

“La Grande Vasière” mid-shelf mud belt : Holocene sedimentary structure, natural and anthropogenic impacts

Jean-François Bourillet¹, Jean-Marie Jouanneau², Claire Macher³, Pierre Le Hir⁴
and Filipa Naughton²

¹ IFREMER-Géosciences Marines-Environnements sédimentaires, BP 70, 29280 Plouzané, France
jfb@ifremer.fr

² Université Bordeaux I, DGO, UMR EPOC 5805, av. des facultés, 33405 Talence Cedex FRANCE

³ IFREMER- Economie Maritime, BP 70, 29280 Plouzané, France

⁴ IFREMER –Dynamique de l’environnement côtier-PHYSED, BP 70, 29280 Plouzané, France

Abstract

The Quaternary sequence of the Armorican continental shelf in the Bay of Biscay is setting down above one regional erosion surface, which has been produced by successive transgressions that occurred during the last deglaciations. The few meters of the sequence covers the Holocene period and it is composed by two clean and sandy units at the base followed by thin (few decimetres) clayed sand unit and mud (few millimetres) unit in the top. The two upper units form the improperly called “La Grande Vasière” area over 8,000 km². The settlement of these sedimentary units occurred since 8,000 C¹⁴ years BP, previously to other coastal mud fields setting of the shelf. Historical grain size data show that the mud field has lost part of the fine content during the last 30 years. “La Grande Vasière” evolves at the rhythm of the cycles of deposition and remobilization. Fluvial supplies and tide currents are the major control factors of the deposition. Bioturbation enhances the homogenization of the surficial sediments. Waves and anthropogenic actions are the main factors for the remobilization of the fine particles. The action of both the storms and the bottom trawls are tentatively quantified.

1. Introduction

The Armorican continental shelf (from N48° to N46°) constitutes the central part of the northern shelf of the Bay of Biscay. It is a wide (200 km from the coast to the shelf-break at 170 m below sea level) wave dominated shelf on a tectonically passive margin. The well-developed Tertiary sequence shows a prograding prism with Pliocene unit at the edge of the shelf (Boillot et al., 1971 ; Guillocheau et al., 2003).

Above these sequences there are nearly ten meters of Quaternary sediments that result from both the low subsidence and the low sediment supply rates (Vanne, 1977). Partly infilled palaeovalleys incise slightly the inner and the outer segments of the shelf (Menier, 2004, Menier et al., in press). The 225 km by 40 km “La Grande Vasière” area (Fig.1) occupies the medial sector (100m bsl) and was defined as a thin (<1m) sandy silt unit (Pinot, 1974 ; Lesueur et al., 2002). This area is a key fishing sector for numerous species. In order to carry out an ecosystemic study of the Bay of Biscay, Ifremer initiated an interdisciplinary program in 2001. The geological history, the sedimentary structure and the impact of natural and anthropogenic factors on the evolution of “La Grande Vasière” were some of the questions proposed by this program.

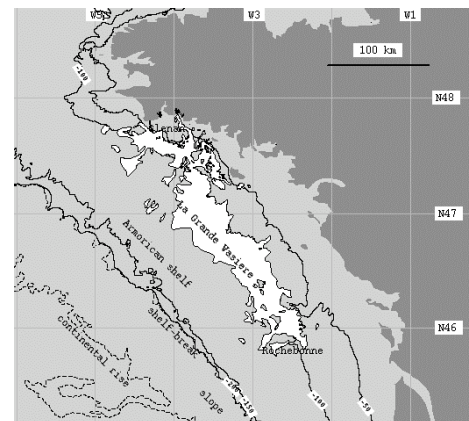


Figure 1: The Armorican shelf and “La Grande Vasière” mud field (in white) from Bouysse et al., 1986.

2. Holocene sedimentary sequence

From the South of Ireland to the Spanish margin, the low preservation of the Quaternary sequences (< few tens of meters) could be explained by the low subsidence rate of this margin, low sedimentary supplies from the continental drainage basins associated with an ocean wards open shelf. Geophysical studies from the TROPICAL sea survey (Bourillet et al., 2003) allow determining the geometry of the soft sediments (Fig.2) over a regional surface, which erodes the Tertiary sequence. Absolute dating of the basement of the cores retrieved in one palaeovalley infill (11,980 C¹⁴ yr BP) just below this surface argues for a Holocene sedimentary cover.

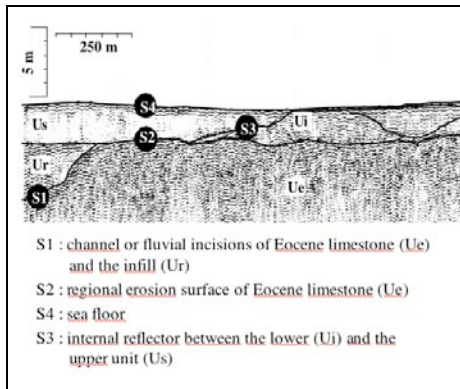


Figure 2 : Internal structure of the Holocene sequence – Chirp profile #Tro-8

Sedimentological analysis of cores pointed out two layers not thick enough to be detected by acoustic. Therefore, the typical sequence could be defined as the succession of :

- the “lower unit” – several meters of clean, bioclastic coarse to medium sand without obvious internal structure. The associated fauna indicates a deposition during a sea level stand of 0 to 50 m of water depth (Andreieff et al., 1971),
- the “upper unit” – several meters of clean, medium to fine grey sand roughly organized on E-W oriented features deposited during a sea level stand between 50 to 100 m of water depth (Andreieff et al., 1971),
- the “surficial layer” – few decimetres of muddy and bioturbated fine sand. The sandy fraction (80 to 90%) comes from either the lower or the upper units. Broken

shells, always found below this layer, are interpreted as a ravinment surface,
 - the “interface layer” - few millimetres of mud.

The two upper layers originate the name “Grande Vasière” despite the small content of mud sediments (10 to 20%).

Only the Glenan area to the North and the Rochebonne area to the South (Fig.1) present a few meters thick Holocene sequence over the lower unit. Glenan cores provide a continuous record of the last 9,000 years indicating that the beginning of “La Grande Vasière” settlement occurred before the setting of the southern mud fields of the Gironde (Lesueur et al. 2002). Pollen analysis allows detecting 8 climatic zones (Naughton, 2005). The most important event occurred after 7,100 C¹⁴ yr BP as showed by the drastic vegetation change in the continent. Increase of precipitation and decrease in seasonality has amplified rivers discharge during this period. This could be linked with the sharp decline of *Turritella communis* communities observed in the cores and probably due to a change in the seawater physical properties.

3. Factors of evolution

Radionuclide analyses of excess ²¹⁰Pb provide a maximum sedimentation rate of 2 mm/yr for the last century (Dubrulle et al., submitted) consistent with previous measurements in the South part (Lesueur et al., 2001). However there are several clues indicating the remobilization of the sediment :

- Narrow furrows controlled by storms with active megaripples cross the seafloor (Folliot, 2004),
- 80% of the ²¹⁰Pb analyses show a vertical profiles leading to suspect a sediment remobilization within the last decades,
- Comparison of sand/clay ratio over the 30 last years (Vanne, 1977 ; Le Loc'h, 2004 ; Bourillet et al., 2005) shows an increase from 4 to 6. Because the present tide or waves energy is not strong enough to transport sand then the only explanation can be the clay loss ,
- Fauna evolution under fishing activities (Le Loc'h, 2004).

Short living radionuclide ²³⁴Th analyses pointed out for a strong seasonality control (Dubrulle et al., submitted). The higher annual rate of

deposition hides the long-term (centennial or millennial) tendency.

The balance between deposition and erosion factors has controlled the evolution of "La Grande Vasière" (Fig.3) :

- For deposition
 - o Fluvial solid discharge contributes to the budget for 1,2 Mt/yr specifically on the studied area (from Jouanneau et al., 1999). From this author, 35% of the suspended matter (SM) goes out the shelf,
 - o The lowest tidal currents of the shelf are precisely located over "La Grande Vasière" and favour the deposition of SM,
 - o Weaker swell activity from April to September enhances the seasonality and the deposition during this period.
- For erosion
 - o Storms and swell remobilize *in-situ* sediments for a dozen of days per year and for a roughly estimated masse between 850 and 2,000 Mt of fine material. Winds historical data shows no significant tendency over the last 23 years,
 - o Fishing activities impacts were carefully estimated according to the fishing effort developed by bottom trawlers operating in "la Grande Vasière" (> 300,000 hours of fishing equivalent to >900,000 nautical miles covered in 2002) and the characteristics of the gears (length of the tow cables, sinking in of the doors and footropes). Trawlers scraped the bottom of between 45,000 and 80,0000 km² in 2002 and thus between 180 and 380 Mt/yr of fine material were remobilized into the sea column,
 - o Action of tidal current is negligible at such a depth,
 - o Buried or sub-surface fauna leads to homogenize the "surficial" and "interface" layers but does not remobilize the fine matter into the sea column (Le Loc'h, 2004).

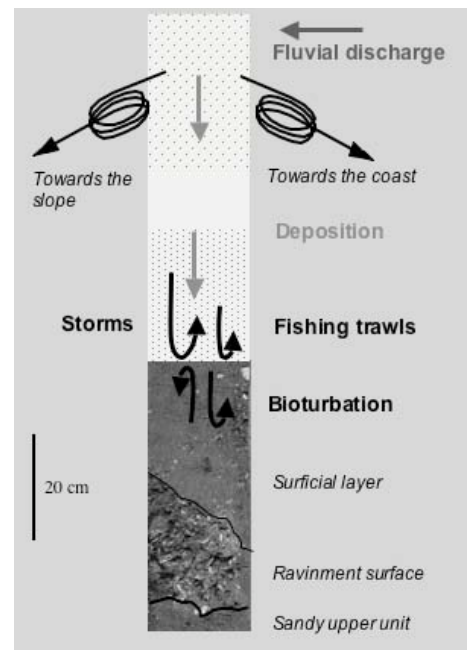


Figure 3 : Sedimentological model and controlling factors of the "La Grande Vasière" mud field

4. Conclusions

"La Grande Vasière" lays down over two sandy units and is a thin (few decimetres) Holocene feature of muddy autochthon sand. "La Grande Vasière" evolution depends on the equilibrium between both the depositional processes (tidal current, fine supply from rivers) and the remobilization processes (storm and fishing activities). Provisional budget of the fine fraction demonstrates that the main factor of the fine material remobilization is caused not only by the storms but also by the anthropogenic activities (representing 10 to 30% of the action of the storms).

5. Acknowledgments

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6. References

- Andrieff P., Bouysse P., Chateaufort J.-J., L'Homer A. and G., S. 1971. La couverture sédimentaire meuble du plateau continental externe de la Bretagne méridionale (Nord du golfe de Gascogne). *Cahiers Océanographiques, XXIII ème année*, 4,343-381.
- Boillot G., Bouysse P. and Lamboy M. 1971. Morphology, sediments and quaternary history of the continental shelf between the Straits of Dover and Cape Finisterre. In: *ICSU/SCOR Working Party 31 Symposium : The Geology of the east atlantic Continental Margin* (Ed F. Delany), Report 70/15, pp. 75-90. Institute of Geological sciences, Cambridge.
- Bourillet J-F., Dubrulle C., Levron L., Jouanneau J.-M., Loubrieu B. and Weber O. 2003. Reconnaissance sédimentologique du nord de la Grande Vasière, Golfe de Gascogne. In: *9ème Congrès Français de Sédimentologie, Bordeaux, 14-16 octobre 2003* (Ed ASF), Livre des résumés, 38, pp. 73-74. ASF, Bordeaux, France.
- Bourillet J-F., Dubrulle C., Goubert E., Jouanneau J.-M., Cortijo E., Weber O., Lesueur P. and Vicaire O. 2005. La Grande Vasière : architecture, mise en place et estimation des facteurs de son évolution. In: *Colloque Défi Golfe de Gascogne* (Ed Ifremer). Ifremer, Brest, 22-24 mars 2005.
- Bouysse P. (coord.), Lesueur P. and Klingebiel A. 1986. Carte des sédiments superficiels du plateau continental du Golfe de Gascogne - Partie septentrionale au 1/500.000. co-éditée par BRGM & IFREMER.
- Dubrulle C., Jouanneau J.-M., Lesueur P., Bourillet J-F. and Weber O. soumis. Modern fine-grained sedimentation in a mid-shelf mud belt : "La Grande Vasière" (Bay of Biscay, France). *Continental Shelf Research*.
- Folliot B. 2004. *La Grande Vasière : étude sédimentologique de deux secteurs septentrionaux*. Mémoire de DEA "Dynamique et environnements sédimentaires" de Lille, Caen & Rouen, Université de Caen, 21 figures, 2 annexes, 38 pp.
- Guillocheau F., Brault N., Thomas E., Barbarand J., Bonnet S., Bourquin S., Estéoule-Choux J., Guennoc P., Menier D., Néraudeau D., Proust J-N. and R., W. 2003. Histoire géologique du massif armoricain depuis 140 Ma (Crétacé-actuel). *Bulletin d'information des géologues du bassin de Paris*, 40: 13-28.
- Jouanneau J.-M., Weber O., Cremer M. and Castaing P. 1999. Fine-grained sediment budget on the continental margin of the Bay of Biscay. *Deep-Sea Research*, 46: 2205-2220.
- Le Loc'h F. 2004. *Structure, fonctionnement, évolution des communautés des fonds meubles exploités du Nord Gascogne*, Université de Bretagne Occidentale, 30 janvier 2004, Brest.
- Lesueur P., Jouanneau J.-M., Boust D., Tastet J.P. and Weber O. 2001. Sedimentation rates and fluxes in the continental shelf mud fields in the Bay of Biscay (France). *Continental Shelf Research*, 21: 1383-1401.
- Lesueur P., Tastet J. P. and Weber O. 2002. Origin and morphosedimentary evolution of fine-grained modern continental shelf deposits: the Gironde mud fields (Bay of Biscay, France). *Sedimentology*, 49: (6),1299-1320.
- Menier D. 2004. *Morphologie et remplissage des vallées fossiles sud-armoricaines : apport de la stratigraphie sismique*, Doctorat de l'université de Bretagne Sud, n°110, 202 p. ISBN : 2-914375-21-2. pp.
- Menier D., Reynaud J.Y., Proust J.N., Guillocheau F., Guennoc P., Bonnet S., Tessier B. and Goubert E. in press. Basement control on shaping and infilling of valleys incised at the southern coast of Brittany, France. *SEPM Spec. Pub., Incised Valleys in time and space*.
- Naughton F. 2005. Analyse palynologique des sédiments de la carotte VK03-58 bis : Vegetation response to climate variability during the Holocene in the NW of France. 20681127, DGO, UMR-CNRS 5805 EPOC, Bordeaux.
- Pinot J.-P. 1974. *Le précontinent Breton entre Penmarc'h, Belle-île et l'escarpement continental. Etude géomorphologique*, UBO.
- Vanney J.R. 1977. *Géomorphologie de la marge continentale sud-armoricaine*. Société d'édition d'enseignement supérieur, Paris, 473 pp.