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Dating the Earliest Pleistocene alluvial terrace of the Alcanadre River (Ebro Basin, NE Spain): Insights into the landscape evolution and involved processes

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ABSTRACT

This work presents the results of a multi-approach study of the extensive highest terrace (Qt1) of the Alcanadre River system (Ebro Basin, Spain). The timing of the earliest morphosedimentary fluvial archives in the Ebro Basin (NE Spain) under exorheic conditions is provided from ESR dating techniques applied to optically bleached quartz grains and complemented by palaeomagnetic data and morpho-pedosedimentary features. A mean ESR age estimate of 1276 ± 104 ka based on the Ti-centre provides the oldest numerical age obtained for a Quaternary terrace in the Iberian Peninsula. The polarity determined by palaeomagnetic analysis is normal, although it must be contained within the Matuyama reversed period. Therefore, Cobb Mt is the more suitable chron, although Jaramillo cannot be fully ruled out. This age is consistent with the last stretch of the Matuyama reversed Chron deduced from palaeomagnetism. Relevant consequences concerning the palaeogeographical setting, palaeoclimatic context and fluvial incision rates are discussed to elucidate the landscape evolution of NE Iberia.

1. Introduction

The Ebro Basin is a large drainage depression in the NE Iberian Peninsula. Intensive Quaternary research began in the 1970s, and a good understanding (mapping, geomorphological features and forming processes) of the main morphosedimentary units outcropping in the Central sector of the Ebro Basin is currently available (Gutiérrez and Peña, 1994). The large sequence of Pleistocene staircase terraces related to the drainage network guided by the Ebro River is remarkable. Nevertheless, the timing of terrace formation and landscape evolution of the Ebro Basin suffers from an important lack of numerical ages (Santisteban and Schulte, 2007). Recently, a significant effort has been made to date staircase terrace sequences in some of the main tributaries of the Ebro River based on luminescence (Fuller et al., 1998; Lewis et al., 2009; Benito et al., 2010; Calle et al., 2013), terrestrial cosmogenic nuclides (Stange et al., 2013) and palaeomagnetism (Sancho et al., 2007; Calle et al., 2013; Gil et al., 2013). However, the chronological database currently available refers mainly to fluvial terraces developed over the Middle and Late Pleistocene, whereas no numerical ages have been reported so far for the Early Pleistocene terraces in the Ebro Basin.

That framework is actually quite similar to other studied basins in Spain (Silva et al., 2013), for which only one single ESR age of 1.140 ± 0.13 Ma is documented in the Arlanzón River valley (Duero Basin) (Moreno et al., 2012). It is also noteworthy, the ESR age of

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0.903 ± 0.058 Ma provided by Rosina et al. (2014) for the earliest fluvial terrace of the Lower Tagus River in Portugal. Palaeomagnetic data from Early Pleistocene terraces are also scarce, highlighting the studies by Pérez-González et al. (2013) in the High Tagus River valley, Benito-Calvo et al. (2008) in the Arlanzón River valley (Duero Basin), Baena and Díaz del Olmo (1994) in the Guadalquivir River valley and Gil et al. (2013) in the Ebro River valley. In addition, Roquero et al. (2015) summarize the available soil data as well as numerical ages from terraces in the Tagus River valley, and they establish several height-age transfer polynomial functions based on soil development indices. As a consequence, the calculated standard ages for the oldest terraces range between 1385 ka (terrace at +84 m above present channel) and 3098 ka (terrace at +130 m above present channel).

Terrace sequences recording Quaternary landscape evolution and their forcing mechanisms have recently been a matter of debate (e.g., Westaway et al., 2009; Vandenberghe et al., 2010; Stokes et al., 2012), underlining the substantial interest in these fluvial archives. In this paper, we present the results of a multi-approach study focused on the oldest terrace level of the Alcanadre River (Qt1 hereafter), a Pyrenean tributary of the Ebro River, in the north-central sector of the Ebro Basin (Fig. 1). A combination of mapping, morphostratigraphy, Electron Spin Resonance (ESR) dating and palaeomagnetism have been used to characterize and date these deposits, which are of major interest because they are evidence of the earliest fluvial activity in the Ebro Basin under exorheic conditions. Based on these results, several new insights into the Early Pleistocene evolution of the Ebro Basin will be discussed in terms of palaeogeography, palaeoclimate and fluvial incision.

2. Study area

The Ebro Basin was formed during the Palaeogene as a consequence of flexural subsidence related to the growth of surrounding mountain chains, particularly the Pyrenees. During the Oligocene and Miocene, the basin was filled with alluvial, fluvial and lacustrine sediments under conditions of continental internal drainage (Muñoz, 2002). This sedimentary regime persisted until the end of the late Miocene (between 12.5 and 8.5 Ma) when the internal drainage system of the Ebro basin opened to the Mediterranean Sea (García-Castellanos et al., 2003). The lowering of the Mediterranean Sea level and subsequent headward erosion of coastal drainages resulted in the capture of the internal lake system and the onset of the denudation of the Tertiary sedimentary infilling guided by the network of the Ebro River.

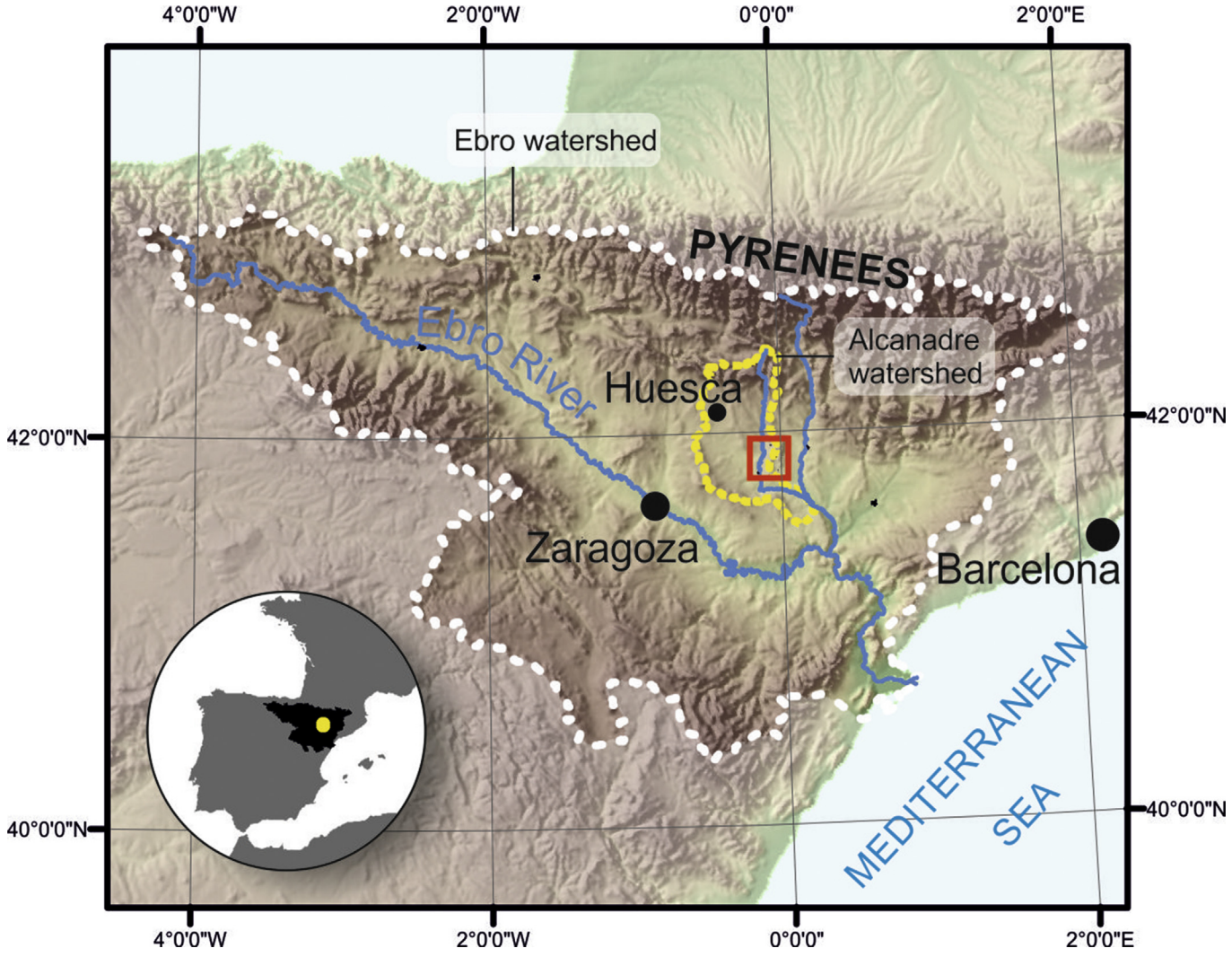

Fig. 1. Location of the Alcanadre River watershed in the Ebro Basin (NE Spain).