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Sedimentary archives of the French Atlantic coast (inner Bay of Vilaine, south Brittany): Depositional history and late Holocene climatic and environmental signals

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ABSTRACT

The late Holocene is of particular interest to our understanding of the evolution of coastal sedimentary systems because this period encompasses warmer and cooler periods, and rising sea level in northern Europe. Based on an approach combining AMS ^{14}C, sedimentological and rock magnetic analyses on sediment cores complemented with seismic data collected in the macrotidal Bay of Vilaine (south Brittany), we document the depositional history of the inner bay coeval to the mid- to late-Holocene transgression in south Brittany. Correlation between sedimentary archives revealed the main sedimentary infilling phases during the last 6000 years. Four units (U1–U4) are recognized in the coastal sediment wedge of the system, corresponding to the stepwise marine invasion of the bay. We show that (1) marine inundation, due to the steep morphology of the bedrock, is diachronous between distal and proximal records. A time lag of ~1000 years is inferred over a distance of less than 5 km; (2) in the outer areas, the sedimentation has been condensed since 3000 years; (3) proximal estuarine archives offer the best record of sedimentary processes covering the last 2000 years, including the Medieval Warm Period (MWP).

Correlations in proximal records in the Bay of Vilaine assess the connection between coastal sedimentary dynamics, climatic conditions and anthropogenic activities during the MWP. We match the preservation of clay deposits to increased river-borne suspended matter transported to the estuary probably as a result of accelerated land-use development (higher soil erosion) in the catchment area between ca. 880 and 1050 AD. Because the preservation of estuarine sedimentary successions is favoured when coastal wave sediment reworking is minimal, it is proposed that the prevailing climatic regime in south Brittany during the MWP likely resembled to that of the preferred negative phase of the North Atlantic Oscillation (NAO). Our data are fairly consistent with other late Holocene records from northern Europe including the Atlantic seaboard. However, they outline the difficulty in interpreting climatic and anthropogenic signatures in coastal sedimentary records where high-resolution chronologies required to unravel their respective influences are still missing.

1. Introduction

Recent climatic outlook has produced a growing interest on the response of coastal sedimentary systems to rising sea levels during the 21st century (IPCC, 2007). It is widely recognized that late Quaternary sea level changes, and especially since the Last Glacial Maximum (Lambeck, 1997), had a primary impact on the physiography of Holocene and present-day coastal environments in the French Atlantic and English Channel systems. During the past 20 years, Late Quaternary infill of incised valleys and estuaries had concentrated research efforts, with the main aim being the ability to produce sedimentary infill models for transgressive sediment sinks with high reservoir potential (e.g., Allen and Posamentier, 1993, 1994; Dalrymple et al., 1994; Zaitlin et al., 1994). On the Atlantic coastline, the combination of sedimentological and seismic studies provided a detailed understanding of the infill of incised valleys during the Holocene transgression (Chaumillon and Weber, 2006a,

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b; Féniès and Lericolais, 2005; Lericolais et al., 2001; Menier, 2004; Menier et al., 2006, 2010; Proust et al., 2001; Tessier et al., 2010; Weber et al., 2004). In south Brittany, the mapping and the morphology of incised valleys has recently been revealed by high- to very high-resolution seismic data, with emphasis on the timing of the stepwise marine invasion between the Bay of Quiberon and the Bay of Vilaine (Menier et al., 2006; 2010). These authors pinpointed the relevance of the bedrock morphology of this highly irregular rocky coast, including the role of topographic sills, on the shape of incised valleys and the different patterns of sedimentary infill towards the coast (Menier et al., 2010). If the diachroneity of the transgression offshore and landwards of a major topographic sill is demonstrated, information dealing with the timing of the marine invasion in most proximal areas of the Bay of Vilaine is still missing.

One main concern of this study encompasses the opportunity to explore the impact of climatic changes on the pattern of sedimentary infill of the Bay of Vilaine during the late Holocene. There is indeed growing evidence that periods of coastal barrier destabilization (Billeaud et al., 2009) and increased estuarine hydrodynamics (Sorrel et al., 2009) are proxy records of the impact of storms in coastal settings, linked to Holocene periodic climatic deteriorations (Bond et al., 1997; 2001; Mayewski et al., 2004). A thorough understanding of the patterns of past storminess is of particular importance in the context of modern anthropogenically driven climatic change (Carnell et al., 1996), because the models predict higher sea levels and a higher storm frequency by the end of the current century (Keim et al., 2004; Lozano et al., 2004). Therefore a proxy-based record of storminess and climatic-induced hydrological changes in Holocene coastal archives would provide both a basis for the evaluation of the impact of past climatic variability on sedimentary dynamics and key data for future predictions of coastal evolution. However, relationships between climate variability at multi-centennial timescales and coastal sedimentary processes on the French Atlantic coast have received insufficient consideration to date. Another challenge on coastal climatic records is to track the influence of the North Atlantic Oscillation (NAO), the major modes of interdecadal and longer-term climate variability in the Northern Hemisphere (Hurrell, 1995; Hurrell and van Loon, 1997; Hurrell et al., 2003; Rodwell et al., 1999; Rogers, 1984; Thompson et al., 2003; Wanner et al., 2001, 2008) on the sedimentary infilling of estuaries and/or embayment systems. Hence due to the proximity of south Brittany to climatic zones dominated by the NAO+ mode in northern France (Hurrell and Deser, 2009), the Bay of Vilaine in south Brittany has a strategic climatologic position to evaluate the fingerprint of past NAO variability on climatic change as preserved in sedimentary successions.

Here we present a comprehensive study dealing with the depositional history of the macrotidal inner Bay of Vilaine, where most of the coastal sediment wedge is related to the mid- to late-Holocene marine flooding of the incised valley. This study focuses on the final stage of infilling, and tackles the impact of past climatic changes on sediment deposition and preservation. Based on an approach combining sedimentological and rock magnetic data, conducted on sediment cores, complemented with very high-resolution (VHR) seismic data, our objectives are three-fold: (i) to establish the timing of the different infilling stages and to evaluate the diachroneity of the marine inundation within the inner bay between external and proximal sedimentary records, (ii) to identify relationships between fluvial and marine dynamics and their influence on coastal sedimentary processes during the infill, (iii) to document connections with other regional records from the French Atlantic and neighbouring coasts during the late Holocene.

2. Environmental setting

2.1. Physiography and geology

The Bay of Vilaine is located in the northern part of the Atlantic coast of France, southeast of the Armorican Massif [47°20′–47°35′N; 2°50′–2°30′W] on the Armorican passive continental margin (Fig. 1). It stretches out on a surface that dips gently to the southwest (1:1000 average gradient; Dubrulle et al., 2007). This study focuses on the "internal domains" (Vanney, 1977) or "*précontinent breton*" (Pinot, 1974) situated between the coastline and the −50 m isobath. These internal zones, varying in width from 5 to 14 km, can be distinguished in two parts (Fig. 1): (i) an inshore part, with water depths shallower than 25 m, mostly consisting in bays (Quiberon and Vilaine) and (ii) an offshore part, featured by peninsulas (Quiberon), islands (Houat, Hoëdic, etc.) and shoals (plateaus of Artimon, le Four, la Recherche, etc.) trending N120, parallel to a major regional fault, the South Armorican Shear Zone.

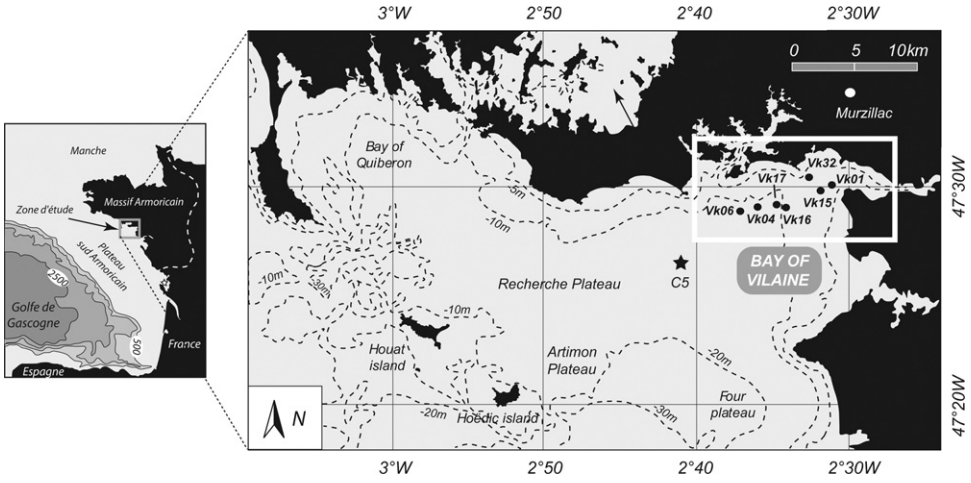

Fig. 1. Geographical location of the study area in south Brittany, and close-up on the bay of Quiberon, the La Recherche Plateau and the Bay of Vilaine (white rectangle). General map (left): the white star corresponds to the position of vibrocores collected in the Ré-Oléron Island area, as discussed in Section 6.2. Core positions are indicated with black circles. Core numbers correspond to the labelling as detailed in the text. Isobaths are given in meters lowest low tide level (LLTL); at le Havre, 0 m a.m.s.l. (above mean sea level) ∼ −4.4 m LLTL (negative and positive values refer to below and above LLTL, respectively). Note that the black star C5 refers to the BRGM drillhole retrieved form the La Recherche Plateau (Bouysse et al., 1974).