

Research Advances

The Identification of Large-Giant Bedrock Landslides Triggered by Earthquake in the Longmenshan Tectonic Belt

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The identification of large-giant bedrock landslides triggered by earthquake aims to the landslide prevention and control. Previous studies have described the basic characteristics, distribution, and the formation mechanism of seismic landslides (Bijan Khazai et al., 2003; Chong Xu et al., 2013; Lewis a. Owen et al., 2008; Randall W. Jibson et al., 2006). However, few researches have focused on the early identification indicators of large-giant bedrock landslides triggered by earthquake (David k. Keefer., 1984; Janusz Wasowski et al., 2011; Alexander L.Strom., 2009; Patrick Meunier et al., 2008; Shahriar Vahdani et al., 2002; Bijan Khazai et al., 2003). This paper presents the identification indicators of large-giant bedrock landslides triggered by earthquake in the Longmenshan tectonic belt on the basic of their characteristics, distribution and the relationship between seismic landslides and the peak ground motion acceleration.

(1) Earthquakes with a magnitude approaching M 7.0 will be generated along active faults.

It is generally accepted that the size of the earthquake-induced landslides has a positive correlation with the earthquake magnitude. The lower limit earthquake magnitude of earthquake-induced landslides is M 4.0, and the generation of rock avalanches requires earthquake with a magnitude approaching M 8.0 (Alexander L.Strom. 2009). The relationship between earthquake and landslides triggered by earthquake in the Longmenshan tectonic belt indicates that the generation of large-giant bedrock landslides requires earthquake with a magnitude approaching M 7.0.

(2) The peak ground acceleration will be greater than 0.4 g, when earthquake occurs.

Ground motion was the most significant factor in triggering the landslides in the Wenchuan earthquake.

Hundreds of thousands of landslides were triggered by the May 12, 2008, Wenchuan earthquake in China, and most of large-giant bedrock landslides occurred in regions with mean peak ground accelerations greater than 0.4 g.

(3) The length of slip surface of bedrock landslides triggered by earthquake is larger than 100 m and its depth is greater than 30 m.

Most large-giant bedrock landslides triggered by the Wenchuan earthquake occurred in the region where there was the most unfavourable system of discontinuities. Faults were among the most important discontinuities and structural controls because they are weakened by more pervasive fracturing. The slip surface of many large-giant bedrock landslides triggered by the Wenchuan earthquake were faults they comprise slip surface at or near to residual strength. It is concluded that the length of slip surface of bedrock landslides triggered by earthquake is larger than 100 m or more and its depth is greater than 30 m or more.

(4) The relative elevation difference of potential landslides is larger than 200 m.

The ground motion records of some large earthquakes indicate that the amplification effect of local topography on seismic waves is striking. A worldwide sample of historical earthquake shows that slopes most susceptible to catastrophic rock avalanches were higher than 150 meters (David K.Keefer. 1984). The statistic analysis of the relative elevation difference of 38 large-giant bedrock landslides triggered by the Wenchuan earthquake demonstrates that the relative elevation difference of most landslides is larger than 200 m.

(5) The thickness of weathered layers is larger than 30 m in the source area.

Most large-giant bedrock landslides triggered by the Wenchuan earthquake occurred after long-time tectonic deformation, unloading and weathering, and resulted from the gradual loss of the intensity of structural plane. The

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size of the earthquake-induced landslide reveals a positive relationship with the thickness of weathering layers and unloading zones. Combined with field investigations, it is inferred that the initial thickness of the weathering layers and unloading zones is above 30 m in the source area.

(6) There are landslide relics triggered by paleo-earthquakes ahead of the massive rock slope failure.

Field investigations suggest that some large earthquake-induced landslides are featured by in situ recurrence, and show a gradual backward movement in the wenchuan earthquake disaster area. There are landslide relics triggered by paleo-earthquakes ahead of the massive rock slope failure. First, there are landslide platform which was landslide relics triggered by paleo-earthquakes ahead of the massive rock slope failure, such as the Wenjiagou landslide. Second, the ancient landslide and debris flow deposits were ahead of the massive rock slope failure, such as the Taihong village landslide in Beichuan County.

(7) Karst, springs or ancient earthquake cracks can be observed in the source area.

Karst is commonly developed in the source area of large-giant bedrock landslides triggered by the Wenchuan earthquake, such as the Taihong village landslide, Woqian landslide and the Donghekou landslide. This indicates that controlling structural plane had expanded before the wenchuan earthquake. The karstification played an important role in corroding rock bridge, reducing the strength of the controlling structural plane.

In addition, there were springs in the source area of the large-giant bedrock landslides triggered by Wenchuan earthquake, such as the Daguanbao landslide which is the biggest earthquake-induced landslide in longmenshan tectonic belt, Taihong village landslide in Beichuan County. These springs also suggest that controlling structural plane had expanded before the Wenchuan earthquake. Furthermore, earthquake motion can generate dynamic water pressure in groundwater migration channels which can reduce the strength of the controlling structural plane.

There are also ground fissures which are relics of the slope deformation triggered by ancient earthquake in the

source area, such as the Taihong village landslide in Beichuan County and the Tangjiashan landslide. As mentioned above, some large-giant bedrock landslides triggered by the Wenchuan earthquake have experienced at least two strong earthquakes (including the Wenchuan earthquake), indicating that the progressive failure plays an important role in the expansion of the controlling structural plane.

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