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Temporal recurrence of hazardous rock avalanches in Sierra de La Sobia (Cantabrian Mountains, Spain)

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Rock avalanches are voluminous debris instabilities originated from a fallen portion of bedrock that suffers pervasive disintegration [1]. Tough rock avalanches are foreseen as low-frequency events, their volume (>10^6 m^3) and runout distance (kilometric scale) make them extremely hazardous processes in populated mountain settings and key contributors to landscape denudation [2]. Deciphering the timing of recurrent rock avalanches is crucial to understand the triggering factors involved in their origin (e.g., role of seismicity) and for risk assessment.

This study focuses on a rock avalanche cluster preserved in the southern flank of Sierra de la Sobia; a limestone massif located in the Cantabrian Mountains (North Spain). The rock avalanche cluster analyzed is spatially related to the Marabio Fault trace, which shows unequivocal evidence of Quaternary activity [3]. Rock avalanches in this area have been interpreted as coseismic based on the following evidence [4]: (i) boulder populations show fractal block-size distributions consistently with dynamic fragmentation; (ii) the kinematic analysis of local minor transverse and parallel faults points to a horizontal N-S compression consistent with the regional stress field; and (iii) slope stability analysis indicates that headscarps will turn unstable if ground acceleration peak rises to 0.10–0.15 g during an earthquake, which is within the values expected according to the 2013 European Seismic Hazard Map. A first attempt of numerical dating was performed through the U-Th technique on calcite cements found in the oldest rock avalanches. Results suggest multiple episodes of cementation during the last ~280 ka, but age dispersion hinders the age bracketing of instability events[4]. Here we present a collection of twenty cosmic ray exposure ages relying on the isotope Cl-36 obtained from limestone boulders sampled in the youngest accumulation bodies of the Entrago and Carrea rock avalanches. Results allow to constrain up to 5 instability events spanning the last ~22 ka and occurring at average recurrence intervals of ~3.6 ka. The youngest rock avalanche event took place 8.5 ka ago and left boulder accumulations close to the headscarp of both rock avalanches. Boulder age dispersion increases accordingly with the increase in runout distance from the headscarp, possibly due to the spatial overlapping of accumulation bodies resulting from different instability events of seismic origin. These preliminary results are promising, because if extended to other rock avalanche clusters of the Cantabrian Mountains, they could help to decipher the recurrence time of severe earthquakes in mountain settings where tectonic deformation occurs at low to moderate rates.

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