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The plateau glacier in the Sierra de Béjar (Iberian Central System) during its maximum extent. Reconstruction and chronology

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ABSTRACT

A detailed study of the glacial morphology in the Sierra de Béjar (Iberian Central System) provided a data set of geomorphic indicators to reconstruct the paleoglaciers developed in this mountain area during the last glacial cycle (Late Pleistocene). Applying a physical-based glacier model and using the geomorphic indicators, a three dimensional reconstruction of the ice mass during the maximum extent of the glaciers has been carried out. We used this reconstruction to project hypsometric curves over the former glaciers and to estimate the ELAs (Equilibrium Line Altitudes) of the paleoglaciers for their stage of maximum extent. At this stage the Sierra de Béjar hosted a plateau glacier, considered as a dome-shaped icecap around 57 km^2 in area. According to our estimations, the maximum thickness of the ice was 211 m, the minimum elevation of paleoglaciers 1210 m asl, and the regional ELA was at 2010 m asl. During later stages, reduction in ice mass due to deglaciation caused the icecap to evolve into an icefield, and finally the main glacier was fragmented in valley and cirque glaciers. The geochronological data obtained with ^{10}Be provides an age of ~27 ka for the maximum extent of the glaciers (GM), whereas the global Last Glacial Maximum (LGM) represents a younger stage of the Sierra de Béjar glacier evolution. Finally, the new data obtained in the Sierra de Béjar allow evaluating the influence of some factors such as the continentality and latitudinal location, in the development of glacial processes in these areas of the Iberian Central System.

1. Introduction

The updated data provided by the Climate Long-range Investigation Mapping and Prediction Project (CLIMAP, 1976), referring to climate reconstructions during the last glacial period, establish the Last Glacial Maximum (LGM) as a global reference stage for reconstructing the earth's climate and the glacial environments of the Late Pleistocene (Mix et al., 2001). Many research projects on paleoglaciers carried out in different regional contexts take this LGM as a base reference for establishing comparisons, when reconstructing ice masses and conducting paleoclimatic interpretations.

The paleoglaciers of the Iberian Peninsula are highly valuable climatic indicators of the Pleistocene cold periods since, like other Mediterranean areas that hosted mountain glaciers, their relatively low latitudinal position and small dimensions make them very sensitive to climate changes (e.g., Messerli, 1980; Hughes et al., 2006; Vieira, 2008; Cowton et al., 2009). The reconstructions of ice masses must be supported by chronologies to place the processes within their evolutionary context. The chronologies obtained for paleoglaciers from some regions of the Iberian Peninsula provide numerical ages for the maximum glacier advance during the last glacial period that precedes the global Last Glacial Maximum (LGM), while in other regions the dates are in agreement with the LGM (e.g., Garcia-Ruíz et al., 2010; Pallàs et al., 2010).

The diachrony of the maximum glacier extent during the last glacial period at different latitudes in Europe has been previously pointed out, especially between the Mediterranean region and the rest of the continent (Seret et al., 1990; Florineth and Schlüchter, 2000; Hughes et al., 2006). However, in the mountains of the Iberian Peninsula, geographic factors such as latitude, orientation, altitude, continentality, etc, do not seem to be enough to explain the reported differences in chronology. Such chronological discrepancies may be related, at least in some cases, to assumptions regarding the dating methods, the use of inadequate dating techniques, or the use of unsuitable materials (e.g., Garcia-Ruíz et al., 2010; Pallàs et al., 2010).

This research in the Sierra de Béjar, a sector of the Iberian Central System, illustrates a phased methodology towards defining the useful geomorphic indicators for a rigorous approach to the chronology and reconstruction of ice masses. The paleoglaciers in the Sierra de Béjar are among the most important in the Iberian Central System and

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were traditionally classified as valley and cirque glaciers (Schmieder, 1915; Carandell, 1924; Sanz Donaire, 1979; Rubio Campos, 1990). The paleoglaciers in Sierra de Béjar have been recently re-classified as a plateau glacier (Carrasco and Pedraza, 1995) comparable with that of the Serra da Estrela, the only sector of the Iberian Central System where this type of paleoglacier had been traditionally described (Lautensach, 1929).

Glacier characterization and a chronological framework are fundamental issues when studying paleoglaciers. However, these aspects regarding the glaciations in the Iberian Peninsula are still under discussion (e.g., García-Ruiz et al., 2003; Perez Alberti et al., 2004; Garcia-Ruíz et al., 2010; Pallàs et al., 2010). In the research carried out in the Iberian Central System, a new morphological indicator of the maximum extent of glaciers has been recently identified (Pedraza et al., 2011), as well as the participation of the paraglacial processes in the generation of moraines (Carrasco et al., 2010). These new data indicate the need for setting out detailed geomorphological mapping, in order to perform a suitable reconstruction of the glaciers and the sampling for the absolute dating of the glacial maximum in the Sierra de Bejar. The aims of this research are to carry out a tridimensional reconstruction of the Sierra de Béjar paleoglacier during its maximum extent, and the calculation of the paleo-ELAs (Equilibrium Line Altitude) as paleoclimatic indicators. We use the ^{10}Be method to date the geomorphic indicators of the maximum glacial extent to provide insight on its chronology.

2. Regional setting

The Sierra de Béjar (Fig. 1) is a NE–SW mountain range of the Iberian Central System. This is an intraplate mountain belt formed during the Alpine orogeny (mainly during the Miocene–Pliocene) by the uplift of the Hercynian or Variscan basement, with a morphostructure determined by fault-bounded blocks with summits at elevations between 1700 and 2300 m asl (e.g., Pedraza, 1994; Casas-Sainz and de Vicente, 2009). This morphology was a crucial factor in the development of plateau glaciers in some of these summits during the Late Pleistocene.

The predominant lithologies in the Sierra de Béjar correspond to granitoids (i.e., monzogranites, granodiorites; Bellido, 2004, 2006). Migmatites, metasediments and quartzitic schists are also present. The Quaternary cover has a limited extent (less than 10% of the land area) and has a limited thickness (1–5 m). It consists of fluvial, glacial, periglacial and landslide deposits (Carrasco, 1997). Glacial till, generally boulders and large boulders with a coarse-grained matrix, is lithologically homogeneous, mostly composed of granitoids and their sandy weathering products. The typical sequence found in the till exposures includes, from the base to top, subglacial traction till (or basal deformation till), subglacial accretion till, subglacial melt-out till, and supraglacial melt-out till (Carrasco et al., 2011).

From the climatic perspective, the Iberian Central System can be classified as a medium Mediterranean mountain with notable Atlantic

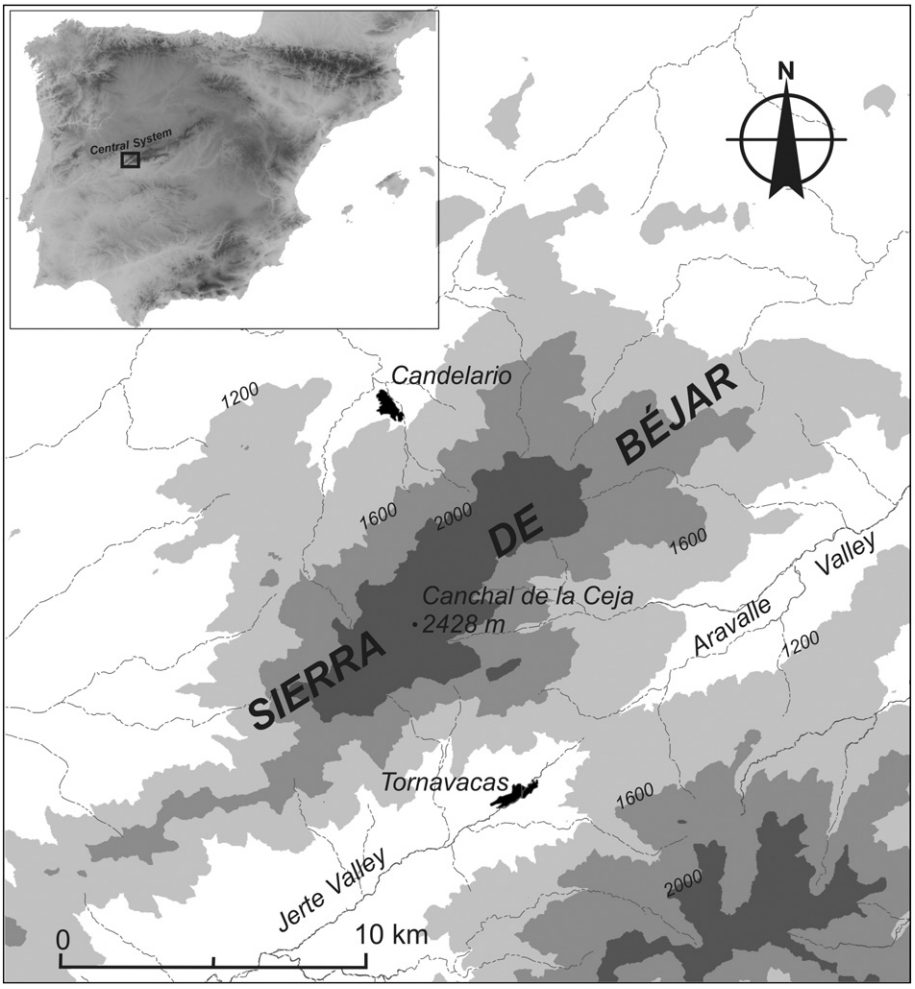

Fig. 1. Location of the Sierra de Béjar (Iberian Central System).