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Origin and diagenesis of lignin and carbohydrates in mangrove sediments of Guadeloupe (French West Indies): Evidence for a two-step evolution of organic deposits

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ABSTRACT

The mangroves of Grande Terre Island (Guadeloupe, French West Indies) are known to store large amounts of organic carbon, and organic-rich sediments have been described to several meters depth. The purpose of the present work was to precisely determine the molecular composition (carbohydrates and lignin-derived phenols) of these organic deposits in relationship with environmental conditions. It was found that within the upper meter of the cores, geochemical data displayed the classical degradation pattern of organic matter (OM) deriving from higher plants. On the one hand, carbohydrates from mangrove tissues underwent fast decomposition, other compounds being simultaneously synthesized by bacteria. On the other hand, lignin phenols were lost rather slowly, i.e. at a similar or lower rate than TOC, their distribution with depth evidencing various lignin decomposition pathways depending on redox conditions. The position of the swamp with respect to salt and fresh water tables strongly influenced these conditions. At depth, results revealed an organic-rich layer, which was characterized by surprisingly well-preserved OM with regard to sugar and phenol compositions. We speculate that the preservation of these compounds might be explained by a rapid and permanent flooding of the mangrove stands that may have occurred more than a thousand years ago. We suggest that the geodynamic context, i.e. the recurrent seismic activity recorded in Guadeloupe, may have induced such a flooding, resulting in the preservation of this OM.

1. Introduction

Mangrove forests, which develop in the intertidal zone of tropical and subtropical coastlines, are among the most productive terrestrial ecosystems, and can be characterized by a strong organic accumulation in their substrate (Chen and Twilley, 1999; Bouillon et al., 2003; Chmura et al., 2003; Bouillon et al., 2008). Additionally, the decay processes of organic matter (OM) in mangrove sediments are highly variable, due to the mixing of marine and fresh water, and to the activity of root systems and macrofauna (Alongi et al., 2000; Marchand et al., 2004; Kristensen et al., 2008). Consequently, mangroves constitute a natural laboratory to study present processes of preservation/decomposition of higher plant remains in waterlogged sediments.

The mangrove of "Le Grand Cul-de-Sac Marin", located on Grande Terre Island (Guadeloupe, French West Indies), is characterized by a clear zonation pattern of mangrove species from saline to fresh water. *Rhizophora mangle* develop on saline sediments, with salinity values ranging from 30 to 40, *Acrostichum aureum* and *Laguncularia racemosa* on a brackish substrate, with salinity values ranging from 10 to 20, and *Pterocarpus officinalis* and *Cladium marescus* on a nearly fresh water soil, with salinity values lower than 5 (Lallier-Vergès et al., 1998). This mangrove swamp system has been aggrading at the same place for several centuries (Feller et al., 1990). In a previous study (Lallier-Vergès et al., 1998), we showed that the sedimentary record reached about 1400 years BP at 180 cm depth beneath the more marine *R. mangle* stand. Beneath the more continental *P. officinalis* forest, the record reached about1400 years BP at only 65 cm and 2700 BP at 185 cm depth. Accordingly, this mangrove is characterized by a very high sedimentary organic content, with TOC values ranging from 17 to 48% on 2 m deep profiles, which is among the highest TOC values ever measured in mangrove ecosystems. Using C/N ratios, Rock-Eval pyrolysis data, $\delta^{13}C$ values and microscopic observations and counts, Lallier-Vergès et al. (1998) demonstrated that there was a strong link between pore water chemistry (i.e. salinity and redox values) and organic matter contents, both in terms of quantity and quality. Finally at depth, an unexpected OM-rich layer, characterized by high C/N ratios and low $\delta^{13}C$ values, was observed beneath most of the mangrove stands.

Carbohydrates and lignin-derived phenols, which are among the main organic components of vascular plants, are powerful indicators to trace higher plant remains and thus mangrove-derived OM in coastal environments (Benner et al., 1990; Opsahl and Benner, 1995;

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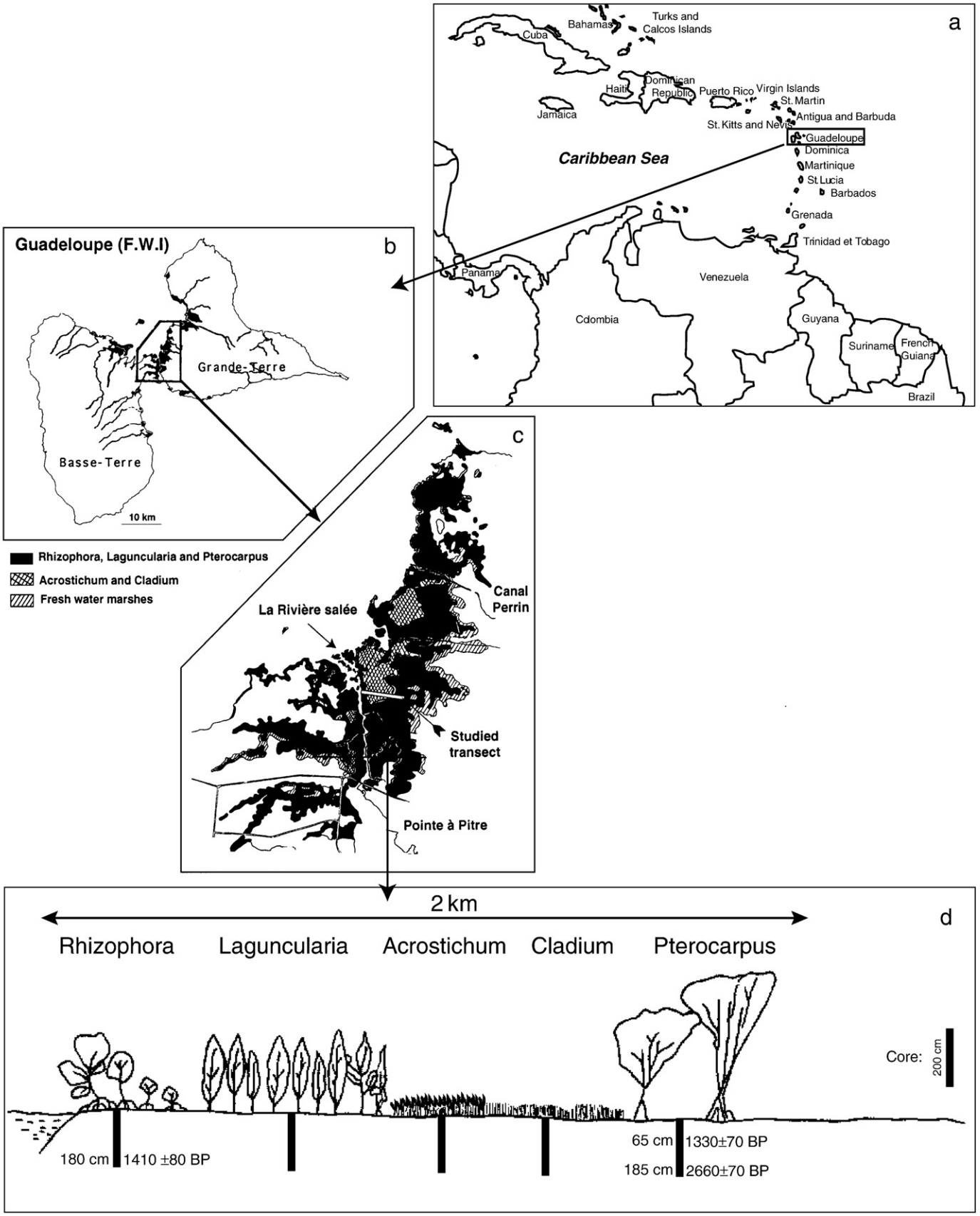

Fig. 1. Maps of the studied area: a) situation of the Guadeloupe Island in the Caribbean Sea; b) situation of the mangrove studied in Guadeloupe; c) surface map of the studied mangrove showing the position of the transect; d) distribution of the various mangrove species along the transect, and radiocarbon dates (from Lallier-Vergès et al., 1998).