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Sedimentary Geology 200 (2007) 15–29
Sedimentary Geology
www.elsevier.com/locate/sedgeo

# Influence of paleotopography, base level and sedimentation rate on estuarine system response to the Holocene sea-level rise: The example of the Marais Vernier, Seine estuary, France

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Received 9 August 2006; received in revised form 5 February 2007; accepted 23 February 2007

## Abstract

The response of coastal systems to allogenic forcing factors is of interest to diverse research communities, including those interested in global change, sequence stratigraphy and modelling. Quaternary systems are of particular interest because they provide analogues for ancient rock records. To understand the processes responsible for the sedimentary evolution of estuarine systems, it is necessary to study as many fluvial systems as possible. The objective of this review of the sedimentary evolution of a coastal marsh is to describe the influence of glacial paleotopography on the record of climatic and sea-level changes. The Marais Vernier, located at the interface between the marine and fluvial parts of the estuary, is a part of the Lower Seine Valley wetland network, which formed after the Last Glacial Maximum. Previous studies have described the Holocene filling, which is composed of peat and detrital material deposited following climatic and sea-level changes. To understand the sedimentary evolution, a paleotopographical (based on drillings and electromagnetic surveys) and a chronological framework (based on radiocarbon dates) for the southern peat marsh were defined. The peat marsh paleotopography has three erosional surfaces. The S1 surface is the oldest and also the highest, topographically; the S2 surface is younger, wider, and incised below the S1 surface; the S3 surface, the youngest of the three, is narrow and deeply incised. Radiometric ages were considered on the basis of their geographical position in relation to the S3 surface. Prior to 7.5 ka cal BP, sediments accumulated only above the narrow area described by the S3 surface, at a rate of 5.5 mm $yr^{-1}$. After 7.5 ka cal BP, shortly after the flooding of the Seine estuary, sediments accumulated as peat deposits over the entire peat marsh at a rate of 3 mm $yr^{-1}$ in response to the sea-level rise. The paleotopography delimits the area of deposition during the Holocene, and thus plays a critical role in determining the vertical accretion rate expressed as a thickness: prior to 7.5 ka cal BP, the vertical accretion rate (5.5 mm $yr^{-1}$) was less than that observed for the Seine estuary (6.8 mm $yr^{-1}$). However, rate of sea-level rise and sediment supply, which also affects sediment accumulation rates, vary in northwestern Europe during the Holocene. Therefore, although the Marais Vernier is a good illustration of paleotopographic influence, the effects of autocompaction, sea level and sediment supply complicate efforts to quantify the degree to which it controls sediment accumulation.


*Keywords:* Paleotopography; Accommodation; Sea-level; Tidal marsh; Radiocarbon dating; Holocene

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doi:10.1016/j.sedgeo.2007.02.007

## 1. Introduction

Sequence stratigraphy was first applied to fossil marine and coastal environments that are mainly controlled by subsidence and sea-level variations (Vail et al., 1977; Posamentier and Vail, 1988). Since then, the sequence stratigraphy of recent coastal systems (*i.e.*, formed during the Quaternary and Holocene) and fluvial environments has been investigated (Starkel, 1987; Zaitlin et al., 1994; Allen, 1995; Knox, 1996; Blum and Tornqvist, 2000; Blum and Aslan, 2006). Estuarine environments represent a transition zone from the fluvial to the coastal domain. These environments are of interest for demographic, economic and ecologic reasons. Estuarine studies aid in understanding the evolution of estuaries and in modelling their anticipated response to global changes in the future. The sedimentary dynamics of estuarine systems depend on paleotopography, sediment supply, rates of relative sea-level changes, and climatic changes (Belknap and Kraft, 1981; Belknap and Kraft, 1985; Shanley and McCabe, 1994; Blum and Tornqvist, 2000; Rodriguez et al., 2005). To improve understanding of estuarine responses to allogenic controls, it is necessary to study as many estuarine systems as possible. Here we focus on the sedimentary evolution of the Seine estuarine system, in particular the response of one coastal marsh in this system to Holocene changes.

The Marais Vernier occupies an abandoned meander 15 km upstream from the mouth of the Seine estuary (Fig. 1). This area is part of the estuarine wetland network that developed in northwestern Europe during the Holocene in response to warming and sea-level rise (Allen, 2000a). In the region, the sea-level rise resulted in transgressive sedimentary bodies, notably at the Seine estuary mouth (Lefebvre et al., 1974; Delsinne, 2005). Because of its low altitude (−2.4 to +0.6 m MSL) and its location at the interface between the marine and fluvial parts of the estuary, the Marais Vernier was affected not only by sea-level variations but also by climatic changes that greatly affected Holocene sedimentation (Frouin et al., 2007).

This study focuses on the filling of the Marais Vernier by Holocene sediments. In this type of environment, the sediment dynamics are controlled by the base-level, which in turn is controlled by the paleotopography, sea-level rise, and sediment supply. The question arises as to which factors, in addition to climate variability during the Holocene period (Lockwood, 2001; Mayewski et al., 2004), control the sedimentary evolution of the peat marsh. Drilling and coring were used to gain a general overview of the paleotopography and the sedimentary fill. The sedimentological evidence and ages of sediment accumulation were used to interpret the depositional history of the basin.

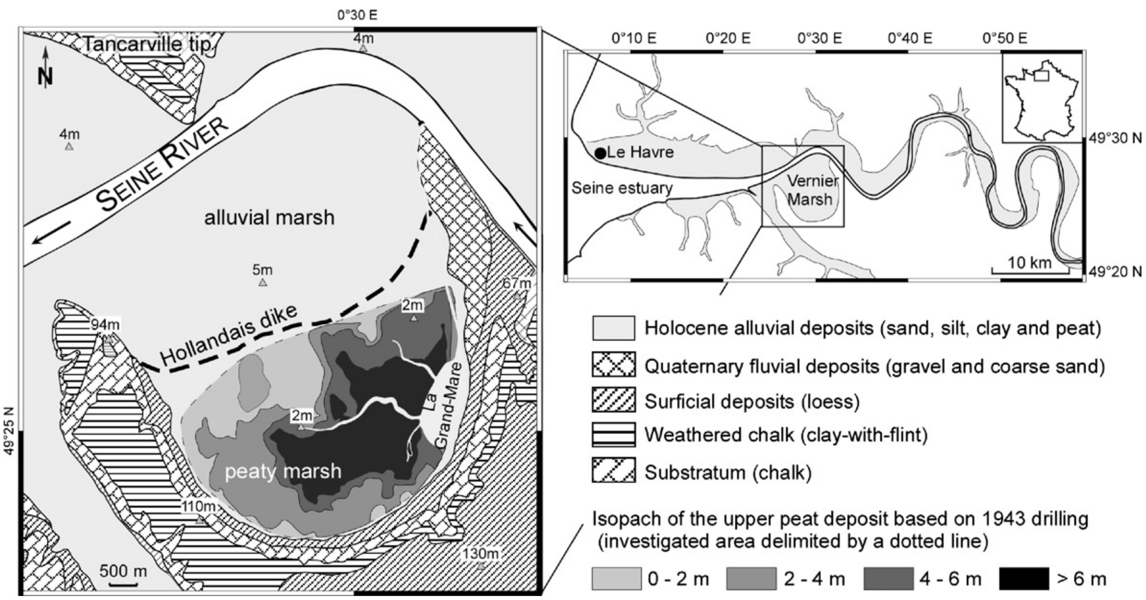


Fig. 1. Location of the Lower Seine Valley and the Marais Vernier. The isopach of peat deposits is based on the description of the 1940s drilling campaign (Direction des Mines, 1949). The drilling demonstrated that the peat cover is thicker in the centre and eastern parts of the peat marsh and thinner in the western part. The elevations indicated on the map are expressed in m NGF, the relation between m NGF and m Mean Sea Level (MSL) being: 0 m MSL ≈ −4.4 m NGF at Le Havre.