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New palaeoenvironmental and palaeoclimatic reconstructions for the Middle Palaeolithic site of Cuesta de la Bajada (Teruel, eastern Spain) inferred from the amphibian and squamate reptile assemblages

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ABSTRACT

In the eastern Iberian Peninsula, the archaeological site of Cuesta de la Bajada (Teruel, Spain) has produced some of the earliest evidence of Middle Paleolithic stone tool traditions together with evidence of equid and cervid carcasses defleshed by hominins. Based on the numerical age of 317-240 ka derived from OSL, ESR and AAR dating methods for the lower part of the Cuesta de la Bajada sedimentological sequence (level CB3), as well as the biochronological inferences for the small and large mammal associations, the site can be attributed to Marine Isotope Stage (MIS) 8 or the end of MIS 9. As amphibians and reptiles have precise environmental and climatic requirements and do not differ at species level from the extant herpetofauna of the Iberian Peninsula, they can contribute to the reconstruction of the landscape and climate. In this paper, the fossil amphibians and squamate reptiles from Cuesta de la Bajada are studied for the first time. The mutual ecogeographic range and habitat weighting methods were applied to the herpetofaunal assemblages to estimate quantitative data for the landscape and climate reconstructions. The climate is shown to have been colder and wetter than today in the interior of eastern Spain, with mean annual temperature up to 2.5 °C lower and mean annual precipitation slightly higher than at present. The monthly climatic reconstruction shows differences in the distribution of precipitation over the course of the year, with more abundant precipitation from late autumn to spring (i.e. from October to May), and more or less similar precipitation to today during the summer months (July and August). This suggests there was stronger rainfall seasonality between winter and summer than currently occurs. The paleoenvironmental reconstruction based on the herpetofaunal assemblage depicts a poorly forested (15–20%) patchy landscape with a large representation of dry meadows and scrubland habitats together with well-evidenced aquatic habitats. These reconstructions are consistent with other proxies recovered at Cuesta de la Bajada (pollen, small and large mammals) as well as other European MIS 8–9 paleoclimatic records. We can thus correlate levels CB2 and CB3 with the later part of MIS 8 (265-257 ka) or with a humid fluctuation within the MIS9b (303-290 ka). It is also possible to provide a new description of the environmental and climatic conditions that occurred in inner Spain during a cold period of the late Middle Pleistocene.

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1. Introduction

The impact of climate variations on terrestrial environments in southern Europe during the last 450 ka is well known from the long pollen records that have been produced from sedimentary sequences from Greece (Tzedakis, 1993, 1994; Tzedakis et al., 1997, 2003, 2006; Fletcher et al., 2013; Sadori et al., 2016), France (Reille and Beaulieu, 1995; Reille et al., 1998, 2000; Beaulieu de et al., 2001), Spain (Desprat et al., 2009; Valdeolmillos-Rodríguez et al., 2011), and off Portugal (Roucoux et al., 2006). These sequences have revealed a pattern of forested intervals under warm-temperate climatic conditions alternating with colder periods characterized by more open vegetation which, varying in time scales of 10,000 to 100,000 years, may represent a response to the Milankovitch-driven global climatic changes recorded in marine isotope records of global ice volume (Prell et al., 1986; Martinson et al., 1987).

Documenting Middle Pleistocene glacial/interglacial alternations in terrestrial records is of great relevance for understanding the harsh conditions that *Homo heidelbergensis* or pre-Neanderthal populations (and associated fauna and flora) had to face on the European continent. However, although interglacial periods are usually well represented in the palaeoenvironmental reconstructions derived from Iberian Middle Pleistocene archaeological sites (see for example Blain et al., 2009, 2012a; 2014, 2015), ancient glacial periods have rarely been documented, unlike in southern France, which has the long sequences of the Caune de l'Arago, Orgnac III, Baume Bonne and Grotte du Lazaret (e.g. Valensi et al., 2000; Hanquet and Desclaux, 2011; Lebreton et al., 2016).

In the whole Early to Middle Pleistocene sequence of the Gran Dolina site (Sierra de Atapuerca, Burgos, northern Spain) no temperatures below the current values have been reconstructed from the herpetofaunal assemblages (Blain et al., 2009, 2012a, 2013). Interestingly, the isotopic $\delta^{18}O$ record from Las Tablas de Daimiel wetland (Ciudad Real, south-central Spain) shows higher values than those of the MIS 1 (Holocene) range for the whole duration of MIS 9 and MIS 8, except for stage 8.2 (= MIS 8a) (Valdeolmillos-Rodríguez et al., 2011). This suggests that the temperatures may have been similar or slightly lower than the Holocene during MIS 8 in the south-central Iberian Peninsula. However, as stressed by Valdeolmillos-Rodríguez et al. (2011), evaporative depletion of ^{16}O in isolated or disconnected shallow waters may have led the primary isotopic signal to become more positive, which would imply that MIS 8 was colder than MIS 1.

In central Spain, the archaeological sites of Valdocarros II (Arganda, Madrid) and Estanque de Tormentas de Butarque (ETB) H-02 (Villaverde, Madrid) have been attributed respectively to the Marine Isotope Stages 8/7 and 6 (Blain et al., 2012b, 2017). During such "cold" periods the climate has been shown to have been more oceanic (although preserving some dryness during the summer) with a more open landscape, as opposed to "warm or temperate" periods when the wooded areas increased to up to 40% of the landscape surface. In level 2 of Valdocarros II (latest MIS 8), the mean annual temperature (MAT) was estimated to be 1.8 °C lower and the mean annual precipitation (MAP) 286.5 mm higher than today in the same area, and the woodlands represented less than 15% of the environment (Blain et al., 2012b). During MIS 6 at H-02 (ETB), MAT was much colder (−3.0 °C in comparison with the current climate) and MAP slightly wetter (+122.8 mm) with woodlands representing 17.3% of the reconstructed landscape (Blain et al., 2017).

To shed light on these ambiguities, we present here quantitative palaeoclimatical and palaeoenvironmental reconstructions of the Cuesta de la Bajada archaeological site (Teruel, eastern Spain) based on their assemblages of fossil amphibians and squamate reptiles, in order to correlate the results with other European MIS 8–9 paleoclimatic records and complete the description of the environmental and climatic conditions of interior Spain during this time period.

2. The site

Cuesta de la Bajada is a Middle Pleistocene site at which some of the earliest evidences of Middle Paleolithic stone tool traditions have been documented in the layers CB3, CB2 and CB1 (Santonja et al., 2014, 2016). The small format tool assemblage, dominated by simple flakes and scrapers, is associated with abundant remains of equids and cervids, in which both percussion and cut marks are well represented. This indicates primary access to defleshed carcasses by hominins (Domínguez-Rodrigo et al., 2015). The preserved lithic record, documenting a complete *chaîne opératoire*, indicates that knapping was performed *in situ* (Santonja et al., 2014).

The site is located in the Alfambra river valley within the Teruel Depression (Fig. 1). Among the 10 fluvial terraces identified in this area (named T10 to T1 from the present-day floodplain to the highest deposits), Cuesta de la Bajada is part of the T4 terrace (+50–53 m above the current river level), locally thickened by synsedimentary subsidence processes. The site was excavated in two phases: the western sector from 1990 to 1994 (Santonja et al., 1994, 2000) and the eastern sector from 1999 to 2011 (Santonja et al., 2014). Both sectors are located about 18 m above the known base of the T4 terrace fluvial sequence of the Alfambra valley (Fig. 1A and B). The archaeological levels from the eastern sector are associated with a small deformation depression located between a cyclic sequence of gravel bars and floodplain muds. Based on a sterile lower level horizon (G) of crudely massive, subangular to sub-rounded pebbles, the subsequent infill sequence of the archaeological site is made up of three layers covering a thickness of 1.5 m (Fig. 1C). From bottom to top, these units are denoted CB3, CB2 and CB1. Finally, these levels are capped with a 1 m-thick series of floodplain facies (P). Sedimentological analyses of the area suggest that the site was formed during a short period of time around a pond not far from a river (Santonja et al., 2014).

The numerical ages derived from the combination of ESR and OSL dating methods indicate that the lowermost level CB3 is 317-240 ka, thus corresponding to the MIS 8 or the end of MIS 9 (Santonja et al., 2014; Arnold et al., 2016; Duval et al., 2017). These numerical data are corroborated by the small-mammal study, in particular the morphological state of *Cricetulus* (*Allocricetus*) *bursae*, *Arvicola* aff. *sapidus* and *Microtus* (*Iberomys*) *brecciensis*. This makes it possible to place the site (CB3 to CB1) in the advanced, but not final, Middle Pleistocene (Sesé et al., 2016). As stressed by Duval et al. (2017), the rodent assemblage from Cuesta de la Bajada can be correlated with Atapuerca Faunal Unit 6 as defined by Cuenca-Bescós et al. (2010, 2016), i.e. roughly 610-230 ka by US-ESR dating (Falguères et al., 1999; Parés et al., 2013) or 820-198 ka by infrared stimulated luminescence (IRSL) dating (Berger et al., 2008). The large mammal association, composed by *Canis lupus*, *Elephas* (*Palaeoloxodon*) *antiquus*, *Stephanorhinus* cf. *hemitoechus*, *Equus chosaricus*, *Cervus elaphus*, *Bos primigenius*, *Rupicapra rupicapra* and *Capra* sp., is also characteristic of the Middle Pleistocene (Santonja et al., 2014).

However, AAR dating suggests an older age of 431 ± 44 ka (i.e. MIS 11/12) for level CB3, which is not concordant with the previously mentioned ESR and OSL estimates. According to Sesé et al. (2016), *Cricetulus* (*A.*) *bursae* is larger in size than the population from Cúllar-Baza (close to 600 ka), but similar to the one from Áridos-1 (MIS 11) and slightly smaller than the one from Valdocarros II (MIS8/7). This suggests that the age of Cuesta de la Bajada