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Research paper

ESR chronology of alluvial deposits in the Arlanzón valley (Atapuerca, Spain): Contemporaneity with Atapuerca Gran Dolina site

Davinia Moreno [a,b,c,*], Christophe Falguères [a], Alfredo Pérez-González [d], Mathieu Duval [d], Pierre Voinchet [a], Alfonso Benito-Calvo [d], Ana Isabel Ortega [d], Jean-Jacques Bahain [a], Robert Sala [b,c], Eudald Carbonell [b,c,e], Jose María Bermúdez de Castro [d], Juan Luis Arsuaga [f]

[a] Département de Préhistoire, Muséum National d'Histoire Naturelle, UMR7194 du CNRS, 1 rue René Panhard, 75013 Paris, France
[b] Area de Prehistoria, Universitat Rovira i Virgili (URV), Avinguda de Catalunya 35, 43002 Tarragona, Spain
[c] IPHES, Institut Català de Paleoecologia Humana i Evolució Social, C/Escorxador, s/n, 43003 Tarragona, Spain
[d] Research Center for Human Evolution (CENIEH), Paseo de Atapuerca, s/n, 09002 Burgos, Spain
[e] Institute of Vertebrate Paleontology and Paleoanthropology of Beijing (IVPP), Beijing, China
[f] Centro (UCM-ISCIII) de Evolución y Comportamiento Humanos. Instituto de Salud Carlos III. Monforte de Lemos 3-5, Pabellón 14, 28029 Madrid, Spain

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ABSTRACT

The Sierra de Atapuerca (Northern Spain) is characterized by a well-developed karst system where several major archaeological sites have been discovered, attesting an almost continuous hominin occupation of the area during the whole Pleistocene period. Previous geomorphological studies showed a connection between genesis of the karst system and the evolution of the nearby Arlanzón river Valley. However, numerical dating results were missing to refine the chronostratigraphical framework of the Arlanzón valley's fluvial incision. To address this, we applied the Electron Spin Resonance (ESR) dating method to sedimentary optically bleached quartz grains from several fluvial terraces. Nine samples were collected from five of the 14 identified terraces. The ESR age results are stratigraphically coherent and in general agreement with both previous geomorphological observations and available palaeomagnetic data. Consequently, an ESR chronology of the geological evolution of the Arlanzón valley is proposed, which can be then correlated to the sedimentary sequence of the palaeoanthropological site of Atapuerca Gran Dolina. Our results provide important information about the chronology of hominid occupation in this area during Early and Middle Pleistocene.

1. Introduction

The Sierra de Atapuerca (Burgos, Northern Spain) is characterized by a well-developed karst system where an almost continuous hominid occupation has been documented since 1.2 Ma, through the discovery of a series of major archaeological sites, such as Sima del Elefante, Gran Dolina, Sima de los Huesos, Galeria or Portalón, among others (Arsuaga et al., 1997; Carbonell et al., 1999, 2008; Pérez-Gonzalez et al., 1999; Rosas et al., 2001; Bischoff et al., 2007). Previous investigations combining geomorphological evolution analysis of the Sierra de Atapuerca landscape (Benito-Calvo, 2004) and the study of the karst systems (Ortega, 2009) revealed a connection between the karst formation and the evolution of the nearby Arlanzón River located southwards (Fig. 1). While the chronology of the archaeological sites is now well established (among others: Berger et al., 2008; Bischoff et al., 2007; Carbonell et al., 2008; Falguères et al., 1999; Moreno, 2011), geochronological data are still missing to constrain the evolution of the fluvial incision of the Arlanzón valley.

To obtain numerical dates on the Pleistocene fluvial system of Arlanzón River, we applied electron spin resonance (ESR) dating to optically bleached quartz grains extracted from sediments. This method has already been successfully used in fluvial contexts, such as the Somme River terrace system in the Northern part of France (Laurent et al., 1998; Bahain et al., 2007), the main tributaries of the Loire River in the Centre Region, France (Voinchet et al., 2010), and the alluvial terrace sequences in Zhangjiajie, northwest Hunan Province, China (Yang et al., 2011).

The aim of this paper is to present the first ESR age results obtained on the terrace system of the Arlanzón River and to

* Corresponding author. Present address: Département de Préhistoire, Muséum National d'Histoire Naturelle, UMR7194 du CNRS, 1 rue René Panhard, 75013 Paris, France. Tel.: +33 1 55 43 27 26.
E-mail address: moreno@mnhn.fr (D. Moreno).

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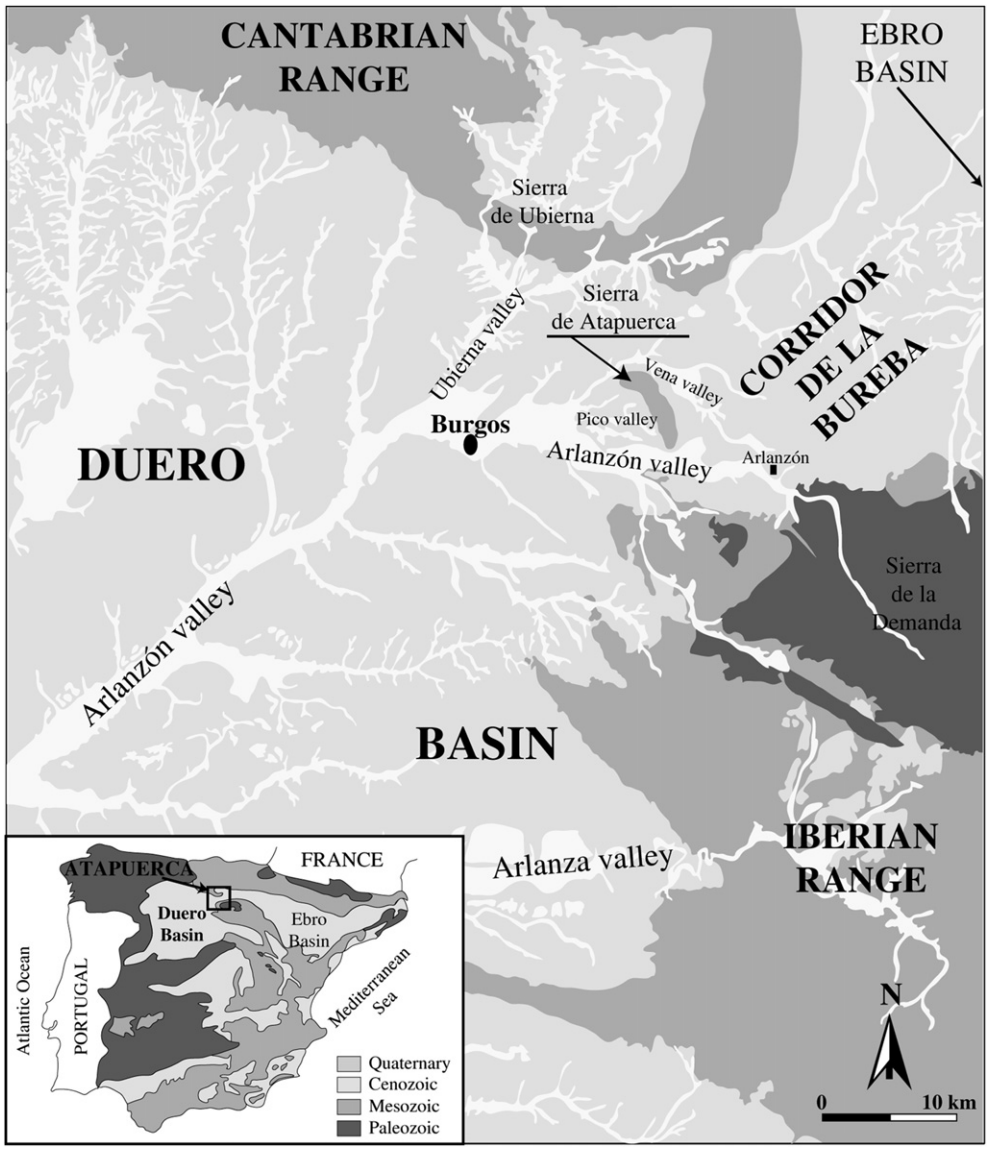

Fig. 1. Geological context of the Sierra de Atapuerca (Modified from Benito-Calvo et al., 2008).

attempt a correlation between the Gran Dolina karstic site and the incision process of the valley.

2. The Arlanzón terrace system

The studied area is located in the North–East part of the Cenozoic Duero River Basin (north-central Iberian Peninsula), which lies between the Iberian and Cantabrian ranges and connects with the Ebro River basin (Fig. 1). The Duero River region constitutes a large endorheic basin filled up during the Palaeogene and Neogene with alluvial and lacustrine detrital sediments (Benito-Calvo et al., 2008). During Upper Miocene and Pliocene, a connection between the Duero basin and the Atlantic Ocean was opened, initializing the incision of the present-day fluvial network of the Arlanzón River and its tributaries (Benito-Calvo et al., 2008; Ortega et al., 2010). This region has then been affected by a tectonic activity during the Late Cenozoic, causing the formation and development of these valleys.

The Arlanzón valley is characterized by a stepped terrace system where 14 terraces have been identified in addition to the present floodplain. These terraces are named from $T1_{AZN}$ to $T14_{AZN}$ (from top to bottom), and are distinguished by relative altitudes (Fig. 2). The fluvial deposits mainly consist of gravels occasionally interstratified by sandy or clayish beds (Benito-Calvo and Pérez-González, 2002; Benito-Calvo, 2004). Previous palaeomagnetic studies carried out on some of the terraces indicated a normal polarity for the $T5_{AZN}$ terrace and a reverse polarity for the $T4_{AZN}$, suggesting the presence of the Brunhes–Matuyama boundary in between (Benito-Calvo et al., 2008).

3. Material and methods

ESR dating of fluvial quartz is based on the detection of various radiation induced paramagnetic centers associated to defects present in the crystalline structure of the quartz (Weil, 1984). Various centers can usually be observed by ESR spectroscopy in quartz, but those showing the best potential to date Quaternary fluvial sediments are the aluminium (Al) (Voinchet et al., 2004) and the titanium (Ti) centers (Tissoux et al., 2007; Gao et al., 2009). Despite of the better bleaching characteristics of the Ti center, its