Indication of the last sea level lowstand and Holocene transgression on the Charente coast : preliminary results of the SIFADO seismic cruise

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Abstract

Preliminary results of high-resolution Sparker seimic investigations (SIFADO) along the Charente shoreline are described. An erosion troncature is observed which is interpreted as the result of a strong incision due to the last sea level fall. Active sand waves are observed which indicate a strong remobilization of Holocene deposits induced by present-day hydrodynamic processes.

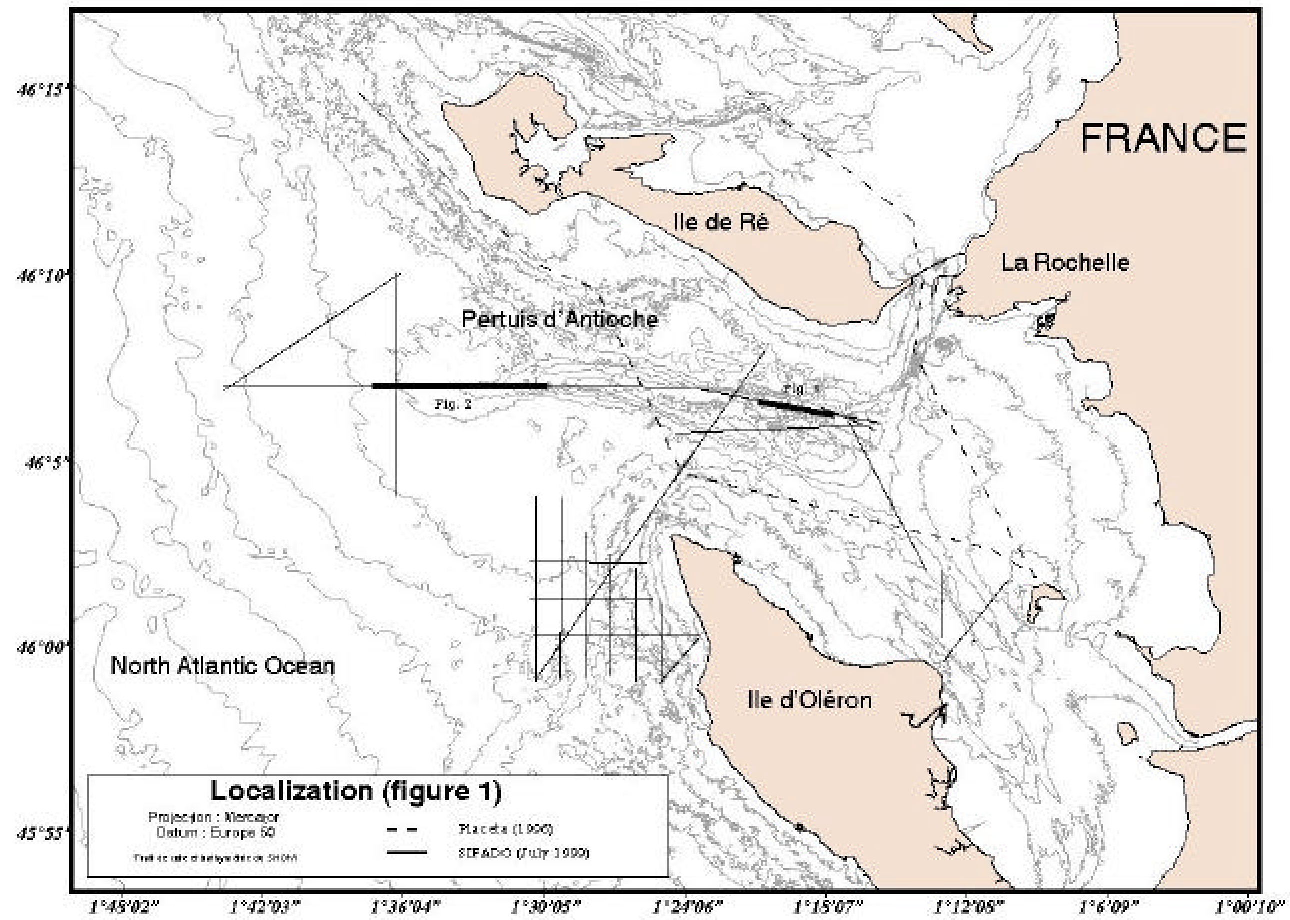
Introduction

New improvements in high-resolution shallow marine seismic investigations provide new seabed images of coastal environment. The Charente shoreline in the inner part of the Bay of Biscay, is a key-area to evaluate the impacts of the latest lowstand sea level and subsequent transgression. Indeed, this region experienced during the last glacial episode a strong eustatic fall estimated at -130 m from the present day shore-line (Anderson, 1998; Bard et al., 1996; Fairbanks, 1989).

Only few high-resolution seismic profiles were shot by the year 1995 in the region (Schillinger, 1996; figure 1). Our objective was to extend this kind of seismic exploration in order to characterise the sedimentary cover and the basement morphology. For their numerous advantages we have shot the profiles using a Sparker package. Records were made with a SIG single channel streamer and a DELPH acquisition system. High quality results allow us to identify new seabed structures and to discuss previous interpretations of the investigated area.

Geological Setting

The basement of the Charente shoreline is composed of upper Jurassic and upper Cretaceous limestone and carbonate sandstone respectively (Barusseau, 1973). This basement was deformed by gentle folding and faulting during the Mesozoic and the Cainozoic (Papy, 1935). A moderate seismic activity is recorded in the vicinity of the Oléron island (Rothé, 1983). The structural trend of the basement has influenced the coastline morphology. It is characterised by marine channels the “ Pertuis ”, which are parallel to the general ENE-WSW trend of the regional fault system. The investigated area includes the “ Pertuis d’Antioche ” between Ré and Oléron islands. This channel is - 40 to - 44 m deep between the islands. The depth decreases at - 19 m seaward featuring a step-like morphology. The channel is interpreted as an ancient fluvial drainage pattern, which was linked to the Charente River valley during the last glacial episode (Barusseau et Martin, 1971; Barusseau, 1973). On land, this valley was partly filled during the Holocene transgression and cores drilled at the Charente river estuary indicate ages of deposits ranging from 7400 years BP to historical periods (Carbonel et al., 1998). Offshore, Barusseau (1973) has proposed that the Antioche channel was sealed by Holocene sediments with increasing thickness toward the sea. For the author, this could explain the step-like morphology observed westward of the channel. Present day hydrodynamics processes including tides, swell and wind force an eastward sediment transport (Barusseau, 1973) and a large shifting of the coastline respectively (Baxerres, 1978; Tesson, 1973).



First Scientific Results

22 profiles were shot representing 166,5 km of new high-resolution seismic data. Three mains results are described:
- the deformation of the Mesozoic basement;
- the morphology of the bedrock;
- the sedimentary cover.

(1) The deformation of the Mesozoic basement

A new structural style is revealed here, consisting of small scale anticline and syncline separated by poorly reflective areas interpretable as fault. The deformation is mainly due to forced folding of the layers along normal faults. No tectonic deformation is observed in the epicentre area of 1972 earthquake (Rothé, 1983), north-west of Oléron island.

(2) The morphology of the bedrock

An erosion truncature of the Mesozoic bedrock is clearly observed from the whole seismic lines. Generally flat, this truncature also deepen at 15 mstd below the sea floor (figures 2). Deepening of the truncature surface is evidenced in the Antioche channel and seaward below the sedimentary cover. This morphology is very similar to that of the inland flat plateau incised by the river valleys. This confirms the hypothesis of fluvial incision to explain the origin of the Antioche channel as proposed by Barusseau (1973). More over, our hypothesis is that the deepest erosion truncature observed seaward below the sedimentary cover (figure 2) could correspond to a branch prolonging the ancient fluvial valley.

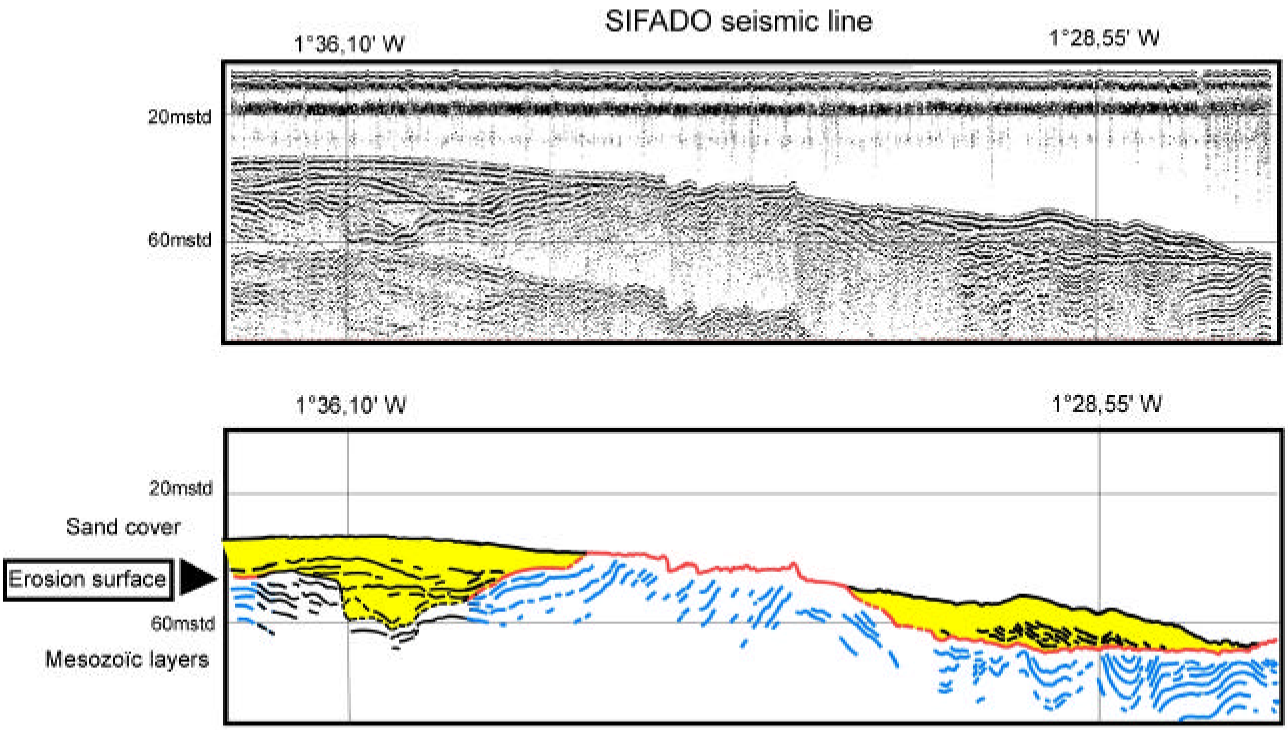


Figure 2 : Incised valley

(3) The sedimentary cover

The sedimentary cover exhibits contrasting styles from west to east along the Antioche Channel. To the West, as mentioned, sediments clearly sealed an ancient incisive channel (figure 2). If one assumes a fluvial origin for the channel, the sedimentary filling could correspond to alluvial or marine deposits from the Holocene transgression. Lying on top of this deposits is a very thin and poorly reflective cover which decreases eastward below the resolution of our seismic records. It corresponds to a sand sheet already identified after dredging by Barusseau (1973) then André (1986). However, our seismic investigation indicate that the thickness of this sand sheet was greatly overestimated by André (1986). More over, we show that the step-like morphology west of the Antioche channel is due to sand accumulation up on a bedrock high. The foot of this bedrock high is covered to the east by a set of reflectors with a prograde geometry. In the deepest Antioche channel sediments are lacking while eastward sand waves clearly occur. The amplitude of these sand waves range from about 1 m to 8,5 m; wavelengths vary between 60 and 200 m and their crest are oriented from N20 to N160 (figure 3). Taking into account the tidal and hydrodynamics of the area characterised by surface current ranging from 2 to 4 m/s, we propose that these sand waves result from combined action of ebb and flood currents. Opposite directions of their lee sides can be interpreted either by sand bank obliquity thank to ebb and flood currents directions or by occurrence of a vortex (Belderson et al., 1986; Pingree et Maddock, 1979; Robinson, 1983).

Discussion

We suggest that the submarine morphology of the investigated area as it is revealed by high-resolution reflection seismic is similar to that in land. That is the flat Charente plateau incised by coastal rivers. The erosion of the plateau achieved by late Pleistocene times. Alluvial deposits from this period are observed on the plateau at a mean elevation which is 20 m above the present day coast (Geological map of Rochefort, 1/50000°). By reference to this elevation and that of the maximum depth of the Antioche channel (- 40 m) the latest incision is estimated to about 60 m. Compare to the Gironde valley (Allen et Posamentier, 1993), such an incision is due to the rapid fall of the sea-level which occur during the last Glacial period (Anderson, 1998; Bard et al., 1996; Fairbanks, 1989).

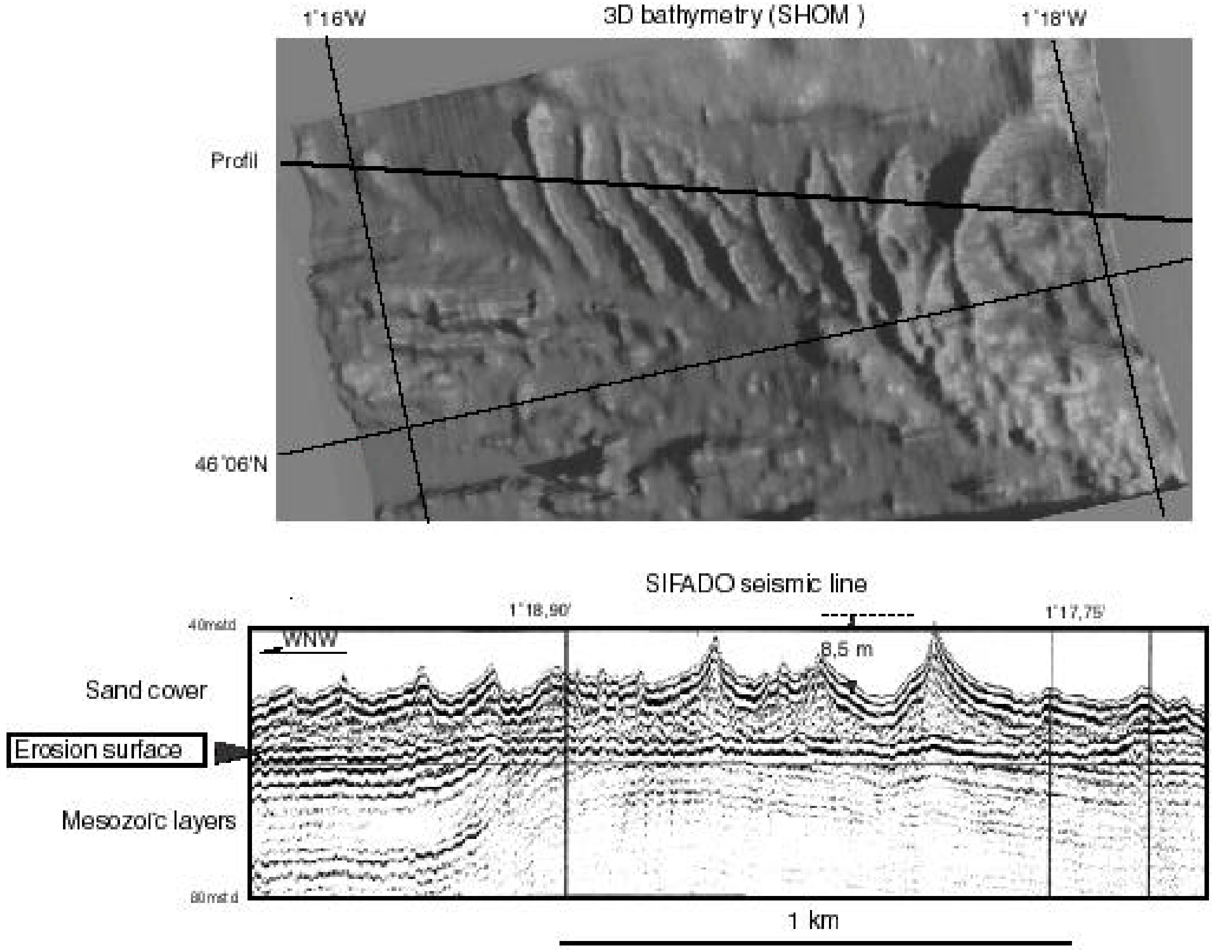


Figure 3 : Sands waves in the "Pertuis d'Antioche"

From our seismic investigation, we observe that the Holocene sediments are not covering the entire late Pleistocene erosion truncature (figure 2). Is that because the sediments deposited during the transgression as disconnected back stepping wedges (Thorne et Swift, 1991). We assume it is much probably the consequence of present-day submarine erosion and transport due to hydrodynamic processes. We note that the depth of the sea floor, west of the Antioche, is shallower than that of the wave base for more than 1 month per year. Then, the combined effects of tides and swells lead to sediment transports for more than 47 days per year (Barthe, et Castaing, 1989). A prograde sedimentary body identified on figure 2 attest for that kind of sand transport. Eastward, the lack of sediments in the deepest Antioche channel could attest for strong erosive bottom currents. As a result of erosion and transport from west to east in the channel are the sand waves which attest of active hydrodynamics.

Finally, irregular distribution of sand bodies, revealed by our seismic data, is interpreted as a result of active remobilization of Holocene deposits shaped by present-day hydrodynamic processes. Such a hypothesis suggests large sediment transport whose quantification is still lacking.

Conclusion

Our preliminary results confirm the relevance of high-resolution seismic exploration for the characterisation of shallow depth marine morphology and sedimentation. Along the Charente coast, our high-resolution seismic approaches illustrate the great variabilities in the distribution, the structure and the thickness of the sediments. These sediments are lying over an inherited Late Pleistocene morphology formed by erosion and incision of the Mesozoic bedrock. Then, sediments were deposited during the following Holocene transgression. However, evidence of sand waves illustrate the occurrence of present-day hydrodynamic driven erosion, transports and remobilization of the Holocene sediments. The quantification of those active sedimentary fluxes is necessary for a better estimate of coastline shift in the region.

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Bibliography

Allen, G.P. and Posamentier, H.W., 1993.Sequence stratigraphy and facies model of an incised valley fill: the Gironde estuary, France, *J. Sediment. Petrol.,* **63, 3**, 378-391.

Anderson, R.C., 1998. Submarine topography of Maldivian atolls suggests a sea level of 130 m below present at the last glacial maximum. *Coral Reefs*, **17** : 339-341.

André, X., 1986. Elaboration et analyse de cartes bathymétriques détaillées du proche plateau vendéo-charentais (Golfe de Gascogne). Reconstitution des paléorivages de la transgression holocène. *Thèse 3° cycle, Univ. Bordeaux,* **n° 2133**.

Bard, E., Jouanic, C., Hamelin, B., Pirazzoli, P., Arnold, M., Faure, G., Sumosusatro, P. And Syaefudin, 1996. Pleistocene sea levels and tectonic uplift based on dating of corals from Sumba, Indonesia. *Geophysical Research Letters*, **23:** 1473-1476.

Barthe, X. and Castaing, P., 1989. Etude théorique de l'action des courants de marée et des houles sur les sédiments du plateau continental du Golfe de Gascogne, *Oceanologica Acta* **12**, 325-334.

Barusseau, J-P. et Martin et G., 1971. Esquisse géologique et structurale des Pertuis charentais et de leurs abords (Golfe de Gascogne, France). *Revue de Géographie Physique et de Géologie Dynamique* **(2), Vol. XIII**, Fasc. 4, p. 403-412.

Barusseau, J-P., 1973. Evolution du plateau continental rochelais (Golfe de Gascogne) au cours du Pléistocène terminal et de l'Holocène. Les processus actuels de la sédimentation. *Thèse d'état, Univ. Bordeaux,* **n° 9124**.

Baxerres, P., 1978. Etude morphologique et sédimentologique de la côte atlantique de Saintonge, de la pointe sud de l'île d'Oléron à la pointe de la Coubre. *Thèse 3° cycle, Univ. Bordeaux*, **n° 1456**.

Belderson, R.H., Pingree, R.D. and Griffiths, D.K., 1986. Low sea-level origin of Celtic sea sand banks - Evidence from numerical modelling of M2 tidal streams, *Marine Geology* **73**, 99-108.

BRGM, 1972. Carte géologique de la France au 1/50000°, feuille de Rochefort.

Carbonel, P.; Dartevelle, H.; Evin, J.; Gruet, Y.; Laporte, L.; Marambat, L.; Tastet, J-P; Vella, B. Et Weber, O. 1998. Evolution paléogéographique de l'estuaire de la Charente au cours de l'Holocène. In: Laporte, L., coord., 1998. L'estuaire de la Charente de la Protohistoire au Moyen Age. La Challonnière et Mortantambe (Charente-Maritime). Paris: MSH, 228p.: ill. (DAF ; 72).

Fairbanks, R.G., 1989. A 17,000-year glacio-eustatic sea level record: influence of glacial melting rates on the younger Dryas event and deep-ocean circulation. Nature, 342: 637-642.

Papy, L., 1935. Brouage et ses marais. *Revue Géographique des Pyrénées et du Sud-Ouest,* **t.6,** p. 281-323.

Pingree, R.D. and Maddock, L., 1979. The tidal physics of headland flows and offshore tidal bank formation, *Marine Geology*, **32**, 269-289.

Robinson, I.S., 1983. Tidally induced residual flows, in*: Physical Oceanography of Coastal and Shelf Seas*, B. Jones, pp. 321-353.

Rothé, J-P., 1983. Sismicité de la France entre 1971 et 1977 - *Annales 1983, Inst. Physique du Globe de Strasbourg*, Strasbourg.

Schillinger, S., 1996. Dynamique sédimentaire des Pertuis charentais. *Mémoire de DEA*, U.B.O. Brest.

Tesson, M., 1973. Aspects dynamiques de la sédimentation dans la baie de Marennes - Oléron (France). *Thèse 3° cycle, Univ. Bordeaux*, **n° 1101**.

Thorne, J.A. et Swift, D.J.P., 1991. Sedimentation on continental margins, VI : a regime model for depositional sequences, their component system tracts, and bounding surfaces. Sedimentation on continental margins. In : D.J.P. Swift and J.A. Thorne, Eds.; Shef sand and sandstone bodies. - *Spec. Publs. Int. Ass. Sediment.*, **14**, 189-255.