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Recent sediment transport and deposition in the Cap-Ferret Canyon, South-East margin of Bay of Biscay

Sabine Schmidt [a,*], Hélène Howa [b], Amy Diallo [a], Jacobo Martín [c], Michel Cremer [a], Pauline Duros [b], Christophe Fontanier [b], Bruno Deflandre [d], Edouard Metzger [b], Thierry Mulder [d]

[a] CNRS, EPOC, UMR 5805, F-33400 Talence, France
[b] UMR CNRS 6112 LPGN-BIAF, Laboratoire des Bio-Indicateurs Actuels et Fossiles, LUNAM Université, Université d'Angers, 2 Boulevard Lavoisier, 49045 Angers Cedex, France
[c] Instituto de Ciencias del Mar (CSIC), Paseo Marítimo de la Barceloneta 37-49, 08803 Barcelona, Spain
[d] Université Bordeaux, EPOC, UMR 5805, F-33400 Talence, France

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A B S T R A C T

The Cap-Ferret Canyon (CFC), a major morphologic feature of the eastern margin of the Bay of Biscay, occupies a deep structural depression that opens about 60 km southwest of the Gironde Estuary. Detailed depth profiles of the particle-reactive radionuclides ^{234}Th and ^{210}Pb in interface sediments were used to characterise the present sedimentation (bioturbation, sediment mass accumulation, and focusing) in the CFC region. Two bathymetric transects were sampled along the CFC axis and the southern adjacent margin. Particle fluxes were recorded from the nearby Landes Plateau by means of sediment traps in 2006 and 2007. This dataset provides a new and comprehensive view of particulate matter transfer in the Cap-Ferret Canyon region, through a direct comparison of the canyon with the adjacent southern margin. Radionuclide profiles (^{234}Th and ^{210}Pb) and mass fluxes demonstrate that significant particle dynamics occur on the SE Aquitanian margin in comparison with nearby margins. The results also suggest show three distinct areas in terms of sedimentary activity. In the upper canyon (<500 m), there is little net sediment accumulation, suggesting a by-pass area. Sediment focusing is apparent at the middle canyon (500–1500 m), that therefore acts as a depocenter for particles from the shelf and the upper canyon. The lower canyon (>2000 m) can be considered inactive at annual or decadal scales. In contrast with the slow and continuous accumulation of relatively fresh material that characterises the middle canyon, the lower canyon receives pulses of sediment via gravity flows on longer time scales. At decadal scale, the CFC can be considered as a relatively quiescent canyon. The disconnection of the CFC from major sources of sediment delivery seems to limit its efficiency in particle transfer from coastal areas to the adjacent ocean basin.

1. Introduction

Submarine canyons are spectacular topographic features that are usually presented as natural conduits for the transfer of particulate matter from the shelf to the deep ocean on both passive and active continental margins (Carson et al., 1986; Gardner, 1989; Palanques et al., 2005; De Leo et al., 2010). Modern sedimentation rates have been found to be substantially higher in some submarine canyons than on the adjacent open slopes at similar depths (Carpenter et al., 1982; de Stigter et al., 2007; Mas et al., 2010). Large accumulations of sediment and detritus have been reported on the floors of canyons in different parts of the word (McHugh et al., 1992). Substantial amounts of these particles are not produced locally within the canyon, but transported from shallow coastal areas typically enriched in nutrients (Mullenbach and Nittrouer, 2000; Puig et al., 2003; Kao et al., 2006; Tesi et al., 2008; Pasqual et al., 2011). Thus, the chanelling of particulate transport within canyons gives rise to high planktonic and benthic production (Stefanescu et al., 1994; Vetter, 1994; Cunha et al., 2011; Hunter et al., 2013).

In spite of numerous studies conducted in submarine canyons around the world, the mechanisms governing the present-day transfer of particulate matter through submarine canyons, as well as the temporal scales involved, are not fully understood at present. This knowledge is important to understand why canyons

* Correspondence to: UMR 5805 EPOC, Université Bordeaux 1, Avenue des Facultés, 33405 Talence Cedex, France. Tel.: +33 540 00 33 15; fax: +33 540 00 33 16.
E-mail address: s.schmidt@epoc.u-bordeaux1.fr (S. Schmidt).

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are "hot spots" for biological activity, and how changes in particle supply (quality and intensity) could affect canyon ecosystems and associated productivity and biodiversity. The question is relevant as submarine canyons are extremely frequent features that incise into continental shelves and slopes of all continental margins. Harris and Whiteway (2011) have recently published the first global inventory of large submarine canyons, identifying a total of 5849 separate canyons in the world's oceans.

In the North-East Atlantic, the Bay of Biscay is bordered, from north to south, by the Celtic, Armorican, Aquitanian and North-Iberian margins, and cut by almost 35 submarine canyons (Reid and Hamilton, 1990; Bourillet et al., 2007; Mulder et al., 2012; Hunter et al., 2013, and references herein). The Aquitanian continental margin is constituted by a sedimentary basinward prograding prism over the marginal Landes Plateau. Two main canyons, the Cap-Ferret Canyon (CFC) and the Capbreton Canyon, have contributed to the construction of a single elongated deep-sea turbidite system, the Cap-Ferret system (Cremer et al., 1985; Fig. 1). The Cap-Ferret Canyon is a deep structural depression that opens off a 60 km wide shelf, and where an important drainage network converges from multiple incised channels. Southward, the Capbreton Canyon forms a deep and narrow E–W incision that begins 200 m from the shoreline and deepens regularly over 270 km down to the junction at 3400 m water depth with the S–N directed Santander Canyon, before merging 75 km further north with the CFC (Fig. 1).

The objective of this work is to characterise the present-day sediment transport and deposition within CFC using a multi-tracer approach. We report here detailed depth profiles of the particle-reactive radionuclides ^{234}Th ($T_{1/2}$=24.1 days) and ^{210}Pb ($T_{1/2}$=22.3 years) in interface sediments collected from 151 to 3168 m depth in the CFC region during the LEVIATHAN cruise (June, 2009). Two bathymetric transects were sampled, along the canyon axis and the southern adjacent margin. We present also downward particulate mass fluxes recorded, by means of sediment traps, in the nearby Landes Plateau between 2006 and 2007. Results of a first investigation of the CFC conducted in 1990 (ECOFER—ECOsystème du canyon de cap-FERet; Heussner et al., 1999) are also included. This dataset is discussed in order to compare the present sedimentation framework (bioturbation, sediment mass accumulation, and focusing) of the CFC and of the adjacent open slope and to define a conceptual framework of the sedimentary activity along the CFC. Based on a comparison with other canyons, we suggest the "Type II" canyon category, as defined by Jobe et al. (2011), to be subdivided into at least two classes.

2. Materials and methods

2.1. Settling particles in the water column

During the ANR-FORCLIM programme, a long-term mooring equipped with two sediment traps (PPS5 TECHNICAP; sampling area 1 m^2) was deployed at the deepest station 6′, on the Landes Plateau (southeast Aquitanian margin) (Fig. 1, Table 1). Settling particles were sampled at two water depths, 800 m and 1700 m respectively, over a 17-month period, from June 22, 2006, to November 23, 2007. Details on moorings, sample processing and data are given by Schmidt et al. (2009) and Kuhnt et al. (2013). Station 6′ (44°33′N, 2°45′W, 2000 m water depth) is also labelled WH in previous works on the Aquitanian margin; the label 6′ is preferred in this work for coherence with the notation of the other sites on the slope transect. During ECOFER, two trap moorings were also deployed, but in the canyon axis, at 2300 and 3000 m water depth, for 14 months from June 1990 to August 1991. Details on moorings and sample processing are given by Heussner et al. (1999).

2.2. Interface sediment

Our investigation deals with interface sediments obtained in the CFC and on the nearby southern margin, the Aquitanian margin down to the Landes Plateau (Fig. 1; Table 2). During the LEVIATHAN cruise (June 2009), two bathymetric transects were sampled between 153 and 3168 m water depth using a multicorer (Oktopus, MUC 8/100) to ensure a good recovery of the water–sediment

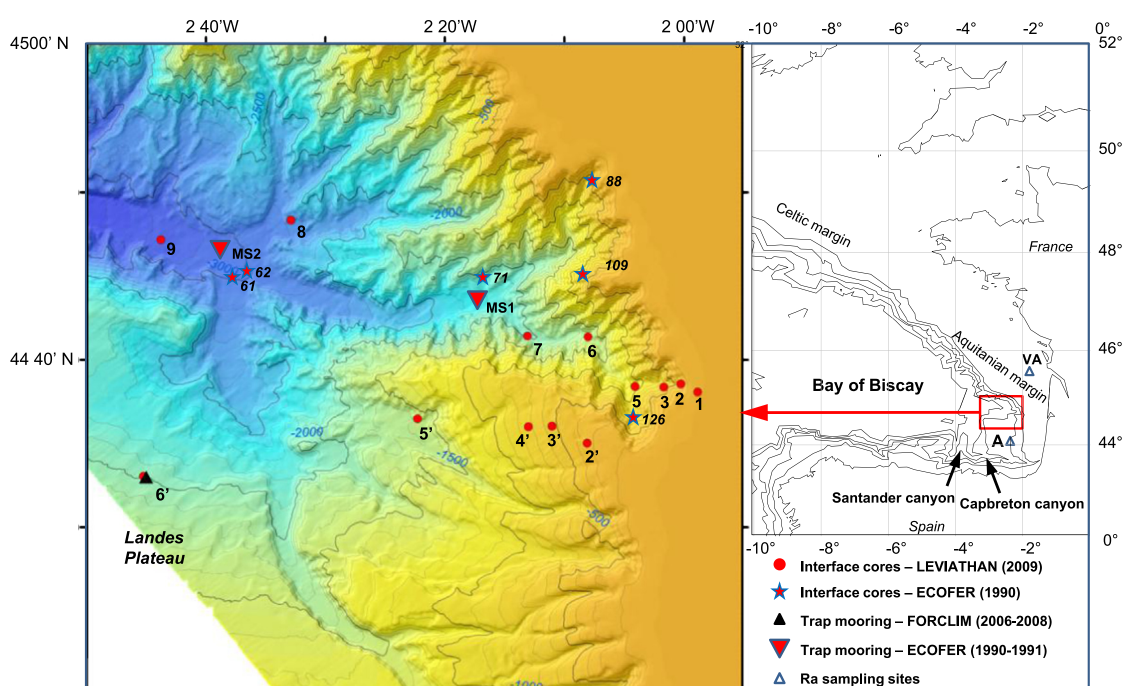

Fig. 1. Enlarged image of the Cap-Ferret Canyon in the S-E Bay of Biscay showing the location of the multicores collected at various depths in the canyon area and along a southern adjacent transect on the Aquitanian margin. Locations of trap moorings and sampling sites of dissolved ^{226}Ra are also indicated.