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Factors Controlling the Spatial Distribution of Coseismic Landslides Triggered by Ludian Earthquake

Yu Zou[1*], Shengwen Qi[1], Yongchao Li[1], Songfeng Guo[1] and Xiaokun Hou[1]

[1]State Key Laboratory of Lithospheric and Environmental Coevolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

(*Corresponding E-mail: zouyu@mail.iggcas.ac.cn)

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Abstract: The spatial distribution of coseismic landslides is critical for understanding earthquake-induced hazards and future disaster mitigation. This study investigates the controlling factors of landslides triggered by the Mw 6.1 Ludian earthquake that occurred on 3 August 2014 in Yunnan Province, China. A total of 1,414 landslides were identified within an area of 704.7 km^2 through image interpretation and field investigation. Geographic Information System (GIS)-based spatial analysis was used to evaluate the relationship between landslide occurrence and controlling factors. The results indicate that slope gradient and distance from the coseismic fault are the dominant factors influencing landslide distribution. Fault movement direction, lithological conditions, and human-induced slope cutting also contributed significantly by increasing rock mass fracturing and slope instability during seismic shaking.

Keywords: ***Coseismic landslides, Ludian earthquake, Spatial distribution, Controlling factors, GIS analysis, Slope gradient, Fault proximity, Landslide susceptibility.***

Introduction

Understanding the spatial distribution and controlling factors of coseismic landslides is essential for earthquake disaster mitigation and hazard assessment in tectonically active mountainous regions. Earthquake-triggered landslides often result in severe damage to infrastructure, loss of life, blockage of river channels, and long-term environmental impacts. The occurrence and distribution of coseismic landslides are influenced by several factors, including slope geometry, lithology, seismic intensity, fault movement, topography, and human activities. However, identifying the dominant controlling factors remains a major challenge in engineering geology and geomorphology (Dai et al., 2011, Xu et al., 2014).

On 3 August 2014, a Mw 6.1 earthquake struck Ludian County in Yunnan Province, China, causing widespread landslides and substantial socio-economic losses. The earthquake occurred in a geologically fragile mountainous area characterized by steep slopes, fractured rock masses, and active tectonic structures. The strong ground motion generated numerous slope failures, making the event an important case study for understanding coseismic landslide mechanisms and spatial distribution patterns.

Landslide inventory and methodology

This study investigated the spatial distribution characteristics of coseismic landslides triggered by the Ludian earthquake. A total of 1,414 landslides were identified within an area of approximately 704.7 km^2 through a combination of high-resolution image interpretation and detailed field investigations. Geographic Information System (GIS)-based spatial analysis techniques were employed to evaluate the relationship between landslide occurrence and various controlling factors.

Several parameters, including slope gradient, lithology, distance from the coseismic fault, slope aspect, elevation, and human disturbances such as slope cutting, were analyzed to determine their influence on landslide distribution. Correlation analysis in GIS was used to identify the dominant factors controlling slope failures during the earthquake.

Controlling factors of coseismic landslides

The analysis revealed that slope gradient and distance to the coseismic fault are the two most significant factors controlling the spatial distribution of landslides. Steeper slopes exhibited a much higher probability of failure because of increased gravitational stress and reduced slope stability during seismic shaking. Similarly, areas located close to the coseismic fault experienced more intense ground motion and consequently higher landslide density.

The study also demonstrated that the movement direction of the coseismic fault strongly influenced the preferred direction of landslide occurrence. Other factors, including lithology and geomorphic conditions, contributed indirectly by affecting slope steepness and rock mass conditions. Human-induced slope cutting was found to significantly increase landslide susceptibility by fracturing rock masses, reducing slope support, and increasing slope angles.

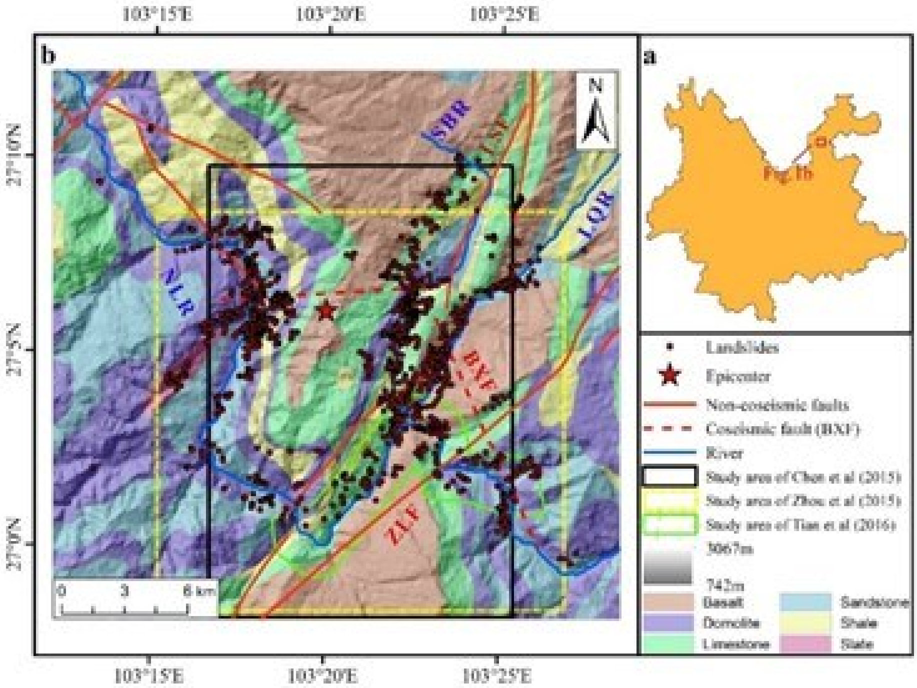

Figure 1, Geological background and seismic landslide distribution map.

Conclusion

The findings highlight the importance of integrating topographic, geological, seismic, and anthropogenic factors in coseismic landslide hazard assessment. GIS-based spatial analysis proved effective for identifying landslide-prone zones and evaluating the dominant controlling factors. The study provides valuable information for future earthquake disaster mitigation, land-use planning, infrastructure design, and slope stabilization strategies in seismically active mountainous regions.

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