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# Organic chemistry and magnetic susceptibility to characterize Late Mesolithic (ca. 8400-7000 cal BP) palaeoenvironmental conditions in the Sado Estuary, Portugal

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## Abstract

Late Mesolithic hunter-gatherer communities (ca. 8400-7000 cal BP; ca. 6450-5050 cal BC) occupied the inner areas of the Tagus and Sado rivers (Portugal) during the Early-Middle Holocene transition. At that time both river valleys were flooded by marine ingression due to the rapid Holocene sea-level rise that occurred until ca. 7000 cal BP, forming large estuarine areas with favourable conditions for occurrence of marine/estuarine species.

The palaeoenvironmental characterization of the Tagus estuarine system shows that, during the Mesolithic occupation, shell middens were placed in the proximity of saltmarsh environments and near the upstream limit of tidal influence. The deceleration of the sea-level rise at ca. 7000 cal BP led to a relative increase in the fluvial sediment supply. However,

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despite the fluvial influence, estuarine conditions prevailed in the area of the Tagus that was occupied during the Late Mesolithic (e.g. Muge tributary) until ca. 6000 cal BP, long after the disappearance of these hunter-gatherer communities.

In the Sado estuary, the information is scarce thus far. Electrical Resistivity Tomography (ERT) profiles were performed to characterize the Late Quaternary palaeovalley morphology. Results revealed a deep channel reaching ca. 40 m below mean sea level (MSL) while tributaries accomplished shallower valleys. Analyses performed in sediment cores collected in the Sado channel show that estuarine conditions prevailed in the area until ca. 3300 cal BP at Arapouco (the most downstream studied area ca. 50km upstream the river mouth), and were identified ca. 4400 cal BP at Laxique (the more upstream studied area ca. 65 km upstream the river mouth).

According to the ERT profile, the Carrasqueira tributary palaeovalley, located near the Arapouco shell midden, reached ca. 15 m depth near its mouth. A 13.5 m sediment core (Arez) was collected on the alluvial plain of the Carrasqueira stream at ca. 2 m above MSL with the aim of characterizing the palaeoenvironmental conditions in the Sado valley during the Mesolithic occupation and its evolution through the Holocene.

In this work we present the preliminary results of the multi proxy analysis (texture, magnetic susceptibility and organic chemistry) performed on the Arez core combined with <sup>14</sup>C dating.

Radiocarbon dates performed on bulk organic material at 10.5 m (median value of 8860 cal BP) and 7.5 m (median value of 7120 cal BP) below MSL indicate that sedimentation occurred since the Early Holocene and the sedimentary column covers the timespan of the Late Mesolithic occupation.

Modern materials such as plastic occur on the top 50 cm of the core pointing to recent anthropogenic influence probably related with rice planting known to occur in the valley at least since the 18th century.

The sediment is essentially composed by mud (< 10% of sand).

Magnetic susceptibility (MS) values lower than  $50 \times 10^{-5}$  SI were measured in almost all samples, with exception of a peak reaching ca.  $560 \times 10^{-5}$  SI at ca. 10 m below MSL and of several (n=10) other peaks reaching values between ca.  $100 \times 10^{-5}$  SI and  $200 \times 10^{-5}$  SI scattered over the sedimentary column. The higher MS values are most probably the result of the input of terrestrial magnetic material brought by the fluvial system to the studied area during periods of higher river flow.

Stable carbon isotopes ( $\delta^{13}\text{C}$ ; varying between -26.1 and -23.0) and the C/N ratio (varying between 10.8 and 17.0) point to the prevalence of estuarine conditions in the entire sedimentary column until, at least, 2 m core depth (top 2 meter sample analysis still on-going). The estuarine conditions are accessed by comparison with values determined in different environments of the present-day estuary.  $\delta^{13}\text{C}$  presents higher values between the core base (10.5 m below MSL) and ca. 7.5 m below MSL pointing to important environmental changes since ca. 7100 cal BP most probably as a response to the deceleration of the sea-level rise.

Although estuarine conditions are known to occur at upstream areas of the Sado valley, the maximum extension of the estuary is still unknown.

**Keywords:** Early, Middle Holocene, Palaeoenvironmental conditions, Landscape evolution, Sediments