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Phytolith and FTIR studies applied to combustion structures: The case of the Middle Paleolithic site of El Salt (Alcoy, Alicante)

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ABSTRACT

The combination of phytolith and FTIR analyses is a powerful tool to investigate the use of fire by past human populations. Here, we apply these methods to study the hearths of the subunit Xb at the Middle Palaeolithic site of El Salt, in Alcoi. El Salt is characterized by recurrent Neanderthal occupations that produced a succession of combustion structures and other anthropogenic remains. Using FTIR analysis we have been able to detect the presence of ashes, thermally altered clay, and phosphatic minerals in the sediments. Phytolith results point to the use of wood as fuel in subunit Xb. However, most of the phytoliths have been deposited in the site by natural agents, probably in the form of bird guano characterized by the presence of distinctive phytoliths of seed coats from *Celtis* sp. Differentiating between natural and anthropogenic deposited phytoliths is essential to evaluate the impact produced by human activities in the archaeological sediments.

1. Introduction

The understanding, control and production of fire are a keystone in Human Evolution that produced physical, cognitive and social changes in early human populations (Heizer, 1963; Oakley, 1970; Perlès, 1977). The human control of fire has a series of adaptive advantages that have been largely discussed in the specialized literature (Heizer, 1963; Cook, 1964; Oakley, 1970; Gregg and Grybush, 1976; Perlès, 1977). Among other advantages, fire allowed humans to expand into regions with colder climates, enlarged human's diet by increasing the range of edible food, and increased the number of working hours and social activities by producing artificial illumination (Oakley, 1970; Leopold and Ardrey, 1972; Stahl et al., 1984; Wrangham et al., 1999). However, when and how humans accomplished a complete control of fire, including its production by archaic populations such as the Neanderthals, is still a debated issue (James, 1989; Weiner et al., 1998; Sandgathe et al., 2011; Berna et al., 2012). Albeit this controversy multiple evidences of deliberate use of fire by Neanderthals has been reported from the Levant and Europe (Albert et al., 1999, 2000, 2003; Madella et al., 2002; Rosen, 2003; Cabanes et al., 2007, 2010; Albert and Cabanes, 2008; Mallol et al., 2010; Aldeias et al., 2012; Fernández Peris et al., 2012; Goldberg et al., 2012; Vallverdú et al., 2012, and references therein).

Defining the preservation state of the combustion structures is a critical aspect to approach the use and control of fire by Neanderthals. Combustion structures might preserve or not depending on numerous aspects such as climatic conditions, sedimentation rates, diagenesis, type of fuel used, and post-depositional disturbation caused by humans or other biogenic agents (Weiner and Goldberg, 1990; Meignen et al., 2001). One of the most successful approaches to define the origin and preservation of combustion structures is the study of the sediment mineralogy by means of Fourier Transformed Infrared Spectroscopy (FTIR) combined with phytoliths analysis from hearths remains (Schiegl et al., 2004; Schiegl and Conard, 2006; Cabanes et al., 2007, 2010; Allué et al., 2012; Mallol et al., 2013; Shahack Gross et al., 2014).

Here, we present new evidence from el Salt site hearths from subunit Xb, which follows the previous micromorphology, phytolith and FTIR analyses conducted in the subunit Xa (Mallol et al., 2013). We applied FTIR analysis to identify the presence of calcitic

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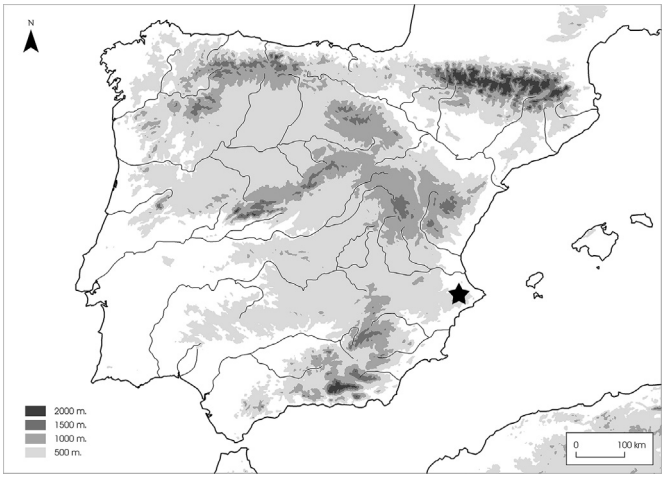

Fig. 1. Map showing the location of El Salt.

ash remains and thermally altered sediments and we used phytolith analysis to study fuel management and human behaviour patterns in relation with fire control.

2. The site

El Salt is a Middle Palaeolithic site located in the South East of the Iberian Peninsula (Fig. 1). The site is located in the South East side of the Sierra de Mariola, in Alcoy (Alicante, Spain) at 680 m above sea level, close to the Serpis and Barxell rivers. This area forms part of the mesomediterranean belt. The current annual precipitation is above 500 mm and mean temperature is 14 °C (Rivas Martínez, 1987). Vegetation cover is often characterized by *Quercus*, coniferous forests and *Juniperus* are sometimes developed. Steppe formations are characterized by Poaceae (such as *Stipa* and *Lygeum*), Asteraceae, Chenopodiaceae (such as *Salsola* and *Suaeda*) (González-Sampériz et al., 2010). The vicinity of other Middle Palaeolithic sites as Abric del Pastor, Cova Beneito, and Coves d'Estroig, in addition to lithic raw material provisioning zones, makes this area especially active during the Middle Palaeolithic (Iturbe et al., 1993; Faus, 2000; Barciela and Molina, 2005; Galván et al., 2009; Machado et al., 2013; etc.).

The Middle Paleolithic sedimentary sequence at El Salt has provided dates between 60.7 ± 8.9 and 45.2 ± 3.4 ka BP (Galván et al., 2014b). These dates place Middle Paleolithic occupations at el Salt during MIS 3, which in the Iberian Peninsula is characterized by variable climate conditions with abrupt climatic changes (Kehl et al., 2014). Vegetation landscapes were highly heterogeneous and responses to differences on climate, geology and altitudinal gradients have been described (Carrión and Munuera, 1997; Moreno et al., 2012). Pollen and charcoal sequences in the area show dry steppe formations next to coniferous woodland, and an important Mediterranean component including evergreen *Quercus*, *Olea*, *Pistacia*, and *Myrtus* during MIS3 (González-Sampériz et al., 2010).

Thirteen stratigraphic units (S.U.) were described by Fumanal (1994) and grouped in five segments according to the archaeological remains and macroscopic features (Fig. 2a). The first segment, at the base of the sequence, is formed by an archaeologically sterile travertine platform (Unit XIII). The second segment (Units XII-IX) shows the highest concentration of combustion structures and archaeological remains. The third segment (Unit VIII to the lower half of Unit V) shows a decrease of anthropogenic impact and an increase of natural sedimentation with an accumulation of large blocks in Unit VI. Nevertheless, six teeth attributed to a Neanderthal adult were recovered from the base of Unit V (Garralda et al., 2014). The upper half of Unit V, which is archaeologically sterile, forms the fourth segment. The last segment encompasses Units IV-I, which contains Holocene sediments with reworked Upper Palaeolithic, Mesolithic, and Neolithic materials (Galván et al., 2014b). Archaeological excavations at El Salt have been carried out systematically since 1986. Lately, an integrated multidisciplinary analyses of the archaeological and sedimentary records was carried out to examine the archaeological palimpsest (Galván et al., 1991, 2006a, 2006b, 2014a, 2014b; Fumanal, 1994; Dorta et al., 2010; Gómez de la Rua et al., 2010; Machado et al., 2011; Marrero et al., 2011; Sistiaga et al., 2011, 2014; Mallol et al., 2013; Garralda et al., 2014; Hernández et al., 2014).

Stratigraphic unit X has been dated around 50 ka BP, and to date has provided the greater amount of archaeological remains. For excavation purposes the stratigraphic unit X has

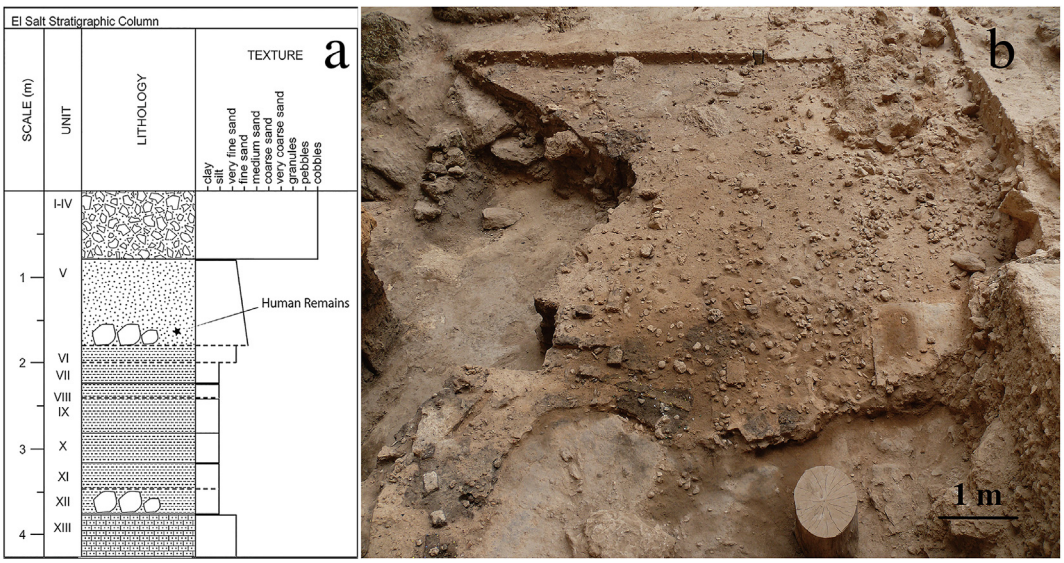

Fig. 2. Stratigraphic units at el Salt and excavation surface in unit X a) stratigraphic scheme showing the main sedimentary features (extracted from Garralda et al., 2014); b) detail of the excavation surface in unit X.

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