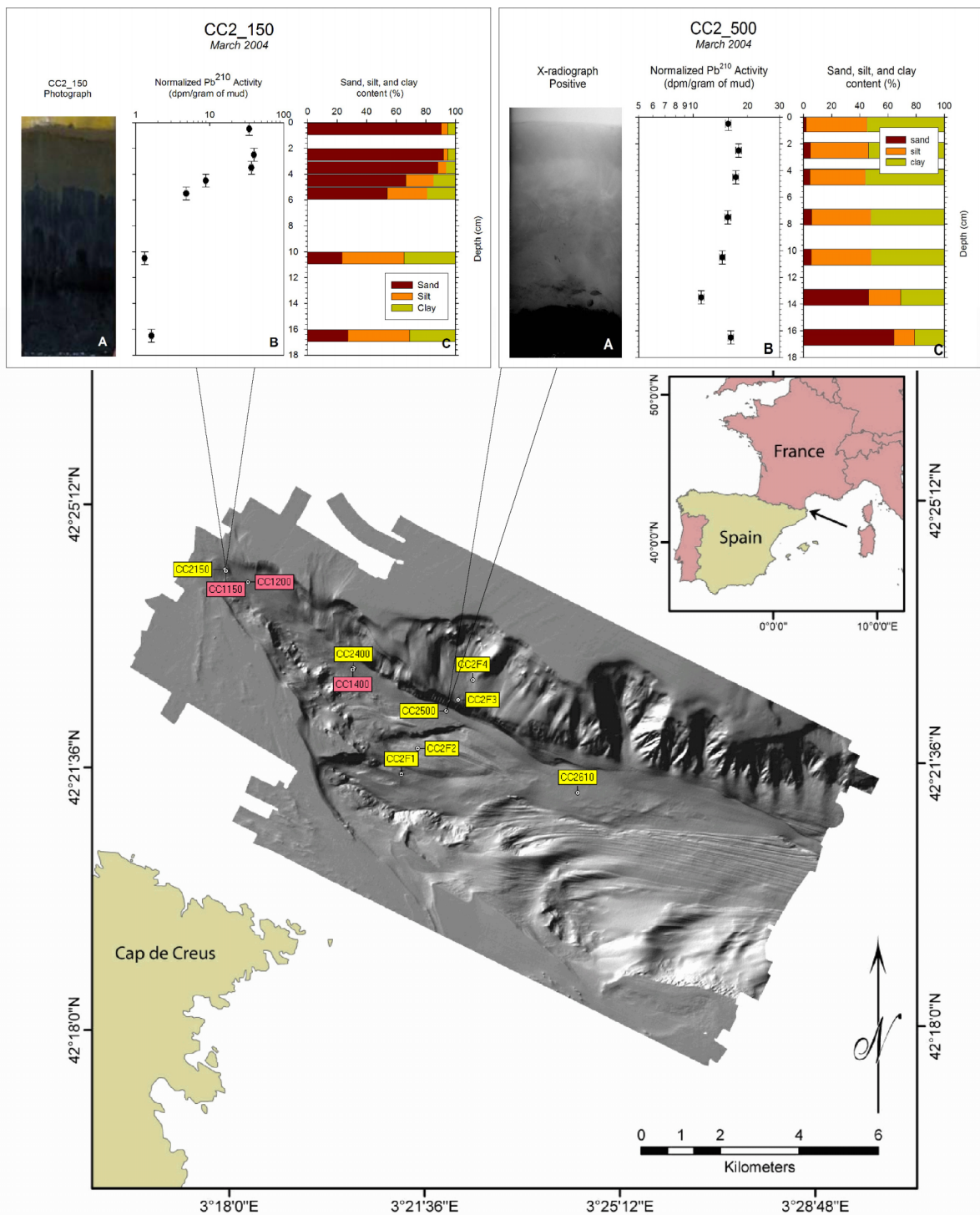


Figure 2. High-resolution bathymetric map of Cap de Creus canyon with core locations.
[A recent sand layer overlies older overconsolidated mud at 150-m water depth, whereas a recent mud layer overlies a recent sand deposit at 500-m water depth, as indicated from the photograph/x-radiograph, grain size and ²¹⁰Pb data. We acknowledge Fugro Surveys Ltd. and AOA Geophysics Inc. for acquiring, processing, and providing the full resolution Cap de Creus data set (multibeam bathymetry, multibeam backscatter, and sub-bottom profiler data). Data acquired with Fugro's M/V "Geo Prospector", Simrad EM300 and GeoAcoustics 534A.]

RELATED PROJECTS

Interdisciplinary collaborations are a necessary component of the EuroSTRATAFORM program, including the free exchange of resources and data. The seabed-sampling plan is extensive in its temporal and spatial coverage, therefore, pooling of resources with C. Nittrouer for analysis of radioisotopic and grain size data will continue. In addition, we anticipate strong collaboration with the researchers collecting time series data, which will greatly aid in the interpretation of the seabed samples collected for the short-timescale analyses (X. Durrieu de Madron, P. Puig, A. Ogston, C. Sherwood, G. Kineke, R. Sternberg). Collaboration with D. Orange and others will continue, with the goal of linking the seabed data to observed morphological features from the high-resolution bathymetry.

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