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Contrasting sediment records of marine submersion events related to wave exposure, Southwest France

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ABSTRACT

Sediment records of two contrasting backshore coastal marshes, extremely vulnerable to recent and historical marine flooding events, located on the SW coast of France, have been investigated using a multiproxy approach. The studied marshes are 30 km apart and have been flooded by similar storm events (7 marine floods in the last 250 years). One is located in a wave-exposed coast but isolated from the sea by a sediment barrier, whereas the other is located in a sheltered estuarine environment and isolated from the sea by a dike. One core was collected in each marsh and information on grain-size, foraminifera, shell contents and stable carbon isotopes was obtained along with an age model using ^{210}Pb, ^{137}Cs and ^{14}C. Core data combined with historical maps give evidence of a typical estuarine backfilling, part of the Holocene regressive parasequence, including an intertidal mudflat at the base and a backshore environment at the top. Despite the absence of grain size anomalies, marine flood-related sedimentation in the backshore area of both marshes is identified by a mixture of marine and terrestrial features, including marine fauna, vegetation debris and variation in the δ^{13}C signature of the organic fraction. Very low sedimentation rates between flood events and/or bioturbation prevents the identification of individual episodic marine floods in the sediment succession. Comparison of the two sedimentary successions shows that the foraminifera deposited by marine submersions are of two different types. Foraminifera are monospecific and originate from the upper tidal mudflat in the sheltered marsh; whereas in the backshore marsh located in a wave-exposed environment, they show higher diversity and originate from both shallow and deeper water marine environments. This study shows that wave exposure can control the faunal content of marine flood sediment records in coastal marshes.

1. Introduction

Coastal marine floods related to tsunamis or storm surges are among the costliest and deadliest natural disasters. Moreover, the risks associated with these hazards are expected to increase in response to future sea-level rise (IPCC 2014), higher storm amplitudes and frequencies (von Storch and Reichardt 1997; Gönnert et al. 2001; Vousdoukas et al. 2016) and growing coastal populations (Lutz and K.C., 2010). Consequently, there is a need to better understand marine floods, also referred here as submersion events. Instrumental records of past marine floods are mainly based on tide gauge measurements (Pirazzoli and Tomasin 2007; Bardet et al. 2011) but are limited to the last 150 years (Wöppelmann et al. 2006). Historical archives may also be useful, but they are only available for the last few centuries and they include uncertainties and biases, especially for older periods (Tsuchiya and Kawata 1988; Liu et al. 2001; Sawai et al. 2008; Breilh et al. 2014; Chaumillon et al. 2017) and are unavailable for many coastal areas. Consequently, sediments are key archives of past marine floods and there is a need to improve our analysis and interpretation of these archives in different environmental settings.

Onshore sediment records of marine floods fall into three main categories (Chaumillon et al. 2017): washover fans (e.g., Leatherman 1976, 1979; Morton and Sallenger 2003; Andrade et al. 2004; Hudock et al. 2014), beach ridges (e.g., Hayne and Chappell 2001; Nott 2003; Nott and Jagger 2013) and sediment layers in backbarrier depressions (e.g., Goodbred and Hine 1995; Donnelly et al. 2004; Williams and Flanagan 2009; Lin et al. 2014). Washover fans are the most voluminous sediment bodies but they may be reworked or lost due to successive storms, barrier transgression or human activity (Sedgwick and Davis 2003). Backbarrier depressions are likely to better preserve sediment records.

In many published examples, marine flood sediment records have been associated with a grain-size anomaly, related to the onshore

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transport of coarse sediments from the eroded barrier to the backbarrier area, where finer sediments are deposited between overwash events (e.g., Nanayama et al. 2000; Donnelly et al. 2004; Goff et al. 2004; Morton et al. 2007; Williams 2011). However, marine floods may propagate inland far beyond the coarse sediment deposit, as evidenced by the example of the Tohoku-oki tsunami event (Chagué-Goff et al. 2012; Goto et al. 2012). This tsunami example also showed that the deposit continued as a mud layer up to the inundation limit, and suggested that geochemical markers and microfossil data may be useful in identifying the extent of the inundation (Goto et al. 2012).

In fact, a large amount of the coast is, including many estuaries and deltas, not bounded by a sediment barrier (Pye and French 1993; Allen 2000), and though vulnerable to marine submersion, they are not likely to provide similar pronounced grain-size anomalies from marine floodings. Therefore, the question arises as to whether sedimentary investigations of past marine floods may be successfully conducted in such categories of lowlands. The aim of this article is to contribute to this question by investigating sediment records within coastal marshes located on the southwest coast of France.

2. Study area

The study area is located along the Atlantic coast of France, in the central part of the coast of the Bay of Biscay (Fig. 1). The coastline shows two large embayments (each about 30 km long and 15 to 20 km wide) into which four small rivers flow: the Lay and Sèvre Niortaise rivers in the northern Pertuis Breton, and the Charente and the Seudre rivers in the southern Pertuis d'Antioche and Marennes-Oléron Bay (Fig. 1B). These embayments, locally named "Pertuis", correspond to incised-valley segments (Weber et al. 2004; Chaumillon et al.

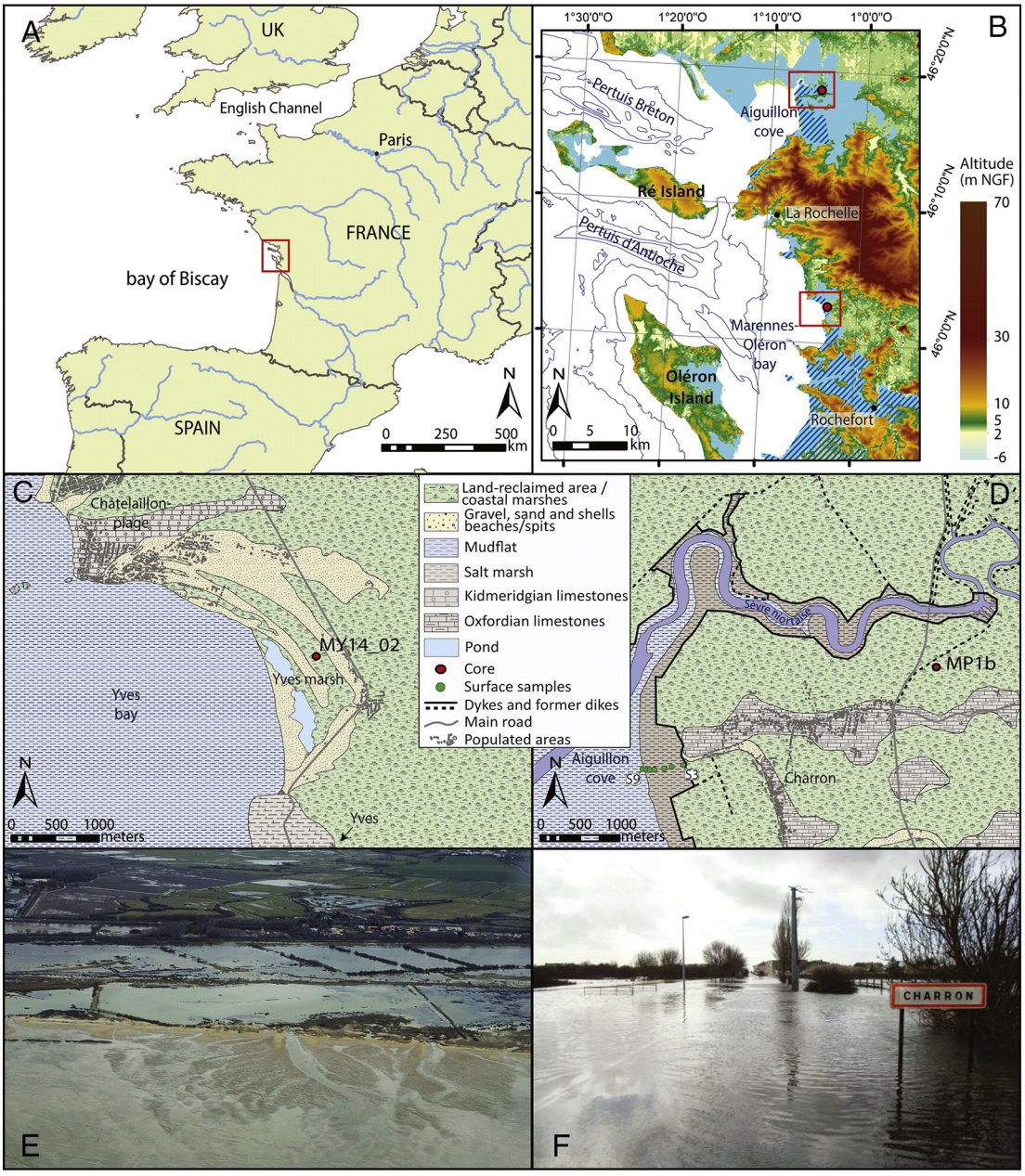

Fig. 1. Location of the study site: (A) map of France, (B) topographic and bathymetric map of the Pertuis region with flooded areas by Martin coastal flooding in 1999 (dark blue hatched) and Xynthia coastal flooding in 2010 (light blue), (C) Yves Marsh geological and morphological map, (D) Poitevin Marsh geological and morphological map, (E) Yves marsh flooded by Xynthia storm in 2010, (F) the flooding inside Charron village in 2010. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)