



Paraglacial dynamics in Little Ice Age glaciated environments in the Iberian Peninsula

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Three Iberian mountain ranges encompassed glaciers during the Little Ice Age (LIA): the Pyrenees, Cantabrian Mountains and Sierra Nevada. The gradual warming trend initiated during the second half of the XIX century promoted the progressive shrinking of these glaciers, which completely melted during the first half of the 20th century in the Cantabrian Mountains and Sierra Nevada and reduced by 80% of their LIA extent in the Pyrenees. Currently, the formerly glaciated environments are located within the periglacial belt and still present to a major or lesser degree signs of paraglacial activity. LIA moraines are devoid of vegetation and composed of highly unstable sediments that are being intensely mobilized by slope processes. Inside the moraines, different landforms and processes generated following LIA glacial retreat have generated: (i) buried ice trapped within rock debris supplied from the cirque walls, which has also generated rock glaciers and protalus lobes; (ii) semi-permanent snow fields distributed above the ice-patches remnants of the LIA glaciers, and (iii) small periglacial features such as frost mounds, sorted circles and solifluction landforms generated by processes such as solifluction and cryoturbation. Present-day morphodynamics is mostly related to seasonal frost conditions, though patches of permafrost have formed in some areas in contact with the buried ice. This 'geomorphic permafrost' is undergoing a process of degradation since it is not balanced with present-day climate conditions. This is reflected in the occurrence of multiple collapses and subsidences of the debris cover where the frozen bodies sit. In the highest areas of the Pyrenees there is a permafrost belt next to the small glaciated environments in the highest massifs. Finally, we propose a model for paraglacial activity in Iberian mountain ranges and compare it to other mid-latitude mountain environments as well as to other past deglaciation stages.