

Rock Slope Failures in Pyrenean Mountains: identification, description, spatialization and questions

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Rock slope failures (RSFs) encompass a wide variety of slope instability processes that are generally deep and can affect large areas. Over the last fifteen years, these processes were particularly studied because they are not always stabilized and can reactivate with sudden and brutal acceleration that can lead to catastrophes. Thus, studying these processes is critical in mountainous areas where human activity is developing. In Europe, while the Alps have been and continue to be extensively studied, RSFs in the Pyrenees (both in France and Spain) have been less investigated. A cross-border inventory for the eastern Pyrenees found 30 large and 20 lesser cases (Jarman et al., 2014) a rather sparse population, which this study will revisit with improved imagery and techniques. In addition, some scattered studies on the Spanish and French sides have focused on the geomorphology and history of these phenomena. These studies showed a certain diversity of RSFs, but emphasize that the Pyrenees appear less impacted by RSFs than the Alps. However, previous geological and climatic conditions have been and still are favorable to this type of gravitational instability.

The aim of The SPIRAL project (part of the European INTERREG VI-A SPAIN-FRANCE-ANDORRA project, POCTEFA 2021-2027 started in Nov. 2023) is to improve the resilience of the Pyrenean territory to catastrophic events as landslides including RSFs through the development of a regional early warning system. To achieve these objectives, a first exhaustive RSFs inventory for the entire Pyrenees was carried out on four steps:

- (i) A compilation of existing spatial information from previous projects and existing databases;
- (ii) A geomorphological analysis of the slopes by aerial photo-interpretation (1956-2022) and visual analysis of images from Google Earth Pro;
- (iii) An analysis of the ground displacements using InSAR data derived from SENTINEL-1 imageries and available from the European Ground Motion Service (EGMS). The methodology used is based on an extraction of Active Deformation Areas (ADA) integrating uncertainty measurements. Thus, areas with velocity exceeding certain thresholds are selected to help locate active and/or suspected RSFs.
- (iv) Field verification for areas with specific types of RSFs or areas whose displacement points require verification to determine whether they are indeed unstable phenomena.

The study will investigate the influence of geological (lithology, structure, neotectonics), geomorphological (glaciation/fluvial incision) and climatic (precipitation, climate change) factors on the past, present and future dynamics of RSFs. We will present examples of major RSFs and RSF clusters, and invite discussion of possible differences between the Pyrenees and other European ranges, with regard to both past history and potential hazard.

Jarman, D., Calvet, M., Corominas, J., Delmas, M., Gunnell, Y. 2014. Large-Scale Rock Slope Failures in the Eastern Pyrenees: Identifying a Sparse But Significant Population in Paraglacial and Parafluvial Contexts. *Geografiska Annaler: Series A, Physical Geography*. 96. 10.1111/geoa.12060.