AGU FALL MEETING
San Francisco | 12–16 December 2016

Present-day sedimentation rates in the Bay of Brest (NW France) and its evolution since the last millenaries

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Scientific context

This study focuses on the sedimentological evolution in the bay of Brest during the last Holocene transgression. This bay is an original confined tide-dominated estuary system connected to the Atlantic ocean by a narrow straight [**Fig.1**]. It is characterized by a well-developed channel which is connected to the main rivers : Aulne and Elorn. The deeper central basin (50m depth), where are observed the maximum tidal current intensities [**Fig.2**], is covered by coarse and shelly sediments [**Fig.3**]. Embayments corresponding to the shallowest parts (< 10m depth), are characterized by silty sediments locally colonized by maërl beds or invasive gastropod (*crepidula sp.)* [**Fig.3**]. Sediments are mainly supplied by the Aulne River which has a mean annual discharge (Q) 5 times higher than the Elorn one [**Fig.2**]. Investigated deposits correspond to the late Holocene sedimentation in context of high sea-level (last 2-3 kyr cal B.P.) and constitute a superficial sedimentary unit averaging 1-2 meters in thickness (Gregoire *et al.*, *Marine Geology in press*).

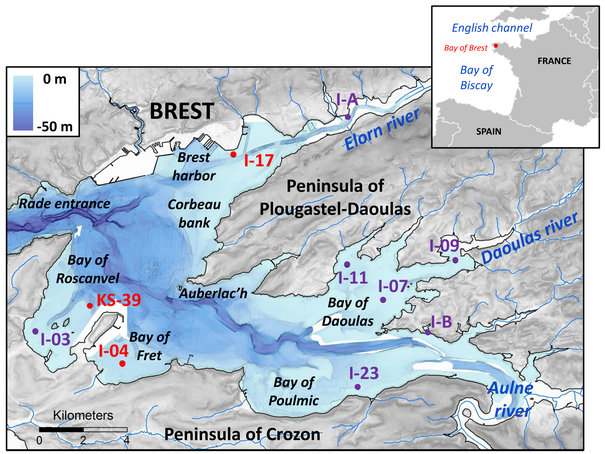


Fig.1: Location map of the bay of Brest and of the cores collected in 2014 and 2015 for this study (I : interface corer ; KS : kullenberg gravity corer)

Objectives

- Determine the sediment rates with a multi-decadal approach
- Compared with the last millennial results
- Estimate the evolution of sedimentation deposits in term of sedimentary budget

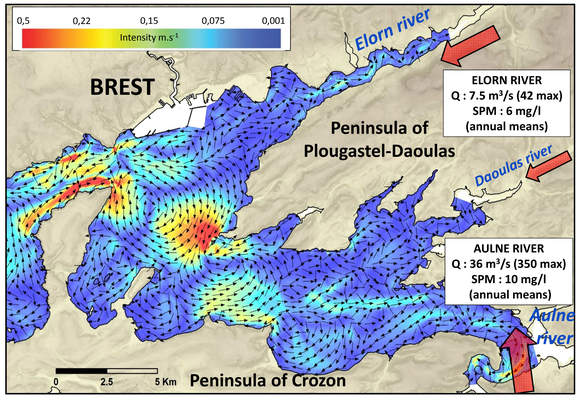


Fig.2: Tidal residual currents at the bottom (1 m) from the 31/01/2014 to the 03/02/2014 during spring tides (coef. 100) (from S. Petton results, *pers. com.*)

The modern tidal circulation controls the sedimentary distribution pattern. The flood generates a residual vortex in the central basin while in the estuaries the currents borrow the paleochannels, which are reused for the discharge during the ebb. The shallower parts of the bay, less impacted by tidal currents, are subject to fine sediment deposition [**fig.3**]. Since the XIXth century, the bay of Brest undergoes an increase of human activities with the extension of the military and commercial harbors, as well as the dredge fishery. These modifications may have generated local changes in the sedimentary circulation and processes deposition.

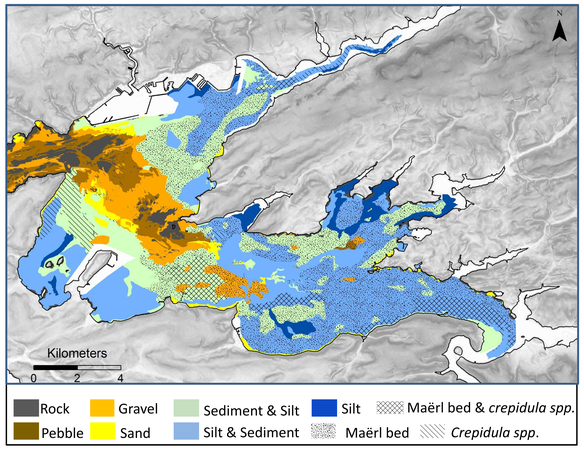
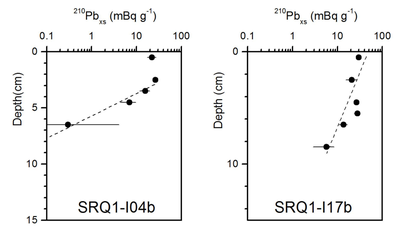


Fig.3: Sedimentary distribution of the bay of Brest according to the Folk classification (Gregoire *et al.*, 2016)

Methodology & Results

Centennial time scale based on $^{210}Pb_{xs}$

From vertical profiles of $^{210}Pb_{xs}$ in sediment, it is possible to determine sedimentation rates. $^{210}Pb_{xs}$ is calculated as the difference of the measured activities of ^{210}Pb and ^{226}Ra, both measured using a low background-high efficiency well-type gamma detector.



Large differences in maximum penetration depths of $^{210}Pb_{xs}$
- from 4-5 cm to > 30 cm
- reveal contrasted present-day sedimentation rates throughout the Bay of Brest.

Fig. 4: Examples of $^{210}Pb_{xs}$ profiles with depth in sediments and corresponding sedimentation rates.

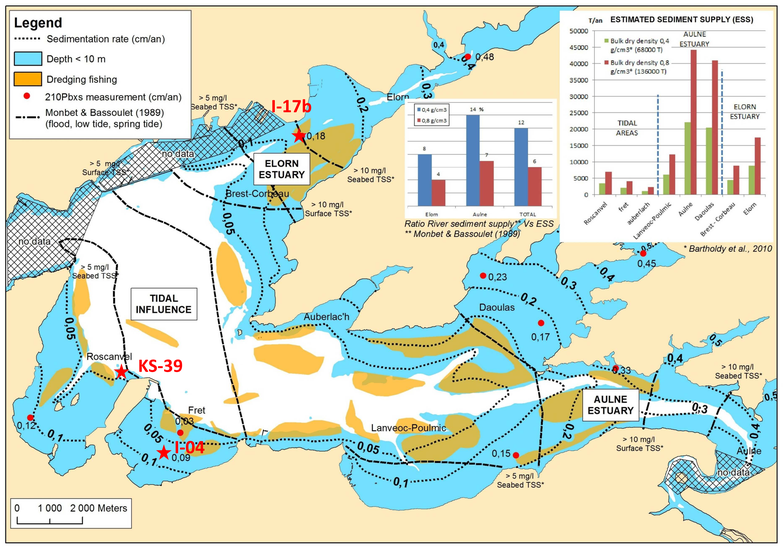
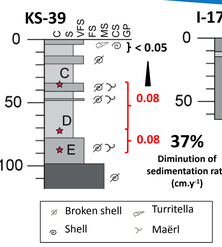


Fig.6: Using measurements of excess ^{210}Pb and ^{137}Cs to interpolate sedimentation rates in the bay of Brest

Millennial time scale, based on AMS ^{14}C

AMS ^{14}C measurements were performed on $CaCO_3$ from marine shells, taken in life position, and from benthic foraminifera. Ages were calculated considering a marine reservoir of 325 year (Tisnérat-Laborde *et al.*, 2010) and thanks to the Calib Rev 7.0.4 software (Stuiver *et al.*, 2013). Sedimentation rates were estimated from depth intervals between two ^{14}C measures. [**fig.5**].



Label	Depth (cm)	^{14}C corrected (yr BP)	Error
A	I-17b (29 cm)	**898**	108
B	I-17b (58 cm)	**1008**	91
C	KS-39 (35 cm)	**1359**	67
D	KS-39 (73 cm)	**1856**	140
E	KS-39 (87 cm)	**2025**	107

Fig. 5: KS-39 and I-17b Descriptive log and ^{14}C ages

Characterics of the sedimentation rates

Negligible in the central part of the bay, the sedimentation rate gradually increases up to 0.5 cm/yr at the river approaches [**fig.6**]. Westward in the shallowest waters of the bays of Roscanvel, Fret and Auberlac'h (tidal areas), sedimentation rates remain rather low, (< 0.2 cm/yr). Based on the map of interpolated sediment rates [**fig.6**], the sediments deposited each year in the bay is comprised between 68 and 136 kT. The range is explained by the difference of bulk dry density used in the estimation. Sediments are deposited preferentially in the Aulne and Elorn estuaries (respectively 72 % and 18 %).

Factors controlling modern sedimentation ?

Even if estimates are not very accurate, the river supply alone cannot explain the total sediment accumulation, about 10 times lower than the total record (10 kT). However, the dredging fishing (De Madron, 2005) can remobilize more than 50 kT of sediment each year. Thus the current sediment deposition should have been maintained by the contribution of anthropic activities (dredging) recycling early Holocene sediments which are redistributed by the local tidal circulation, and participate finally to the sedimentary budget of the bay.

Evolution since the last millenaries ?

The difference between $^{210}Pb^{ex}$ and the ^{14}C sedimentation rates highlight a decrease in deposition intensity (> 30 %) since 2 kYears. This diminution needs to be confirmed, but we hypothesize it can be correlated with the decrease of sediment supplied from the rivers due to the human activities like the construction of dams and modification of agricultural practices in the watershed. The extrapolated sediment rate imprinted the decoupling evolution in watershed sediment production and marine hydrologic intensities in the two estuaries during the Late-Holocene period.