Study on the formation mechanism of post-earthquake debris flow in Yinchanggou, Asbestos County after the 9.5 Luding earthquake

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Abstract: Mudslide is a kind of sudden geological disaster, and its formation and development are mainly controlled and influenced by geological, geomorphological and climatic factors. Especially, a large amount of loose solid material produced after earthquakes reserves a large amount of material source for mudflow activities. It is very easy to break out the mudslide disaster under the addition of extreme weather such as strong rainfall, which causes serious losses. In this paper, we study the post-earthquake mudslide that occurred in Yinchanggou after the 9.5 Luding earthquake as an example, and analyze the watershed characteristics of Yinchanggou, especially the characteristics of the mudslide disaster under the seismic conditions, the mechanism of disaster, and put forward the countermeasures of disaster prevention and mitigation on the basis of which, in order to provide references for the later related mudslide disasters.

Keywords: mudslide; geologic disaster; disaster-forming mechanism; prevention and mitigation countermeasures

Introduction

Yincanggou is located in Asbestos County, Ya'an City, Sichuan Province, which is in the transition zone from the Hengduan Mountain Range of the Tibetan Plateau to the Sichuan Basin, and the main rupture of the Freshwater River Fracture Zone passes through here, with a steeper topography, an alpine canyon landscape, and strong geological and tectonic activities. By 9.5 Luding earthquake, fracture tectonic activity is more active, resulting in landslides and avalanches and other geologic hazards occur frequently, the ditch material source type is diverse, the material source reserves are extremely rich, seasonal rainfall is significant, easy to lead to the chain of mudslide disaster, thus bringing a larger scale of hazards. 9.5 Luding earthquake, as of September 8, more than 20 aftershocks of Ms2.5 grade, the largest of them! Ms4.5 earthquake occurred in the study object Shiyue River basin near Tianwan Township, and at the same time the asbestos county territory of Wanggangping Township, Caoke Township, Xinmin Township have been affected to varying degrees by the aftershock impact of collapses, landslides, mudslides, and other secondary hazards of the potential increase in the geodetic disaster preparedness task is more arduous.

1 Environmental background of the study area

The study area is located in the southwest of Ya'an City, Ganzi Tibetan Autonomous Prefecture in the southeast, Dadu River passes through here, with a large area, more than 260 kilometers away from Chengdu, connected to Luding County in the north, Yuexi County in the south, Hanyuan County in the east, Kangding City in the west, and close to Hailuogou Glacier Forest Park. The study area is located in the northwestern part of Asbestos County, Wanggangping Yi and Tibetan townships, provincial highway 211 line side of Shiyue Ping, about 35km away from Asbestos County, by the provincial highway 211 through the connected, convenient transportation.

In terms of geomorphology, the terrain in the area is mainly high in the west and low in the east, high in the north and south, low in the center, specifically showing the south, north and west terrain to the east, the central tilt of the terrain state, the highest elevation of 5693 m, the lowest elevation of 735 m. There are mainly alpine and very alpine, alpine and alpine, meso-mountains, low mountain and river valley terrain of three types.

Climatic conditions, the type of subtropical monsoon climate, most of the region is located in the low latitude zone, the average annual temperature is mostly above 14 ℃, according to the 2012-2022 observation data of Ya'an meteorological stations, the average annual temperature is 18 ℃, the average annual minimum temperature is 13 ℃, the maximum temperature is 23 ℃, the average annual wind speed is 3.9 m/s, rainfall is mainly concentrated in the months of June-September.

2 Conditions of mudflow formation after 9.5 earthquake in Yinchanggou

(1) Topographic and geomorphologic conditions

Although there is no large number of man-made development activities in the region, but by the earthquake disturbance, the surrounding mountains loose traces of obvious, rock surface is more broken, by the post-earthquake landslide impact of the vegetation cover is reduced, the surface stress concentration, coupled with the ditch on both sides of the mountain slope is steeper, the debris slump occurs more frequently, so in the ditch and ditch bank has accumulated a large number of loose accumulations, which for the initiation of the mudslide to provide a rich material source base. This provides a rich material base for the initiation of mudslide. The terrain is obviously cut and fractured. The downstream of the bank of the main gully and the downstream of each branch gully are relatively gentle, with slopes between 25°-35°, and the gully valley is also in a "V" shape, with more accumulations. The width of the main ditch in the study area varies significantly, with narrower widths in the upper reaches of the main ditch and wider widths in the middle and lower reaches; narrower widths in the upper reaches of the branch ditches and wider widths in the lower reaches of the branch ditches. The overall change in the direction of the ditch is moderate, which provides a good channel condition for mudflow circulation.

(2) Material source conditions

The main material source of debris flow formation and development is provided by the material source of the slope surface. In the

location of the debris flow gully mouth to the middle reaches of the river channel, there are a large number of landslides on both sides of the gully, with different scales, and the collapsed material produced by the landslides is an important part of the material source of the slope surface, which can be mainly classified into two categories according to the source according to the field investigation: one is produced by the landslides of overburden soil, and the other is produced by the landslides caused by the fracture structure. One is generated by overburden soil landslides, and the other is generated by fracture structure caused by landslides. The pile of overburden soil body landslides is loose, and the slip surface is clearly visible. The reason for its generation is that the mountain body has been shaken by the earthquake, which makes the surface layer of the weathered rock body fall off, which is in the form of broken pieces and sandy soil, and slides rapidly from top to bottom, and then piles up at the foot of the slope.

Conversion relationship between sources, the types of sources are complex and diverse, and each type of source is intertwined with each other, and the slope sources, which are jointly composed of the accumulation of overburden soil landslides and the accumulation of landslides caused by fracture tectonics, are carried to the river under the scouring of runoff in the ditch, and transported to the downstream and slowly deposited to form ditch piles. Congestion material source in the case of heavy precipitation catchment area expansion, the flow becomes larger, wash away the original blockage, the blockage will be carried to the middle and lower reaches of the channel, the formation of channel piles. Ditch bank avalanches and slippery material sources when encountering strong rainfall or runoff enhancement, can also be washed and carried into the ditch to form ditch accumulations, from the indirect participation to change to direct participation in the mudslide movement.

(3) Water source conditions

The starting water source of mudslide is mainly from atmospheric precipitation. Glacier meltwater and groundwater recharge to a lesser extent, it is difficult to constitute a favorable condition for the initiation of mudslides, and the local rainfall in the study area is greatly influenced by seasonal factors, and surface runoff is therefore controlled by seasonal rainfall. As the study area is close to the Dadu River, the original groundwater source is sufficient, so the degree of infiltration of surface runoff formed by rainfall is weak, and the confluence of heavy rainfall is the main source of water that causes the formation of mudslides. Under the action of heavy rainfall, rainwater quickly gathered in the channel, rainfall at the same time will also be the slope of the original types of loose accumulations and washed into the channel, along the channel and down to uncover the bottom of the scouring of the way to carry the roll of the channel within the source of the loose material to the form of “snowball” to the downstream constantly in motion, and the mudflow in the process of continuous movement, the kinetic energy of its In the process of continuous movement, the kinetic energy of the mudslide becomes larger and larger, and the scouring force is enhanced, thus further expanding the scope of influence.

3 Post-earthquake mudslide disaster mechanism in Yinchanggou

(1) Analysis of the formation conditions of mudslide disaster chain

According to the remote sensing interpretation and field investigation, there exists a geologic disaster chain of internal and external geologic synthesis in the study area, especially in the area of fracture tectonics, which is the most obvious and the main area where the geologic disaster chain is most likely to be generated in the study area. Earthquake, landslide and rainfall are the main triggering factors for mudslides in the study area. Through investigation and research, it is found that the causes of the geohazard chain in the study area are mainly characterized by the following features: fragile ecological and geological environments, massive development of fractured rock bodies triggered by earthquakes, and short-term heavy rainfall.

(2) Mudslide disaster chain pattern and development process

The study area is located in the southwest of China, belonging to the high mountain valley landscape, with a high proportion of mountains and a relatively fragile geological environment, and is also in the area where the Freshwater River Fracture Zone and the Anning River Fracture Zone intersect, with frequent earthquakes and strong tectonic activities. At the same time, due to the development of geologic disaster chain in the southwest mountainous area is generally characterized by complex internal and external power coupling process, and various types of disaster formation mode, among the many geologic disaster chain modes, the earthquake- landslide-debris flow disaster chain is the most typical disaster chain evolution mode in this study area, with a relatively single chain link, which is the internal and external power coupling role of the type of geologic disaster chain. Its internal power mainly comes from the earthquake and fracture zone extrusion and tear caused by the external power mainly from the rainfall impact. Yinchanggou mudslide disaster chain is the main controlling factors of earthquake, landslide and heavy rainfall, the main triggering factor is rainfall, in the whole mudslide disaster chain evolution process, presenting the disaster chain typical “domino effect”, “chain reaction” and other characteristics, revealing the mudslide In the process of development, the scale of movement and the scope of danger are constantly enlarged.

The 9.5 Luding earthquake tectonic activity produced a large number of avalanches and slides of different scales, and Yinchanggou is close to the epicenter area, so a large number of loose solids have been accumulated in the watershed. According to the remote sensing interpretation analysis, a large number of loose accumulations were distributed in the river channel of the watershed and on the bank slopes on both sides of the valleys of the tributary ditches, and a large number of solid sources were washed and carried into the main ditch channel under the support of the rainfall factor, which continuously provided the material source base for the mudslides.

According to the on-site investigation, combined with remote sensing image analysis, the Yinchang ditch debris flow disaster chain is mainly for the earthquake and rupture tectonic activities induced a large number of landslides, a large number of landslides in the ditch and slope surface accumulation, by the effect of heavy rainfall, the water gathering and convergence erosion of the ditch bottom bed and the bottom of the two sides of the slope so as to start the loose solids and outbreaks of debris flow, and finally alluvial deposits in the ditch at the

mouth of the silt accumulation. According to the on-site investigation, the development process of Yinchanggou debris flow disaster chain is analyzed as follows:

(1) Initiation stage

Affected by the Luding earthquake, numerous avalanche and landslide disasters developed in the watershed, and a large number of landslides piled up in the ditch or on the steep slopes on both sides. Under the action of strong rainfall, the water content of the landslide accumulation body increases, by the strong water scouring action occurs transport into the channel, with the rainfall process continues, when the water content in the landslide body reaches a critical value, the geotechnical properties of geotechnical change, the original equilibrium state is destroyed, the source of initiation and accelerated scouring, carry carry the formation of mudslides.

(2) Movement stage

After the mudslide start, in the narrow channel upstream and local avalanches and slides frequent section, the channel is easy to be blocked, the formation of local congestion, resulting in a small-scale weir, blocked small-scale accumulation is not stable, in the case of the water flow velocity becomes larger is very easy to be washed down, triggering paroxysmal mudslides, further expanding the scale of mudslides. Mudflow in the process of movement on the bed of the ditch and the ditch bank slope side erosion is constantly increasing, mudflow damage capacity is constantly increasing, while the entire movement process kinetic energy is also accumulating, the cascade effect is obvious.

(3) Bed siltation stage

After the mudslide reaches the mouth of the ditch, the terrain becomes wider and narrower, and its kinetic energy and transportation capacity is gradually weakened, and the source of the landslide carried down from the middle and upper reaches of the river is constantly silted up at the mouth of the ditch, forming a piling fan. It was analyzed that, with the continuation of the mudslide in the later stage, the silt accumulated on the accumulation fan, and the thickness of the accumulation body gradually increased; at the same time, part of the high-energy materials might rush across the river and form a weir after stopping the accumulation, and part of them might be directly washed into the tributaries of the Dadu River, and be scattered and silted up in the accumulation area.

4 Conclusion

This paper takes Yinchanggou in Asbestos County as the research object, based on the post-earthquake engineering geological investigation data of the 9.5 Luding earthquake, combined with the means of literature search and field research, carried out the research on the mechanism of Yinchanggou mudslides in the area of post-earthquake active rupture influence, the chain development process and other research, and the main conclusions are summarized as follows:

(1) Through literature research and field investigation, it is concluded that the Yinchanggou debris flow is a viscous debris flow, and under the influence of the earthquake, the loose accumulations in the watershed increased dramatically, and the micro-geomorphology changed, and under the action of heavy rainfall, the debris flow was formed with a gradually larger scale, a long duration, and was still more active after the earthquake.

(2) By analyzing the drone images and satellite remote sensing interpretation, it is concluded that, under the influence of seismic and tectonic activities, the types of material sources in the study area are mainly composed of slope sources, ditch and ditch bank avalanches and slides, and congestion sources, etc. The weathering of the overlying rock and soil bodies produces debris flows. The landslides generated by weathering of overlying rock and soil bodies are small in scale but large in number and widely dispersed. The stability of the landslide body is poor in the later stage affected by rainfall factors, which is easy to produce secondary disasters.

(3) The geologic disaster chain in the study area is subject to the combined effect of internal and external geology, and the original fragile geo-ecological environment, earthquake-induced fractured rock body, and short-term strong rainfall are the basic conditions leading to the generation of geologic disaster chain. Yinchanggou geohazard chain development process is mainly divided into three stages of initiation, movement, bedding siltation, in the earthquake and fracture tectonic activity under the joint action of the weathered rock body and bedrock extrusion produced by landslides in the torrential rainfall and favorable topographic coupling, and ultimately triggered the generation of mudslide hazards, the chain process is obvious.

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