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Glacial chronology, environmental changes and implications for human occupation during the upper Pleistocene in the eastern Cantabrian Mountains

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A B S T R A C T

Interest in the evolution of Pleistocene glaciers, environmental change and human occupation in southern Europe is now growing thanks to the availability of fresh dating in different mountains. The demise of Neanderthals in the north of the Iberian Peninsula and the expansion of anatomically modern humans took place between 40 and 30 ka (MIS3) under cold and wet climatic conditions. Hypotheses differ regarding the migration and demise of Neanderthals, relating to environmental, human or cultural factors. The aim of this study is to establish glacial evolution in the eastern Cantabrian Mountains related to environmental changes and climatic evolution during the MIS3 and MIS2 and human occupation including the Neanderthals' demise. The study is based on glaciomorphology by glacial reconstructions, morphostratrigraphic sequences, equilibrium line altitude estimation, numerical dating (^{14}C, AMS, and OSL), palaeoclimate sequences and human occupation.

Three glacial stages during MIS3 and MIS2 have been established. S-I took place during MIS3 in a cold and wet environment associated with snowfall coming from cold, humid masses from the N, NW and SW and available dates place S-I at 42–31 ka. S-II was characterised by shorter and thicker glaciers, which point to a cold, dry and more stable climate, and this is coetaneous with the European Last Glacial Maximum. S-III was a brief period, still poorly dated but attributed to the Late Glacial, characterised by small glaciers housed at altitude and absent from lower mountains.

A lack of harmony has been detected between environmental cooling and population and this may have been a response to environmental changes in N and NW Europe. Neanderthals disappeared from the Cantabrian region at the time of the S-I glacial advance during a cold and wet period at the end of the MIS3. If they had adapted to environmental changes, including abrupt cold events (H6, H5) with important environmental consequences, factors other than environmental ones may have been the cause. The weight of the cultural hypothesis seems more likely in view of the environmental changes, glacial evolution and the continuity of oceanic climates.

1. Introduction

Interest in Pleistocene glaciers in the southern European context and the chronology of the different glacial stages is now increasing thanks to the availability of new dating in different mountains (Pérez-Alberti et al., 2004; Hughes and Woodward, 2008; García-Ruíz et al., 2010; Palacios et al., 2011; Jiménez et al., 2013). In the Iberian Peninsula considerable evidence has been collected of glacial stages prior to the Last Glacial Maximum (LGM) in the north of Europe in both Atlantic and Mediterranean environments (Jiménez et al., 2002, 2013; García-Ruíz et al., 2003, 2010; Pérez-Alberti et al., 2004, 2011; González-Sampériz et al., 2006; Jalut et al., 2010; Moreno et al., 2010; Serrano et al., 2012, 2013). The present day controversy is on the possible synchrony between the

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peninsular and European LGM in the Pyrenees or the Central System (Pallàs et al., 2006; Calvet et al., 2011; Palacios et al., 2011).

There is a long history of studies on Pleistocene glacial stages in the Cantabrian Mountains, which were first attributed to two Quaternary glaciations, Riss and Würm (Penck, 1897; Obermaier, 1914; Saenz, 1935; Hernández-Pacheco, 1944, 1961; Nussbaum and Gigax, 1953; Lotze, 1962) and later to a single recent Quaternary glacial period (Martínez de Pisón and Arenillas, 1979; Alonso et al., 1982; Smart, 1986, 1998; Frochoso, 1990; Castañón and Frochoso, 1992; Gale and Hoare, 1997; Serrano and González-Trueba, 2002; Serrano and Gutiérrez, 2002; González-Trueba, 2007a, 2007b). New dates and palaeoglacial reconstructions (Moreno et al., 2010; Jalut et al., 2010; Serrano et al., 2012, 2013) show that the glacial maximum of the Cantabrian Mountains may have been prior to the European LGM. All dates point to a distinct behaviour of Cantabrian glaciers compared with those of Europe during the end of MIS3 and MIS2.

The demise of the Neanderthals in the north of the Iberian Peninsula took place between 40 and 30 ka (MIS3) during a climate characterised by abrupt changes with periods alternating between cold and warm together with the expansion of the anatomically modern human (AMH) and changes in industrial and cultural typologies. The Neanderthal was specialized in exploiting ecotonal ecosystems with a wide variety of resources in small areas; moreover, the AMH was able to exploit open landscapes in cold and dry environments. The AMH survived and expanded in the Cantabrian Cordillera from 42 to 41 ka cal BP (Sepulchre et al., 2007; Hoffecker, 2009). According to Finlayson the temperature patterns and climate variability of the last 85 ka determined changes in habitat and distribution of hominids, cold stable periods were alternating with extinctions and warm periods with persistence (Finlayson, 2004, p.58). The main discussion on the hypothesis regarding the migration and demise of the Neanderthal focuses on whether it was triggered by the expansion and imposition of AMH and its direct competition by 'competitive exclusion' (Banks et al., 2008); by the assimilation by AMH, which shared some of its genes, which remains a very premature hypothesis (Havarti, 2012); or by migration and extinction related to environmental changes that occurred during MIS3 and the subsequent population dynamics of the species (Finlayson, 2004; Finlayson and Carrión, 2007).

2. Regional setting

The Cantabrian Mountains are located in the north of the Iberian Peninsula, (43°N; 5°0′W to 2°0′W) stretching 700 km in an east-west direction (Fig. 1). The western area is formed by the Asturian basement of slates, quartzites, limestones, sandstones and conglomerate of Devonian and Carboniferous age. The complex structure and differential erosion built up isolated massifs on limestones, quartzites and sandstones and eroded depressions on slates and turbidites. Rivers deeply eroded and cut structures on the north side, while adapting to structures in the south side. The eastern area was covered by Mesozoic outcrops: Triassic sandstones and conglomerates, Jurassic and Cretaceous marls, sandstones, limestones, and turbidites. The climate is governed by the exposure of mountain ranges to the Polar Front, their relative height and proximity to the sea. The north side has a hyperhumid oceanic mountain environment with over 2500 mm/year of rainfall, whereas to the south the climate is transitional Atlantic-Mediterranean, with around 600 mm/year of rainfall. The studied area is an important fluvial and environmental threshold between the Atlantic and Mediterranean basins.

3. Material and methods

We selected the glaciomorphological and palaeoclimate sequences, and human occupation information from previously published studies. The glacial sequence analyzed comprises: (i) glacial reconstructions based on geomorphological maps (1/10.000 to 1/25.000 scales) and morphostratrigraphic sequences (González-Trueba, 2007a, b; Pellitero, 2009, 2013, 2014; González-Trueba and Serrano, 2010; González Trueba et al., 2011; Serrano et al., 2012, 2013); (ii) Equilibrium line altitude estimation by the AAR method in eight massifs for each stage (Serrano et al., 2013a, b); (iii) Chronologies based on numerical dating either by ^{14}C, AMS, U/Th and OSL (Table 1). The different dating techniques imply chronological uncertainty about the maximum ice extent and the LGM in the Iberian mountains. Although the dating procedures, AMS, ^{14}C, and OSL, pose different limitations and problems, such as possible contamination of samples of aquatic organic matter affected by old carbon, evolution of complexes or fine deposits undetected during field work, and the results can be questionable, the coherence of the dates obtained by AMS and OSL techniques increases the consistency of glacial chronologies; (iv) Sedimentological archives and a sequence of Loss of Ignition (LOI) in the Picos de Europa (Serrano et al., 2012) used as evidence of environmental changes directly related to glacial evolution; and (v) Information on environmental changes and human population in the eastern Cantabrian Mountains has been obtained from natural deposits and archaeological research (Gutiérrez and Serrano, 1996, 2007; Baena et al., 2004; Cabrera et al., 2004; Rasilla de la and Straus, 2004; Garralda, 2005; Straus, 2005; Iriarte et al., 2005; Sánchez Goñi and

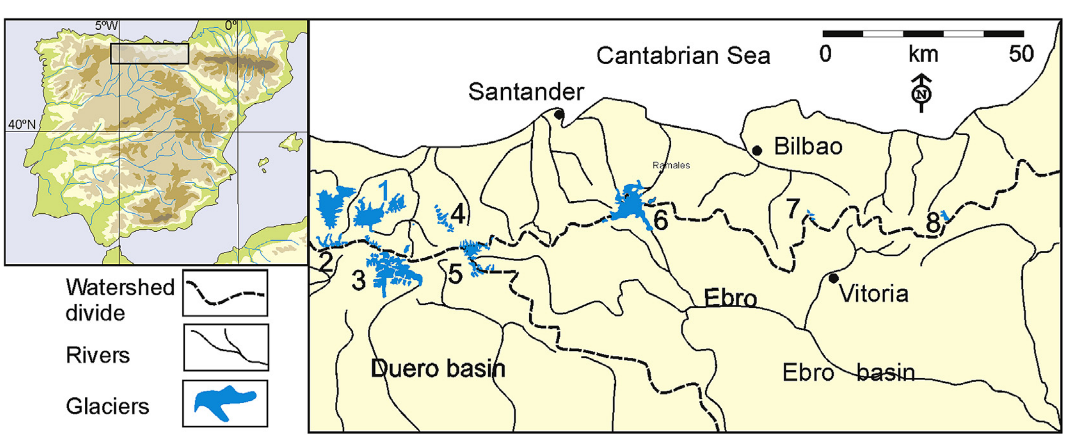

Fig. 1. Location of study area and distribution of studied glaciers by massifs. 1, the Picos de Europa. 2, Cebolleda. 3, Fuentes Carrionas. 4, Peña Sagra. 5, Alto Campoo and Valdecebollas. 6, Pas. 7, Gorbeia. 8, Aralar.