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Inventory of large landslides along the Central Western Andes (ca. 15°–20° S): Landslide distribution patterns and insights on controlling factors

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ABSTRACT

The western flank of the Central Andes hosts some of the largest terrestrial landslides (v > km^3), which morphologies are particularly well-preserved due to low erosion rates related to the hyper-arid climate prevailing in this region since the Miocene. First-order questions are pending about the factors controlling the development and the triggering of those large-scale slope failures. Previous studies provided some geomorphological analysis and dating on individual study cases, but a regional-scale vision of landslide processes long the Central Western Andes is missing.

Here we report an original inventory of large landslides (areas from 0.1 to 180 km^2) established along the western flank of the Central Andes between latitudes ca. 15 and 20° S, and from the Pacific coast to the Altiplano. Based on manual mapping (using satellite images analysis, Google Earth and DEMs analysis) and a compilation of previous works, we inventoried more than a thousand large landslides in this region. We then statistically explored the database according to the landslides typology, size, abundance and relation to geologic, tectonic and climatic settings of the Central Western Andes in order to provide a first insight on their controlling factors. Landslide size-frequency distribution follows a power-law with an exponent of 2.31 ± 0.16 and a cut-off of 4.0 ± 1.9 km^2 showing a strong contribution of the largest landslides to the cumulated landslide area. We revealed a dominance of rockslide typology (86%) characterized by in-mass slides, the rest being rock-avalanche type (14%) marked by typical granular-flow morphologies. Combination of specific lithology and great local relief emerge as favorable conditioning factor for large landslide initiation, in particular in the case of river incisions though ignimbrites of the Paleogene-Neogene (Huaylillas Formation), concentrating >30% of the landslides. Moreover, landslide clusters tend to follow crustal faults networks suggesting a long-term control of tectonic activity. Most of the identified landslides are paleo events. We tentatively argue that their triggering could not have been possible in the current hyper-arid conditions of the Atacama Desert and its periphery. Future research providing dating on some of the landslide clusters identified in this study is needed to explore possible temporal correlations between periods of landslide activity and external seismic and/or climatic cycles.

1. Introduction

Landslides are ubiquitous gravity phenomena on Earth, found in any environment with slopes. Their triggering is conditioned by the internal mechanical and hydrological properties of geomaterials (Guzzetti et al., 1996; Stead and Wolter, 2015), and may depend on external factors associated with seismotectonic activity (Fan et al., 2019) or climatic variations (Pánek, 2019). They constitute one of the major sources of hazard, responsible for thousands of victims and billions of dollars in damages each year (Petley, 2012; Froude and Petley, 2018; Wallemacq and House, 2018). The constant growth of the world population associated with the ongoing climate changes are factors that may severely increase the level of risk and hazard related to landslide activity (Gariano et Gariano and Guzzetti, 2016; Haque et al., 2019). In this context, a better understanding of landslide processes and their causative factors is crucial and those questions have received a growing interest (Wu

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