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Last glacial maximum and deglaciation in central Spanish mountains

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The Central System mountain range stretches from northeast to southwest across the center of the Iberian Peninsula. The range is formed by granitic intrusions and glandular gneiss from the Variscan orogeny or earlier mountain-building events that were completely levelled during the Mesozoic and later fractured and uplifted during the Alpine orogeny by an extensive network of faults trending north-south and southwest-northeast. Maximum altitudes occur in Sierra de Gredos (40ž 15' 35'' N; 15ž 17' 53'' W, max. elevation 2592 m at Pico Almanzor) and in Sierra de Guadarrama (40ž 51' N, 3ž 57' W; max. elevation 2428 m at Pico de Peñalara).

The occurrence and magnitude of the glacial formations in these mountain ranges were based initially on Penk's (1884) observations and later on extensive studies by Obermaier and Carandell (1916;1917) and others (see synthesis in Martínez de Pisón and Palacios, 1998). Until recently, however, there was no data on the age of these formations. Some disperse data exists on the dating of glacial landforms in the northern Iberian Peninsula, but there is no information is available for the central and southern areas (Hughes, Woodward y Gibbard, 2006).

The results of the present study are from direct dating methods and use the cosmogenic isotope 36Cl for glacier formations (morainic ridges and blocks) near the peaks of Almanzor and Peñalara. Major elements were determined by XRF fluorescence spectrometry; U and Th by neutron activation analysis and B and Gd by neutron activation prompt gamma analysis. AMS analyses (36Cl/Cl, 37Cl/35Cl) were performed

at PRIME Lab (Purdue University). CHLOE software was used to calculate the exposure ages for different erosion rates (E) of the rock surface: zero erosion and E=5 mm/kyr. Production rates of 36Cl were obtained according to Phillips et al (2001) and the latitude and elevation scaling of production rates was based on Lal (1991).

The formations dated on the north face of Almanzor Peak include morainic blocks from an ancient glacier tongue that occupied Gredos Gorge, and are associated with five of the seven closely spaced ridges found at the junction to Pozas Gorge, 14 km downstream from the summit. The results of the 36Cl analyses revealed ages from 23000 to 21000 YBP, while the bed rock thresholds located at two sites in Gredos Gorge (8 km and 4 km from the summit) were dated 15700 and 15400 YBP, respectively.

The glaciers on the east face of Peñalara Peak are smaller and advanced to a distance of only 1800 m, leaving a series of five morainic ridges. The ages of the blocks on the ridges ranged from 22000 to 17000 YBP. The bed rock threshold located right below the peak was dated 16000 YBP.

The results from the study show that the Last Glacial Maximum in the center of the Iberian Peninsula occurred about 21000 YBP. Glaciation has since remained stable, despite small advances and recessions that lasted a few thousand years. The results also reveal that rapid and definitive deglaciation took place 17000-16000 YBP. These findings are consistent with those obtained in studies on other European mountains, and with a more recent one conducted in the Pyrenees (Pallas et al. 2006). In the case of the Central System mountain range, no earlier glacial formations were found.

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