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Late Holocene vegetation dynamics on an Atlantic–Mediterranean mountain in NW Iberia

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ABSTRACT

Detailed studies on the late Holocene vegetation dynamics of the mountains of NW Iberia are rare. Furthermore, the impact of human activities and changes in fire activity on the natural vegetation are not well-known over these areas. In order to improve the knowledge on these topics, pollen and charcoal analyses were conducted on two new sedimentary sequences from the Teleno Mountains. Between ca 4500 and 3200 cal yr BP, *Pinus* type *sylvestris* and *Betula* dominated the forests that covered the uplands of the Teleno Mountains. At this point this pine-birch forest was replaced with heathlands and grasslands, which persisted during all the Iron Age and the Roman period until ca 1500 cal yr BP. This abrupt deforestation process could be caused by fire, grazing, and/or mining activities linked to the exploitation of the metal resources of these mountains. Around 1250 cal yr BP a *Betula* forest established in the uplands of the Teleno Mountains, probably following a decrease in human activities. The gradual rise in regional population density since ca 300–200 cal yr may be linked to the increase in fire activity that triggered the replacement of birch forest with heathlands. Lastly, the extent of the *Pinus pinaster*-dominated forests in the lowlands is an illustrative example of how the economic activities of the local human population have controlled the vegetation cover in this area, as it is very clear in the pollen record the recovery of natural *P. pinaster* forests since ca AD 1900 associated to the start of resin exploitation.

1. Introduction

Many palaeoecological studies have been conducted in the NW Iberian mountains during recent decades. The majority of the published palynological sequences are from sites in the Eurosiberian region, although there are also few palaeobotanical records from continental mountains located in the Mediterranean region. This information has improved our knowledge of vegetation responses to climate changes in this area during the late Quaternary (Allen et al., 1996; Muñoz Sobrino et al., 2001, 2005, 2007). In the same way, recent palaeoecological records have enhanced the role of NW Iberia as a glacial refuge area for temperate (Gómez-Orellana et al., 2007) and Mediterranean trees (Ramil-Rego et al., 1998a) during Pleistocene cold stages. Nevertheless, the present knowledge about late-Quaternary vegetation dynamics in NW Iberia is still incomplete. The vegetation development and the timing of the first human-induced deforestation processes in the inner and continental mountains of NW Iberia are especially interesting research questions, as these areas are almost completely deforested at present. Although there are several pollen sequences from this area, such as those from the Sanabria Lake area and the surrounding mountains (Allen et al., 1996; Janssen, 1996; Muñoz Sobrino et al., 2004), their chronologies are not accurate enough to track the late Holocene impact of human activities on the landscape (with the exception of the La Roya sequence; Allen et al., 1996).

Patterns of Holocene fire activity and their influence on vegetation dynamics have been widely reported from many sites around the world (e.g., Clark, 1988; Colombaroli et al., 2007; Gavin et al., 2007; Higuera et al., 2008), including several sequences from central and SE Iberia (e.g., Carrión and van Geel, 1999; Carrión et al., 2003; Franco-Múgica et al., 2005a). In contrast, detailed microscopic charcoal analysis has not been frequently employed in the sequences from the Cantabrian Range and the NW Iberian mountains, although there are some exceptions (e.g., García Antón et al., 1997). The study of macrofossils can also help complete the interpretation of the vegetation history, usually providing a higher taxonomic resolution than palynological analysis and presenting a local origin (Birks and Birks, 2000). In the Iberian Peninsula, studies assessing pollen and macrofossils are almost absent (García Antón et al., 1995; Carrión-Marco et al., 2010).

In this context, we conducted a palaeoecological study in the Teleno Mountains, a mountainous area of NW Iberia that is very close

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to the Iberian Central Plateau. Our first aim was to improve the knowledge of the mid- to late-Holocene vegetation dynamics of the innermost massifs of NW Iberia and discuss the similarities and differences with other studied sites from N and W Iberia. We also aimed to reconstruct the regional fire activity of this area by means of charcoal analysis to increase our understanding of the long-term fire ecology of these Atlantic–Mediterranean mountains, where lightning incidence is currently very high. Furthermore, this area has remained almost continuously inhabited since the Bronze Age, and some of the occupation periods are expected to have had an important impact on the natural vegetation, such as the Roman period (when extensive mining activities took place; Matías, 2006). Nevertheless, it is not clear how important the human impact was on the environment during this period and to what extent had human activities altered the 'natural' vegetation when Romans arrived in the area. As a result of this, we aimed to evaluate human impacts on the natural vegetation of this mountain range during the last millennia and whether the impact depended on the considered altitudinal belt. To shed new light on these three main questions, we conducted pollen, microscopic charcoal and macrofossil analyses on two cores from different altitudinal belts of this mountainous area.

2. Study area

The Teleno Mountains are located in the SW corner of the León province and are one of the westernmost massifs of the Cantabrian Range (Fig. 1.a). This mountain chain divides the Eria and Duerna basins (both tributaries of the Duero River) and runs for approximately 40 km from NW to SE. Its highest peak is the Teleno Peak (2183 masl). This area has two main geological units: 1) an Ordovician basement that is mostly composed of quartzites and slates and 2) Quaternary deposits of variable grain size that are located in the foothills of the massif (Sánchez Fernández, 2005a). As a result, the soils that developed over these rocks are acidic, shallow and coarse-grained. The geomorphological setting is characterised by gentle slopes and quartzitic ridges at the top of the mountains. Furthermore, glaciers must have been important in the northern slopes of this mountain range, with moraines below 1400 masl in the area (Alonso Otero, 1982). In addition, extensive scree slopes are one of the most characteristic features of the Teleno Mountains landscape. This area is currently characterised by a sub-Mediterranean climate. The mean annual temperature is approximately 10 °C, and the average annual rainfall is about 700 mm, with a summer drought that lasts for two to

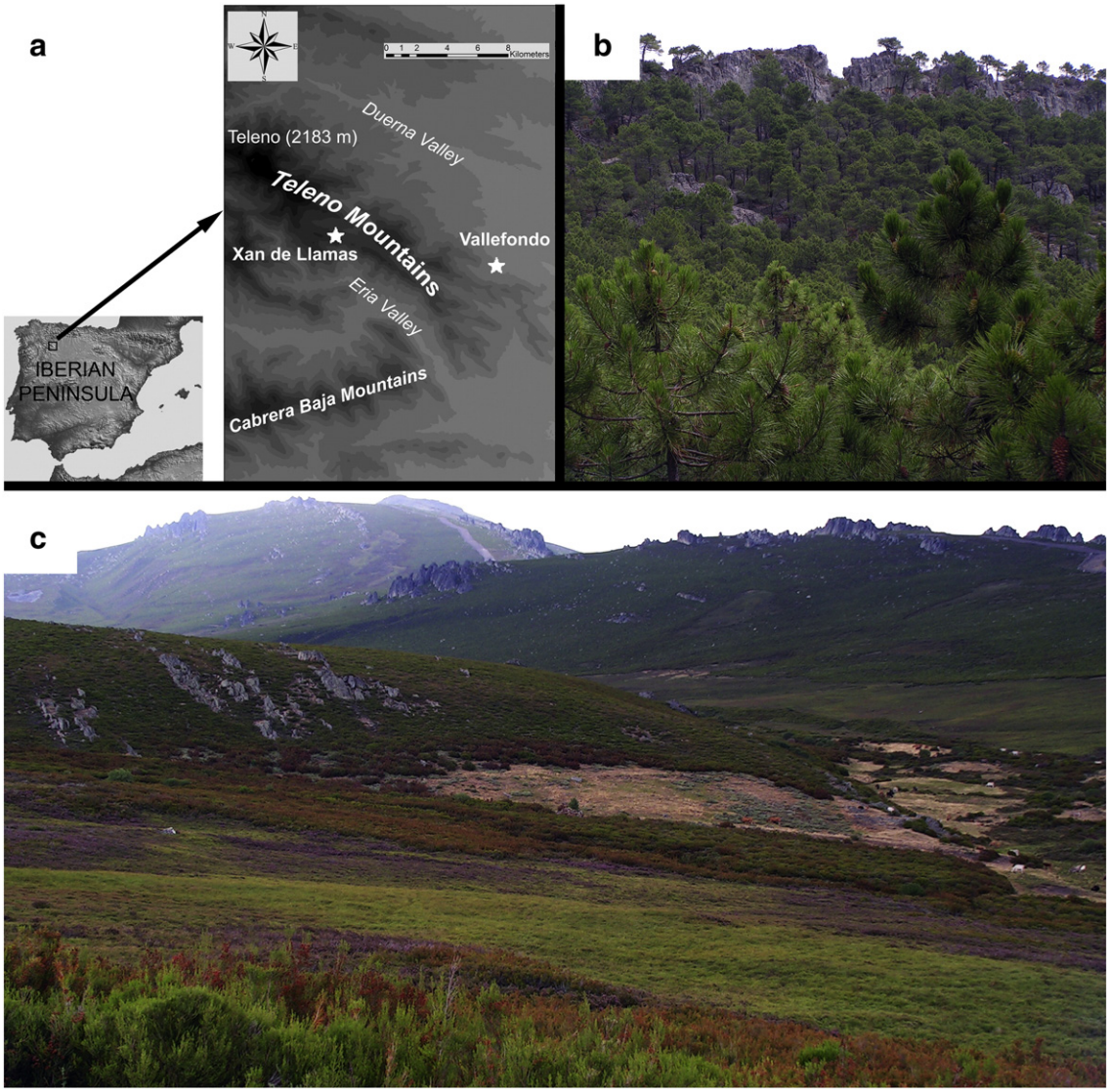

Fig. 1. a) Map showing the study area of the Teleno Mountains in NW Iberia. White stars represent the exact location of the two sampling sites: Xan de Llamas and Vallefondo. b) Landscape close to the Vallefondo area. *Pinus pinaster* forest on quartzite outcrops, where this species survived high human impact periods with increased fire activity and/or logging. c) Landscape of the Teleno Mountains highlands (Xan de Llamas area), which is covered mainly by extensive heathlands. The Teleno Peak is in the background (2183 masl).