Debris Flow Disasters Induced By Forest Fire

---Taking the Reneyong Gully as An Example

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Abstract：Debris flow is a kind of natural geological disasters occurred in the mountains areas,caused by a special flood along the steep mountain valleys or diarrhea elicited by flood erosion, which contains a large number of mud, sand, stones and other solid matter. The mechanism of debris flow occurrence and development is complex, affected by many factors,such as the destruction of the ecological forest fire, the fire heating process reducing the overlying soil moisture,leading to weakening the structural strength of soil,which creates the condition of the debris flow, shallow soil landslide and soil and water loss. This paper take the debris flow of Reneyong gully in Zhengdou village, Xiangcheng county, Sichuan Province of China as an example, describe the development features and genetic analysis of the post-fire debris of Reneyong gully. This paper focuses on discuss the relationship between forest fire and the debris flow.

The introduction

The post-fire debris flow is a kind of special phenomenon of the disaster, it refers to the forest fire, the occurrence of debris flow increased frequency. There was a forest fire in Mount YuanGen,Reda village, Xiangcheng county, Sichuan Province of China On 1 June 2014 at 1840(Fig. 1).After 4 days of tough break,the forest fire basically put out on June 5th10am.Then debris flows of Reneyong gully occurred on 5 June 2014 at 1608(Fig.2).The duration of the debris flow about eight minutes, the flow of it about 100m^3/s.A large number of the source of the Reneyong debris flow mainly in the formatiaon of sediments dominated by the Yuangen mountain forest fire.

Fig.1 The forest fire of Yuangen shan

Fig.2 The debris flow of Reneyong gully

Fig.3 The remote sensing image of Reneyong gully

Summary of The natural environment background

Location and characteristics of the debris flow gully

The Reneyong gully located in Zhengdou village Xiangcheng County of Sichuan Ganzi Tibetan Autonomous Prefecture,is the first tributary on the left bank of Dingqu River,belongs to the Jinsha river water system(Fig.3).Mizoguchi geographical coordinates: latitude 29°18′05.5″,longitude 99°33′04.1″.The basin located in the east of Reda township, south to Rong county Bensong township, west to Zhongzan village Batang county , north near Dingbo township, from the Xiangcheng county town about 85 km.

The Reneyong debris flow gully total length of 8.53km, the basin area of 24.28 square kilometers,the highest point of elevation channel 4210m, the lowest elevation Mizoguchi is 2870m, height 1340m,the ridge is narrow, different steep slow and valleys cutting relatively deep upstream and middle for the "V" type valley and downstream more gentle and broad as the "U" in the valley, the ditch domain average longitudinal slope of about 145.9 per thousand.The main types of landforms is eroded plateau landscape and erosion landscape of river.

According to the characters of the slope valley, the gully has the conditions of catchment and the formation of debris flow disaster.The catchment area is the middle and upper slope valley, the source is in the upper part of the slope and valley slope sediments ,circulation area is in the middle and lower reaches of the valley slope .Therefore, the loose slope upper slope valley deposits and post fire debris has become the main form of the debris flow disaster.

Geological survey

Disaster forming region geomorphic unit belongs to the plateau area, the microrelief belong to the aggressive mountain ravines,the emergence stratum mainly is the Upper Triassic sandstones ,slate and the Quaternary pluvial slope and moraine deposits.

The tectonic units in the area belong to the northern section of the Hengduan Mountains,the southern tip of the Shalu Mountains,the transition zone of yunnan-guizhou plateau to the qinghai-tibet plateau.Regional structure for the Jinsha River deep fracture, the regional crustal stability is good.According to relevant data, the seismic fortification intensity is Ⅶ, the peak ground acceleration 0.05 to 0.10 g.

Conditions of engineering geology and hydrogeology

The regional distribution of the strata mainly include hard rock group formed by the bedrock and loose rock groups composed of Quaternary.Groundwater types of this area is divided into unconsolidated rock pore water and bedrock fissure water.Loose rocks pore water in the valley of the rain period the overall slope without water,the aquifer group of bedrock fissure water is composed of the Mesozoic Triassic sandstone,slate and periods of magmatic rocks.In steep terrain, erosion, and due to the intense structure function, fault and fissure development,thus the rich

deposit of structural fissure water.Recharge source of groundwater in the area are mainly precipitation and supplies,visible,the hydrogeological conditions of this area is simple.

Development characteristics of the debris flow of Reneyong gully after forest fire

Before the YuanGen mountain forest fires,the vegetation development and Joe, irrigation, grass coverage is good in ReneYong gully, no debris flow events over the past hundred years and debris flow occurrence frequency is relatively low.

Affected by the forest fires occurred in June 1, 2014, in the role of local heavy rain,There happened a large debris flow along the ReneYong gully,the landslide outbreak lasted about 20 minutes, occurs with large noise, mudslides rushed out of the total amount of about 20×104 m3and the velocity is about 6.0 m/s.

The direct danger area of debris flow is Rene Village in the ditch(Figure 4),The main object of harm is houses,authorities,the Rene village primary school, Village Road, bridge and part of the farmland.Mainly by the way as the buried roads, destroyed houses and the debris flow into the DingQu River at the same time, caused the water up to more than 3m , the high intensity of debris flow downstream sediment transport caused more damage (Figure5, 6, 7).

Fig.4 The danger zone of Reneyong gully

Fig.5 The debris flow buried roads

Fig.6 The debris flow destroyed houses

Fig.7 The debris flow buried farmland

The genesis analysis of the post-fire debris flow of Reneyong gully in Zhengdou village, Xiangcheng county, Sichuan Province of China

The main inducing factors of debris flow nothing more than the natural factors such as rich solid

material, steep terrain,abundant water and rainfall stimulating factors，but also human irrational development activities [1].

The fundamental cause of debris flow of Reneyong gully

The fragile ecological environment of plateau provides rich material source

Rene village debris flow gully is located in the plateau, the ecological environment is fragile and strong weathering of rock mass, rich source of loose solids in the gully, and the distribution of it is wide and long distance.The regional geological environmental conditions provides favorable conditions for the formation and supply of debris flow.

Short-term heavy rainfall provides induced conditions

Plateau climate variability, at the same time,the environment of local watershed has bigger difference,there is a mountain across the four seasons, ten mile different day said, the water easily rise to fall. Local heavy rainfall upstream,produced water conditions,at the same time, the forest fire caused the self-restraint ability lower, aggravated soil erosion,then the mud-rock flow occurred. The formation of surface runoff rainfall in "6.8" is the major source of debris flow, heavy rain is the main motivating factors include mudslides.

The topography

Debris flow forming region on the topography have the characteristics of mountain high groove depth, steep terrain, longitudinal slope down steep gully bed and river basin shape is easy to flow together,this provides a good topography conditions for the formation of the debris flow sediment source and water source development .

The earthquake reduced the slope stability

On August 30, 2013, the distance of the earthquake in derong village is close to where the debris flow gully,the earthquake reduced the stability of slope,caused local collapse of the slope strengthening, increase the source of debris flow volume.

Effects of forest fire on debris flow

Fire is an important disturbance factor in forest ecological system, which has certain effect on the occurrence of forest debris flow.Research shows that, in the area of forest fire effects,when the fire cause soil hydrological characteristics changed substantially, the burned areas will often experience intense soil erosion, debris flow risk increased significantly in the months after the fire and the next few years[2-5].For instance, the forest fires of Yang Fang gully in Sichuan Muli County Mai Dilong township in March 1973 led directly to the outbreaks of a once-in-a-century rainstorm debris in July 1973 .As another example, the section of the Sichuan Tibet highway Zhubalong ditch, suffered an anthropogenic fire in 1977 dry season , so that the forest vegetation in the watershed was destroyed ,then the rainy season in June and in August has happened twice disastrous debris flow [8].Forest fire effects on debris flow, therefore, is quite big.

Fig.8 Bare surface after fire

Fig.9 Rescue and fire fighting smoke point for a deep ditch buried

There was a forest fire in Mount YuanGen of the upper reaches of the Reneyong gully on 1 June 2014 at 1840, after four days, the fire was put out on June 5 to 10 PM.The fire burned area is large, more than 8000 acres, accounts for about a quarter of the whole basin,the surface exposed and a large amount of loose solid material is formed on slope after the fire(Figure 8). Influenced by local rainstorm,the large-scale landslides of Reneyong gully occurred.Effects of forest fire on debris flow is mainly manifested in the following aspects:

Forest fire destroyed vegetation, promote the occurrence of debris flow [7]

The forest fires have serious damage to vegetation,and vegetation is a key factor controlling the occurrence of debris flow.The roots of the plant can increase the soil cohesive , the branches and leaves of plants can be intercepting rainfall, the litter of vegetation can reduce surface runoff, the plant has a protective effect on the soil, it can effectively inhibit the occurrence of soil erosion. The reduction of vegetation mainly from 3 aspects to create the conditions for the occurrence of debris flow after the fire.First of all, the plant's root mat splitting and destroyed in the high temperature,then loose, fragile and eroded soil surface produced, that provides plenty of material for debris flow [5].Secondly, the reduction of vegetation will change the forest soil hydrological characteristics, improve the ability of surface runoff and infiltration capacity.The study of fire erosion process found that ,in a few years after the fire, the recession of the plant roots increased the permeability of water,then promoted the shallow landslide,landslide debris flow.Finally, plant leaf area reduction, litter and humus consumption, reduced vegetation on rainfall interception, will improve the raindrop erosion.

Forest fire changed the rainfall threshold debris flow needs

The rainfall threshold is an important criterion for the initiation of debris flow and the important parameters in the debris flow forecast.Usually the occurrence of debris flow need high intensity rainfall.The post-fire debris flow initiation also requires a certain amount of rainfall.Due to the lack of vegetation protection after the fire, the consumption of surface litter and humus,the change of hydrophobic layer and soil structure,the rainfall threshold of debris flow will be reduced in the burned area[7]. The Reneyong gully old landslide platform development,it show that the channel history there has been large-scale debris flow, it belongs to the old flow gully.But the channel has not had the large scale of debris flow for nearly 100 years,the debris flow occurrence frequency is low,and the heavy rainfall is not the maximum rainfall intensity in recent years,this means that the fire reduced the mudslide start rainfall threshold.This means that the fire reduced rainfall threshold for initiation of the debris flow of Reneyong gully.

Forest fire provides more fine sediment source for the occurrence of debris flow

Forest fire in the fire burning process, the heat would destroy the soil structure, soil bulk density, porosity and other physical properties change radically,at the same time due to the large number of death cause of plant root rot,reduces the soil cohesive force, these changes cause burns a lot of loose sediment. A large number of ash charcoal, etc produced in the process of forest material burning is the important matter of the occurrence of debris flow,so the loose sediment and a large number of ash is the important source of post-fire debris flow [6].At the same time, in the process of rescue fire fighting, the deep buried of smoke point and other activities making the amount of debris flow potential source increased(Figure 9).

The ashes after forest fire promote the occurrence of debris flow

The ash layer produced by the burning of forest fire is not only an important source of the post-fire debris, and has a complex influence on the occurrence of the post-debris flow. On the one hand, the ash has the characteristics of strong water absorption,the ash covered in burned surface has certain protective effect on soil.But it is only in the show when the rainfall is very small or

beginning to rain.Once the advent of heavy rainfall or rainfall reached later, when fully saturated in the ash layer, surface runoff is then generated,these ashes will be transformed into a slurry containing ashes, then promote the occurrence of debris flow.

In conclusion, the debris flow is in the plateau of the fragile ecological environment, under the effect of short-term heavy rainfall, the excitation of the flood, and the slope self-restraint ability reduce caused by the fire, loose materials source exposed, at the same time, on the slope has large deadwood and ashes.Combination of these two, due to the channel slope,the debris flow disaster formed .

The Conclusion

Study the relationship between forest fire and the debris flow is the result of the 1990s about Wells[3], Wohl and Pearthree in landslide survey found that due to the fire, the fire burned down the slope vegetation and the debris flow occurrence frequency increased significantly, thus found the relationship between the debris flow occurrence and the forest fire.At present, in order to reduce the dangers and the losses of debris flow after forest fire, the United States, Australia, Spain and other countries have carried out the researches of the debris flow after forest fire, and positive progress has been made [6, 9].China is a country of forest fires occur frequently, in order to prevent the occurrence of the post-fire debris flow and provide scientific basis for prevention and control of the post-fire debris flow measures, it is imperative to strengthen the relationship between forest fire and debris flow research.

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