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# Historical embayed coastal evolution under a high energetic hydrodynamic event

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## 1. Introduction

The Portuguese coast of Estremadura (NW of Lisbon) is a present day cliff coast with narrow embayed beaches, most of them with estuaries of small catchment rivers (fig.1). The case study covers 2100m coastline and an indentation ranging between 200m to 300m (fig.2). The embayment is open to W and SW waves, but sheltered to NW dominant waves. The waves can reach 2,5m of significant height ( $H_s$ ) during winter and storms ( $H_s > 5m$ ) are frequent.

The research was developed in the framework of the FMI 5000 Project dealing with the evaluation of the balance between fluvial and marine influences, as well as the impact of extreme events.

## 2. Methodological approach

- Geomorphological survey, including GPR
- Coring
- Detailed sedimentologic analysis (1cm thick core samples)
- Sediment statistical determination
- Pollen and other microfossils (Non-Pollen Palynomorphs)
- Geochemical methods (Total Organic Carbon -TOC and Total Nitrogen - TN; TOC/TN ratio;  $\delta^{13}C$  and  $\delta^{15}N$ );
- Radiocarbon dating (using Bayesian analysis)
- Historical documents

## 3. Results

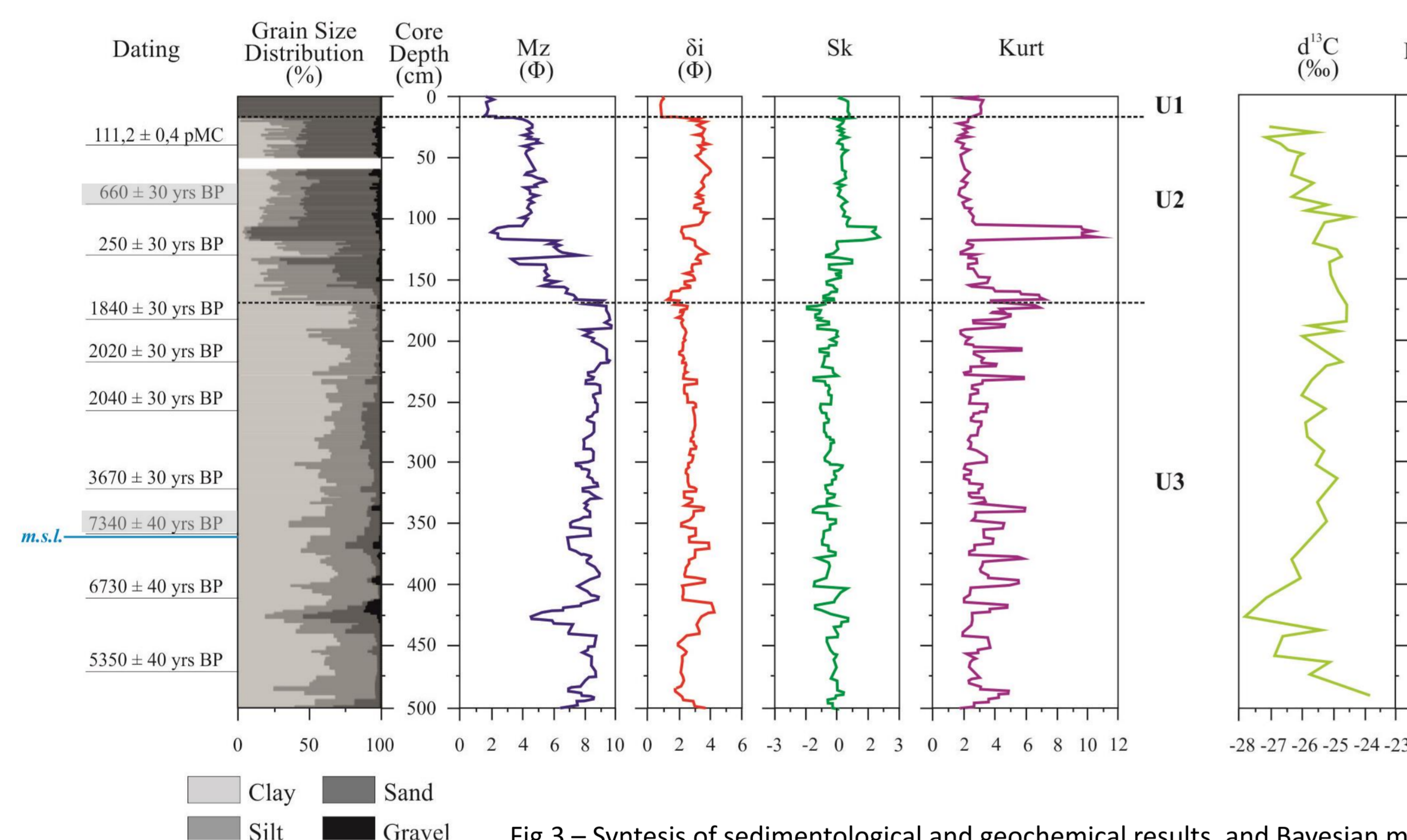


Fig.3 – Synthesis of sedimentological and geochemical results, and Bayesian modelling approach to radio carbon dating.

## 4. Paleo – environmental synthesis

(i) **An intermittent lagoon** before modeled 6000 cal BP shown by sediments from the base to 440cm, with sand and silt always > 25%;  $^{13}C/^{12}C$  ratios point to a marine influence in this phase (fig. 3). Pollen and microfossils (fig. 4), as well, show a weak marine signal of a eutrophic alder (*Alnus*) fringed lagoon.

(ii) **A seasonal or oxbow lake** from modeled 6000 cal BP to 1840±30 cal BP (440cm-170cm). The sediments are less sandy, with sand < 50%, more frequently < 20%, with episodes of floods marked by layers of gravel, sand and silt, with deposition rate between 0.04 to 0.47 cm/year (green cluster in fig. 5). The pollen signal (fig.4) seems to be mainly local and hence from a small seasonally inundated lake. The dominant species are semi-aquatic quillworts (*Isoetes*). Marine indicators are nearly absent during this phase. High charcoal values show local burning and human presence. The abrupt change seen in the pollen and charcoal signal (185cm) and later in the sediment composition (170cm) points towards strong human intervention in the slopes of the drainage basin.

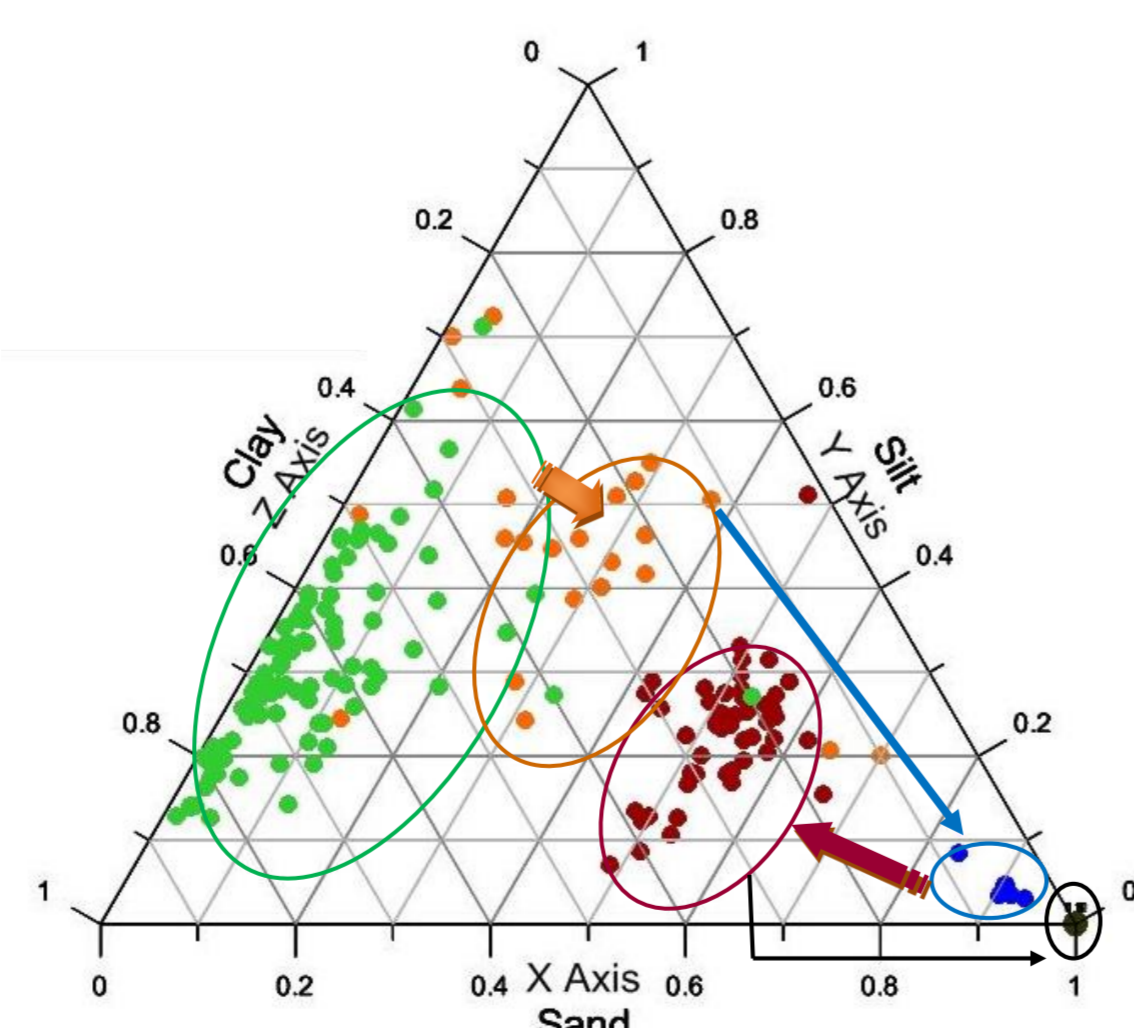


Fig.5 – Sequence of sedimentological packages. Intermittent lagoon and seasonal lake or oxbow in green, coastal plain, 1st episode of infilling in yellow, extreme hydrodynamic event in blue, 2nd episode of infilling in brown and dune filled in black.

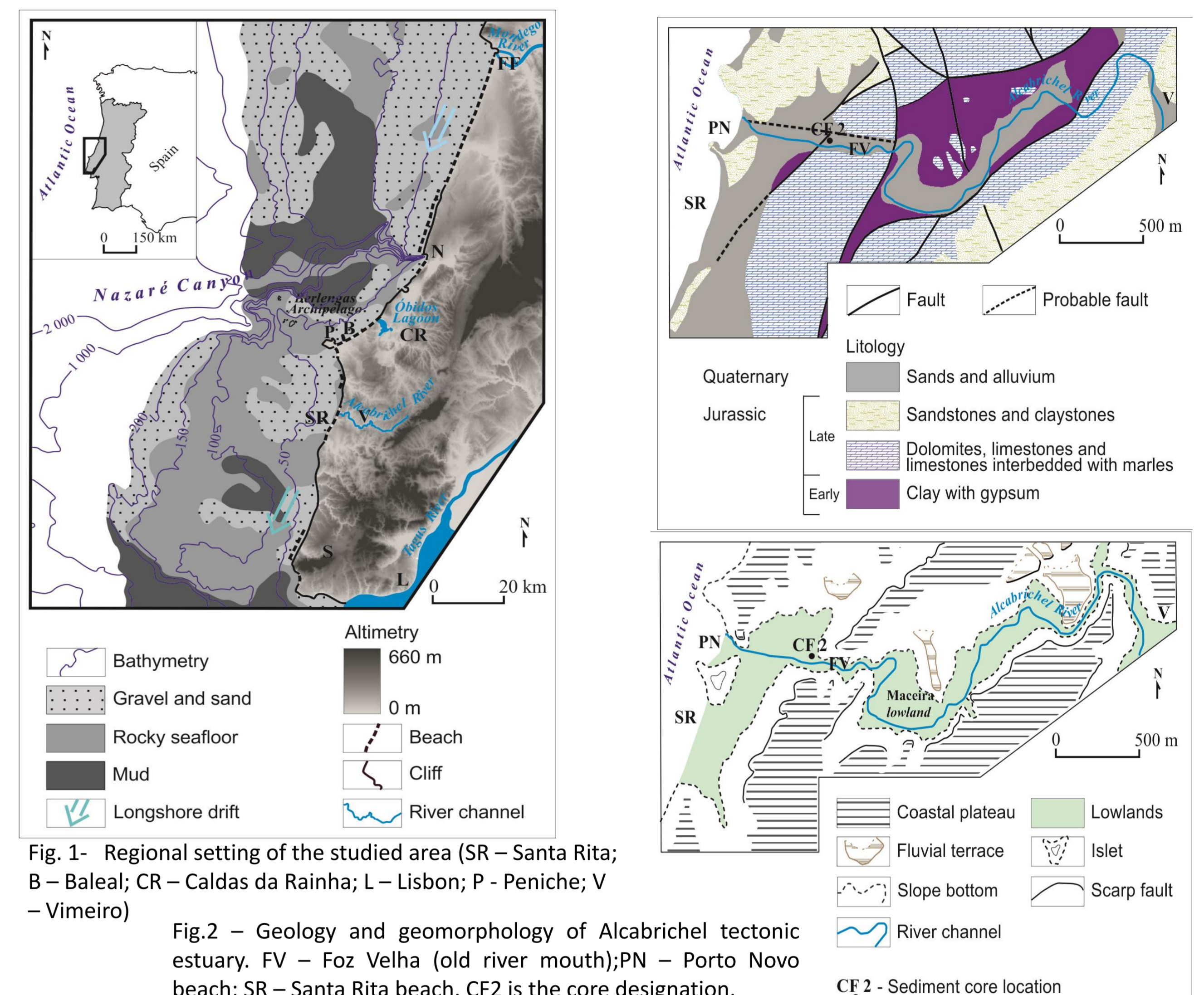


Fig. 1- Regional setting of the studied area (SR – Santa Rita; B – Baleal; CR – Caldas da Rainha; L – Lisbon; P – Peniche; V – Vimeiro)

Fig.2 – Geology and geomorphology of Alcabrichel tectonic estuary. FV – Foz Velha (old river mouth); PN – Porto Novo beach; SR – Santa Rita beach. CF2 is the core designation.

CF2 – Sediment core location

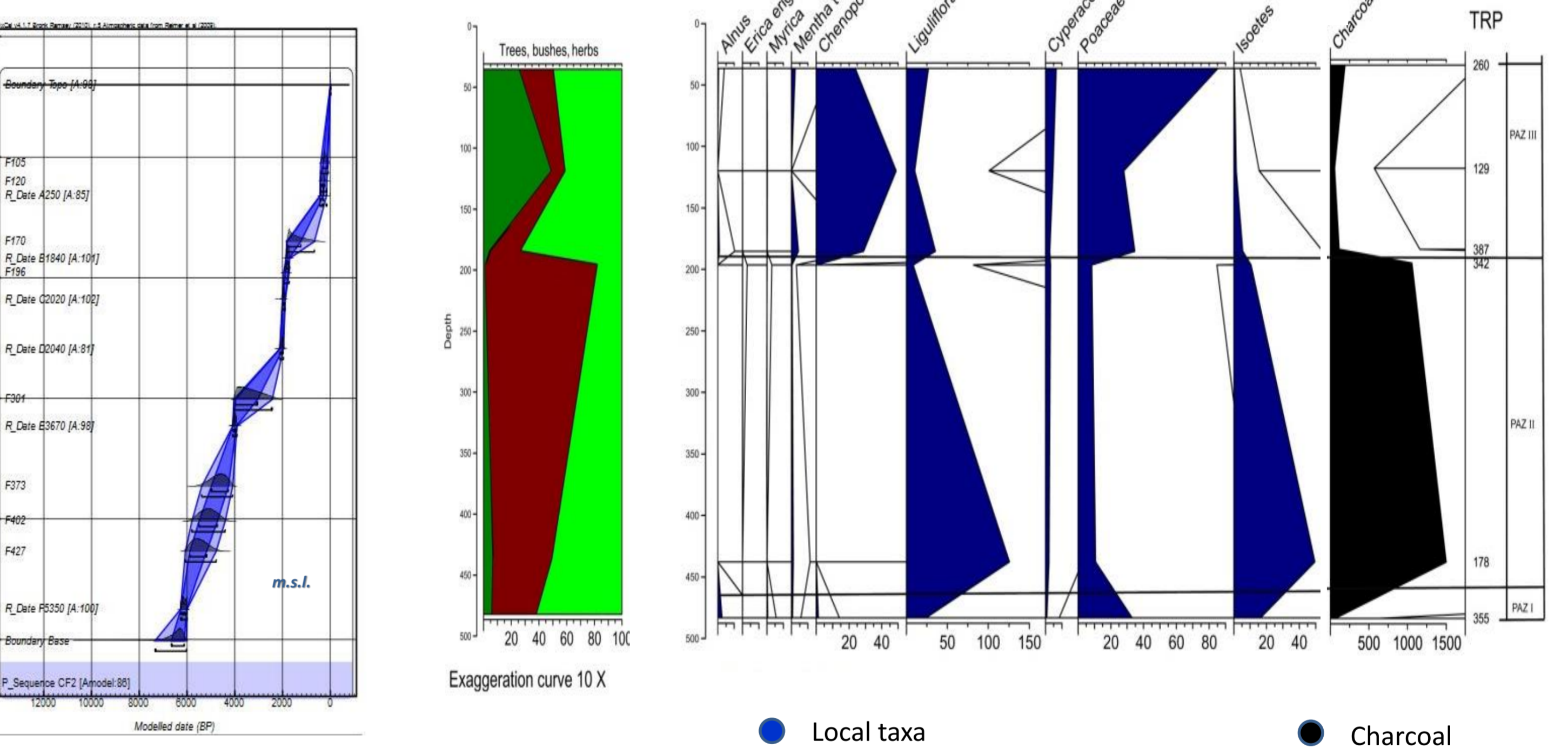


Fig.4 – Condensed pollen diagram with pollen assemblage zones (PAZ).

(iii) **A coastal plain/wetland** represented by sediments from 170cm to 20cm, with gravel sand and silt > 50%, and where sedimentation rate reaches 0.56cm/year.

In this section, from 1840±30 cal BP to the last century, 3 sedimentary packages are present:

- from 170cm to 113cm, the **1<sup>st</sup> episode of infilling** mainly with sand and silt (yellow cluster, fig. 5);
- a 6cm thickness layer, of 90% sand, the coarser sand recorded in the core sediments (blue cluster), showing a **high hydrodynamic event**;
- from 107cm to 20cm, the **2<sup>nd</sup> episode of infilling**, with gravel, sand and silt, the sand being > 40% (brown cluster).

During this episode from the Roman Age to the XIX century, the pollen signal shows a marsh dominated by Chenopodiaceae, a common salt marsh family. Marine indicators (dinoflagellate cysts) are present. High values of arboreal pollen (*Pinus*) may point to an increased regional input of pollen at this stage but may also show the documented reforestation of the last centuries. Throughout this phase there are signals of agriculture and pastures. Historical documents from the XII century mentioned a relative large lagoon enough to feed local population and the monks of an ancient monastery that was abandoned during the 17th century.

(iv) **A dune field** represented by the top 20cm sediment show the current conditions since the last century (black cluster fig. 5)

The infilling episode that built up the coastal plain starting post 1840±30 cal BP is considered to be the combined result of natural resilience related to previous sea level stabilization, human intervention, river dynamics and the result of an extreme coastal phenomenon.

The sediments show a high energetic hydrodynamic event after 250±30 cal BP and are probably the result of the **tsunami** that followed the **Lisbon earthquake (1755)**.

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