Formation Mechanism of Cascading Disasters from High-elevation Landslide-Debris Flow in Junlian, Sichuan and Emergency Monitoring and Early Warning: Postprint

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Abstract

On February 8, 2025, an extra-large high-position landslide-debris flow disaster occurred at Jinping Village, Mu' ai Town, Junlian County, Yibin City, Sichuan Province, causing significant casualties and property losses. Based on field investigation, remote sensing monitoring, engineering geological data, and emergency monitoring data, this study systematically investigated the chain-process mechanism and emergency response effectiveness of this disaster. The research indicates that the landslide occurred in a tectonic erosion middle-mountain landform area at the transition from the Sichuan Basin to the Yunnan-Guizhou Plateau, featuring typical "L-shaped" high-steep terrain characteristics, with a vertical height difference of 283 m from the rear wall of the source area to the shear outlet and an average slope gradient of 42.7°. The regional geological structure is complex, located at the eastern margin of the Sichuan-Yunnan rhombic block and adjacent to the Huayingshan fault zone, with fractured rock masses and soft-hard interbedded structures providing potential sliding surfaces for the landslide. The winter freeze-thaw cycles influenced by the "Kunming quasi-stationary front" led to progressive deterioration of the rock mass, while the anomalous heavy rainfall exceeding 300 mm since January 2025 served as the direct trigger, causing saturation of the rock and soil mass, sharp increase in pore water pressure, and a dramatic 40–50% reduction in shear strength. The landslide evolution exhibited a chain process of "crack development–freeze-thaw deterioration–rainfall infiltration–through-going failure–high-speed movement–debris flow transformation," with a peak velocity reaching 56.29 m/s. The emergency monitoring system employing collaborative application of slope radar and rockfall radar successfully provided early warning for the secondary collapse on February 12, ensuring safe evacuation of rescue personnel. This study reveals the compound disaster-causing pattern of "freeze-thaw deterioration + anoma-

lous rainfall" in the Wumeng Mountain area, providing a scientific basis for geological disaster prevention and control in similar regions.

Full Text

Preamble

A Study on the Cascading Formation Mechanism of the High-Position Landslide-Debris Flow Disaster and Its Emergency Monitoring and Early Warning in Junlian, Sichuan

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Abstract

On February 8, 2025, an extremely large-scale high-position landslide-debris flow disaster struck Jinping Village, Mu' ai Town, Junlian County, Yibin City, Sichuan Province, resulting in substantial casualties and property damage. This study systematically investigates the cascading formation mechanism of this disaster and evaluates emergency response effectiveness based on field investigations, remote sensing monitoring, engineering geological analysis, and emergency monitoring data. The landslide occurred within a tectonic-erosional middle mountain region at the transition between the Sichuan Basin and Yunnan-Guizhou Plateau, featuring characteristic L-shaped high-steep terrain with a vertical elevation difference of 283 meters from the source area' s rear scarp to the shear outlet and an average slope angle of 42.7°. The area exhibits complex geological structures, located on the eastern margin of the Sichuan-Yunnan rhombic block and proximal to the Huayingshan fault zone, with intensely fractured rock masses and interbedded soft-hard strata that provided potential slip surfaces.

Winter freeze-thaw cycles, influenced by the Kunming quasi-stationary front, progressively degraded the rock mass, while abnormally intense rainfall exceeding 300 mm since January 2025 served as the direct triggering factor. This precipitation caused soil saturation, a sharp increase in pore water pressure, and a dramatic 40–50% reduction in shear strength. The landslide evolution followed a cascading process of "fissure development–freeze-thaw deterioration–rainfall infiltration–through-going failure–high-speed movement–debris flow transformation," attaining a peak velocity of 56.29 m/s. The emergency monitoring system, employing collaborative slope radar and rockfall radar technology, successfully issued early warnings for secondary collapses on February 12, ensuring safe evacuation of rescue personnel.

This study reveals a compound disaster pattern of "freeze-thaw deterioration plus anomalous rainfall" in the Wumeng Mountain region, providing a scientific

basis for geological hazard prevention and control in similar areas.

Keywords: high-position landslide; debris flow; freeze-thaw action; extreme rainfall; monitoring and early warning

Note: Figure translations are in progress. See original paper for figures.