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Ground penetrating radar in the medieval oyster shell middens of Saint-Michel-en-l'Herm (Vendée, France)

Elsa Cariou[a,*], Agnès Baltzer[b], Donatienne Leparoux[c], Julie Ledoyen[b], Françoise Debaine[b]

[a] Laboratoire de Planétologie et Géodynamique (LPG), UMR CNRS 6112, Nantes University, 2 rue de la Houssinière, BP92208, 44322 Nantes Cedex 3, France
[b] Laboratoire Géolittomer LETG, UMR CNRS 6554, Nantes University, Campus du Tertre, BP81227, 44312 Nantes Cedex 3, France
[c] Geotechnics, Environment, Natural Hazard and Earth Sciences Department, Institut Français des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux, CS4, 44344 Bouguenais Cedex, France

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ABSTRACT

This study presents the integrated results of GPR (Ground Penetrating Radar) and sedimentological analysis, performed on the giant shell middens of the medieval site of Saint-Michel-en-l'Herm (Vendée, France). Avoiding the use of destructive methods like large-scale digging, the purpose of this study was to determine the internal structure of the northern midden and the links with its substrate, and to obtain insight on the manner of its construction. Four GPR profiles were obtained along the main axis of the midden, on the shell mound, and at its foot, in an area leveled by the former extraction of shells. Sedimentological analysis is also presented from study of the extant parts of the midden and with hand auger cores taken along one of the GPR profiles. The integrated results show that each sedimentological facies is related to a specific radar facies, allowing the mapping of lateral and vertical facies variations along the GPR sections. Within these deposits, the major tilted reflectors correspond to thin soils and trampled surfaces. Their geometry and the stacking pattern highlight multiphase deposition triggered by successive inputs of large volumes of shells (in the range of 100 m^3), from west to east. Below the exploited parts of the midden, the data are interpreted to show the presence of undisturbed shells, although, an ancient dug area was also identified by GPR. Finally, sedimentological and GPR data both show evidence of a midden established on the west bank of a channel, progressively infilling the channel eastward. These results illustrate the relevance of GPR in answering major questions common to all large shell middens.

1. Introduction

Saint-Michel-en-l'Herm (Vendée, France) is an inland village situated 7 km from the modern French Atlantic coastline (Fig. 1). In the marshes at the eastern end of the village, three enormous shell mounds composed of billions of joint and closed oyster shells (*Ostrea edulis*) had been deposited, but their medieval age remained unknown until the archaeological findings of the XXth century (e.g., Baudouin, 1916; Gruet and Prigent, 1986; Godard, 1995). Brought together, the three mounds formed an S-shaped superstructure with a length of 800 m, rising to a height of 8 m above the level of marshes (Fig. 2). These dimensions make the Saint-Michel-en-l'Herm site one of the largest shell middens in the world.

Since the XVIth century, dozens of authors have questioned and discussed the origin of these mounds, alternatively interpreted as natural structures, e.g. storm deposits or fossil oyster reefs, or as anthropogenic structures e.g. cult buildings, breakwaters, fortifications or channel infillings (see a review in Godard, 1995). During the XXth century, the mounds were exploited for industrial use, and leveled. Only 10% of the northern mound remains (Fig. 1), but old photographs suggest that industrial exploitation was essentially superficial, except in the southernmost parts, where three ponds were dug and are still visible nowadays (Fig. 2). An assessment of the deposition process of the mounds, by focusing on their remaining parts, is still possible. However, the outcropping parts are now officially protected while the leveled parts have been converted into exploited meadows. Digging at the site is prohibited, and hindered by the shallow water table. Gaining further insight on these enigmatic mounds, their building and their signification requires using a non-traditional method capable of providing subsurface data without digging.

Non-destructive geophysical surveys are becoming increasingly frequent in archaeological studies and offer numerous possibilities (Rodrigues et al., 2009, 2015; Forte and Pipan, 2008). Among the techniques used for such surveys, Ground Penetrating Radar (GPR,

* Corresponding author.
E-mail addresses: elsa.cariou@univ-nantes.fr (E. Cariou), agnes.baltzer@univ-nantes.fr (A. Baltzer), donatienne.leparoux@ifsttar.fr (D. Leparoux).

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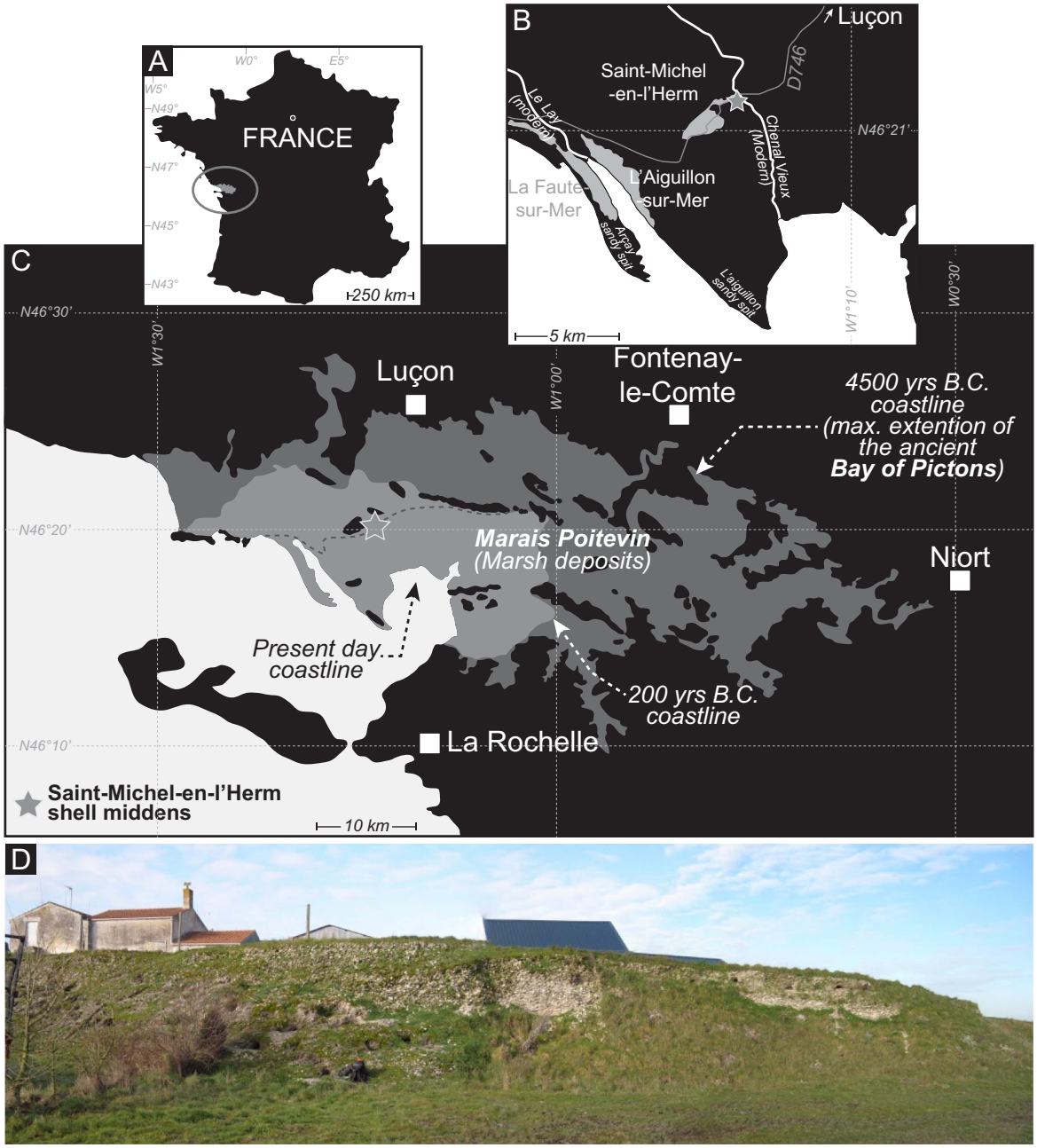

Fig. 1. A) Location of the Marais Poitevin (ancient Bay of Pictons) along the French West Coast. B) Location of the Saint-Michel-en-l'Herm shell middens (star), about 7 km from the modern coastline. C) Evolution of the coastline during the infilling of the Bay of Pictons, compiled after Verger et al. (1975) and Joussaume and André (1998). The dark grey dashed line indicates the position of the Late Medieval coastline according to Godard (1995). Saint-Michel-en-l'Herm shell middens (star) were situated along the coastline during the Late Middle-age. D) Outcrop of the northern midden in 2016.

illustrated in Fig. 3) allows characterization of the internal structures from surface measurements, if the resolution and the investigation depth are adapted to the goals assigned (Jol, 2009; Grealy, 2006). The GPR principle is based on temporal electromagnetic pulse propagation and reflections as well as diffraction phenomena on interfaces with dielectric contrasts. Its resolution is accurate enough to differentiate archaeological and historical remains from natural sedimentary layers (Conyers, 2013). GPR is well established as a tool for sedimentological analysis (e.g., Neal, 2004; Pueyo-Anchuela et al., 2009), and for archaeological recognition in natural dunes and limestones (e.g., Clemmensen and Nielsen, 2010; Poirier et al., 2017), as well as in anthropogenic structures (Barone et al., 2007). GPR was recently used in Brazil to determine the internal structure of several large Neolithic shell mounds and localize archaeological targets like sepultures and ceramic materials (e.g., Schimmel et al., 2002; Rodrigues et al., 2009, 2015). However, until now, GPR has only occasionally been used to thoroughly investigate shell middens.

GPR measurements, eight hand-auger cores and outcrop observations were carried out in this study, in order to provide transects of both the remaining and the leveled parts of the northern mound. The objectives were: 1) to differentiate the radar signatures of oyster shell deposits from those of the surrounding sediment, in order to facilitate the determination of the total extension of the middens; 2) to identify the geometry of the basement of the northern midden, in order to define its relationships with its substrate and environment; 3) to investigate the internal geometry of the northern midden, in order to understand its building modalities.