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Development characteristics of debris flow and its influence on migration site

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ABSTRACT

With the increasing of social and economic activities of the human beings, people's claiming for the nature is also increasing continuously. People's wanton claim destructs the natural resources, causing debris flow and other geological disasters in the mountainous areas. With the increasing of claiming amount, the geological disasters have also been more and more serious. Debris flow is a kind of joint movement of solid (rock and earth mass) with large grain difference and liquid (water), with the composite and incongruous mixtures of high-concentration water, sand and gravel. Debris flow is a typical disaster geological phenomenon and landform process, which occurs in a short time, but has extremely great destructive power due to huge kinergety. The occurring of debris flow will not only destruct the local regional environment, but will also endanger and threat people's life security and economic construction. In this paper, taking a region as an example, the author will discuss the development characteristics of debris flow and evaluate its influence on the migration site, and propose preventive and control measures.

KEYWORDS

Debris flow; Development characteristics; Hazard; Evaluation.

INTRODUCTION

Debris flow is a kind of special flood flow with a lot of solid substances like sand, stone and huge gravel generated in the valley or slope due to precipitation (storm, glacier and snow melting water). With the rapid development of human society and economy, the economic construction in the mountainous is also developed and strengthened continuously, causing continuous destruction to the ecological balance in some regions in the mountainous economic construction. Meanwhile, the improper preventive an control measures taken by people will cause serious debris flow disaster in some mountainous areas. According to relevant statistics in recent years, there have been more than 8500 debris flow gullyes detected and categorized in 31 provinces, municipalities and autonomous regions in China. Therefore, the research on debris flow has become a problem urgently to be solved in the economic development of mountainous areas in China. Researching and analyzing the development characteristics of debris flow and its influence on the migration site are of significance for the construction of gully and valley areas. Taking a region as an example, in this paper, the author discusses the development characteristics of debris flow and its influence in detail and proposes effective preventive measures to reduce the occurring of debris flow disaster.

Debris flow is a kind of flood flow formed after saturated dilution of mountain containing sand and stone and loose soil by storm or flood. The area, volume and flow of debris flow are all very large, while debris flow landslide occurs in the small area of mountains with diluted soil. The typical debris flow consists of sticky mud rich in silt and clay and the suspending coarse an solid clastics. Under the condition of appropriate terrain condition, when storm or flood occurs, a lot of water will penetrate the water flowing slope or the solid deposition of the mountainous gully. After these substances are soaked in water, their stability will be reduced, when the solid substances reach the saturated moisture, they will move downward under the action of their own gravity, so as to generate debris flow. Debris flow occurs suddenly with a swift and violent state, and in the process of movement, it can carry the huge stones for movement together. In the process of movement, debris flow has strong energy, so it has a great damage.

With a short time, perhaps several hours or even several minutes, debris flow is a natural disaster distributed in various areas worldwide with special terrain and landform. In case of debris flow disaster, the moving debris flow will destroy town, field crops, economic construction and threat people’s life security. In addition, as debris flow consists of sand, stone and slurry, in the process of movement, it also might block river course and hinder river transportation, so as to cause flood.

OVERVIEW OF RESEARCH REGION

The research area is a broad valley in Southwest China, with an area of 7516. 9 km^2 and high altitude. The terrain in this area is fluctuated obviously, mainly dominated by high mountains, narrow valley and broad valley. The stratum is Zhongba-Langjiexue continental margin displacement mixed terrene, with development of late Triassic Xiugang Group suture line flysch mixed combination. The new structure within the region is mainly reflected as differential rise, the dike area is reflected as slow deposition, high mountainous area is locally reflected as slow rise with denudation, it is frequent that earthquake occurs in this area, and the seismic strength is high. With mild semiarid plateau climate in this area, there is no significant change of climate throughout the year, with great daily temperature change and low average temperature. This area has developed gullies, with short stream and swift current, sudden rise and fall of water level and strong mountain washing and cutting abilities.

DISTRIBUTION AND TYPE OF DEBRIS FLOW IN THE RESEARCH AREA

(1) Type of debris flow in this area. Upon investigation, there are 141 debris flows developed in this area. Through the observation of landform conditions for the occurring of these debris flows, it can be known that some belong to slope debris flows, while some belong to gully debris flows. Classified from the physical forms of debris flow, all these developed debris flows belong to diluted debris flows. Classified by the formation, the debris flows in this area include debris flow and water-rock flow, in which the water-rock flow mainly occurs in the gullies with wide water area, more ravine branches and fewer solid grains.

(2) Among the 141 developed debris flows in this area, there are 53 slope debris flows, and the remaining 88 are gully debris flows. There are 60 debris flows on the left bank of the river in this area, including 9 slope debris flows and 51 gully debris flows; there are 81 debris flows distributed on the right bank, where 44 are slope debris flows and 77 gully debris flows, the debris flow distribution is as shown in the TABLE 1 below.

TABLE 1: Distribution of debris flow on both banks of the broad valley

Location	Gully debris flow (number)	Slope debris flow (number)	Total	Debris flow distribution density (number km^{-1})
Left bank of broad valley	51	9	60	0.5
Right bank of broad valley	37	44	81	0.68
Total	88	53	141	0.59 (average)

DEVELOPMENT CHARACTERISTICS OF DEBRIS FLOW

This area has complicated geological conditions, with severe movement of new structures, low temperature for a long time and in the dry, cold and strongly frost weathering weather. The precipitation in this area is highly concentrated, and the short rainstorm is strong. These special natural geological environments create conditions for the formation of natural disaster, and the debris flows developed in this area reflect significant regional characteristics.

(1) There are more debris flows and are densely distributed. The mountains on both banks of the broad valley have high altitude and small gradient, which creates favorable terrain conditions for the development and molding of debris flows; influence by climate environment, the mountainous rocks in this area are easily crushed and the frost weathering here is relatively strong, therefore, new loose substances are easily to occur; the precipitation in this area is concentrated, and the short rainstorm is strong, which provides full water conditions for the development and formation of debris flows.
Under the action of the above conditions, totally 141 debris flows are generated on both banks of the broad valley with a length of about 120km, and the disasters constituted by these debris flows have a dot and linear density up to 1.18/km, see TABLE 1 for details.

(2) Gully debris flows have small area in this broad valley. By reference to the investigation statistics about these 141 debris flows, it is known that among the 88 gully debris flows, the largest area is up to 83.97 km^2, while the smallest one is only about 0.68 km^2, with an average area of 8.07 km^2, and the median of the flow area is only 3.1 km^2, specifically as shown in TABLE 2.

TABLE 2 : Statistical form of flow area of gully debris flows

Location	Within km^2		5-0 km^2		10-5 km^2	
	Number	Mean value	Number	Mean value	Number	Mean value
Both banks	51	2.07	17	7.08	6	12.19
Left bank	35	2.13	8	7.48	3	12.91
Right bank	16	1.94	9	6.73	3	11.46
Location	**15-0 km^2**		**20-5 km^2**		**Aove 25 km^2**	
	Number	Mean value	Number	Mean value	Number	Mean value
Both banks	5	16.77	4	23.47	5	46.77
Left bank	0		1	20.89	4	49.41
Right bank	5	16.68	3	24.33	1	36.18

(3) The gully debris flows on both banks of the broad valley have short and small gully and large gully bed slope deposition. According to relevant statistics, the main gully of the broad valley has a length of 0.92-16.43kn, with average length of 3.70km, and median of gully length 2.74km. The statistical result of gully debris flow length on both banks of this broad valley is as shown in TABLE 3.

TABLE 3 : Statistics of gully debris flow length on both banks of the broad valley

Position	Within 1km		1-3km		3-5km	
	Number	Mean value	Number	Mean value	Number	Mean value
Both banks	2	0.95	46	1.93	22	4.04
Left bank	2	0.95	27	1.85	13	3.88
Right bank	0	/	19	2.05	9	4.28
Position	**5-7km**		**7-9km**		**Above 9km**	
	Number	Mean value	Number	Mean value	Number	Mean value
Both banks	8	5.47	6	8.24	4	13.06
Left bank	4	5.66	2	8.38	3	13.58
Right bank	4	5.28	4	8.17	1	11.50

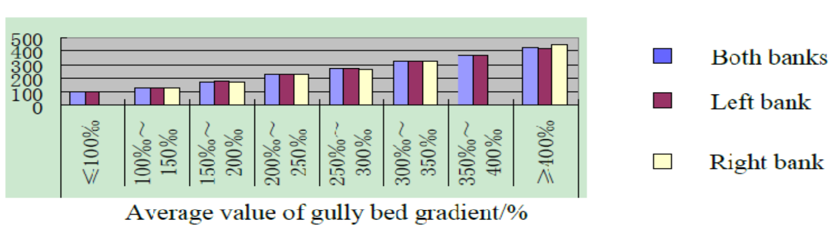

Figure 1: Average gradient diagram of gully bed of valley debris flow in the broad valley

TABLE 4: Quantification of susceptibility of debris flow gully

No.	Influential factors	Susceptibility classification							
		Serious (A)	**Score**	**Medium (B)**	**Score**	**Slight (C)**	**Score**	**Ordinary (D)**	**Score**
1	Serious degree of collapse landslide and water and soil loss (natural and artificial factors)	Serious corrosion of collapse landslide, multiple deep landslide and large collapse, loose surface soil, quite developed washing gully	21	Develop collapse landslide, multiple shallow and medium collapse, sporadic vegetation coverage, developed washing gully	16	Sporadic collapse, landslide an developed washing gully	12	No collapse, landslide and developed washing gully`	1
2	Sediment fee length along the course (%)	>60	16	16-301	12	30-10	8	<10	1
3	Active degree of debris flow accumulation fan at the mouth of gully	River-shape bending or blocking, main flow of large river deviates due to squeezing	14	No significant charge of river shape, only the main flow of large river is suppressed	12	30-10	8	<10	1
4	River gulley longitudinal slope (° ‰)	<12° (213)	12	12°-6° (213-105)	9	6°-3° (105-62)	6	<3° (52)	1
5	Influential degree of regional structure	Strong rising area, seismic area above Level 6	9	Rising area, seismic area of Level 4-6, medium or small branch fracture or no fracture	7	Relative stale area, seismic area below Level 4, small fracture	5	Sedimentation are, small or no influence of structure	1
6	Forest, bush and grass vegetation coverage within the area (%)	<10	9	10-30	7	30-60	5	<60	1
7	Recent one-time silting change of the river gully (m)	>2	8	2-1	6	1-0.2	4	<0.2	1
8	Lithology influence	Soft rock/yellow earth	6	Hard and soft alternate	5	Weathering and joint developed hard rock	4	Hard rock	1
9	Storage of loose substances along the gully ($10^4M^3/km^2$)	>10	6	10-5	5	5-1	4	<1	1
10	Gully bank slope gradient (‰)	>32° (625)	6	32°-25° (625-466)	5	25°-15° (466-268)	4	<15° (268)	1
11	Cross section of loose substance in san production area	V valley, valley in valley, U valley	5	Expanded U valey	4	Composite section	3	Flat type	1
12	Average thickness of loose substances in sand production area (m)	>10	5	10-5	4	501	3	<1	1
13	Basin area (km^2)	0.2-5	5	5-10	4	Below 0.2, 10-100	3	>100	1
14	Basin relative height difference (m)	>500	4	500-300	3	300-100	3	<100	1
15	River gully blocking degree	Serious	4	Medium	3	Light	2	No	1

According to the table above, we can see that the gully channel of debris flows in the broad valley is short, which is closely related with the small area of debris flow. From this table, we can also see that the channel length on the left bank changes greatly compared with that on the right bank.

In the process of formation of debris flows, the gulley bed gradient is an important factor for the formation and movement of debris flow. According to the statistical result of gully bed gradient of debris flow in this area, the flow debris with gully bed gradient with 50‰-300‰ account for 90.7% of the total debris flows, in which the debris flows with gradient 100‰-300‰ account for 54.7%. According to the statistics of average gully bed gradient in the research area as shown in Figure 2, there is only 1 debris flow with gully bed gradient within 100‰, while 66 with gradient 100‰-300‰ and 12 with gradient ‰-300‰. According to these statistical results, we can see that the gully debris in this area have a large average gradient value of gully bed, therefore, they bring favorable conditions for the debris flow. The gradient diagram of gully bed in this broad valley is as shown in Figure 1.

(4) The debris flows have a large scale of accumulation fan and the accumulation is completed. The broad valley provides a favorable condition; the debris flows on the accumulation fan are unstable in routine, and in the process of movement, it is very easy to form "broad but scattered" gulley mouth accumulation fan; the important substances in the debris flows are mainly from the sand at the valley, so as to increase the scale of broad valley debris flow. Due to the above factors, the scale of debris flow accumulation fan is expanded.

The breakout of debris flow will inevitably have significant influence on the migration site construction. This is mainly reflected in two aspects: the direct influence is reflected in the fact that if the existing gully bank is not subject to engineering treatment, the debris flow washing and deposition will cause unstable migration site and influence people's life and property safety. The indirect influence is that in the water diversion project of the original design, there might be not enough size and longitudinal slope, which obviously cannot meet the requirements for drainage of debris flow. If the design and construction are conducted only according to the drainage plan, it is extremely possible to generate deposition, and in case of extreme condition, silting might occur, and in turn, the overflow will influence the stability of the proposed migration site.

INFLUENCE OF DEBRIS FLOW ON THE MIGRATION SITE AND COUNTERMEASURES FOR CONTROL

(1) Hazards of debris flow brought to people. As the debris flow in this area has a short gully and small area, and the important substances of the debris flow are mainly sand accumulation and frost weathering materials, generally the debris flows formed are not large in scale. In addition, this gully debris flow has a large accumulation fan area, small slope and small gully flow speed, the impact force is relatively small, and the main hazards are washing and silting.

What is mainly influenced in this broad valley is the highway on both sides of the broad gulley. In case of debris flow, it is easy to silt up the highway on both banks to hinder the road or form water way on the highway, so as to influence people's normal traveling. Furthermore, it will seriously influence people's production, the accumulation fan in this area has a large area, whole most of the farmlands are on the accumulation fan, when debris flow moves, it will destroy or silt up farmland, forestland, grassland and the infrastructures in this region, so as to bright great economic loss to people. The quantification of susceptibility of debris flow gully is shown as TABLE 4.

(2) Control measures. In order toe ensure to people's life and property security and the smooth running of road, the debris flow should be controlled comprehensively according to the local condition. Therefore, aimed at the debris flow in this area, the control should be dominated by civil engineering measures; set a reasonable ground sill or check dam to stabilize the gulley bed in the broad valley; set a retaining dam at the gully mouth to retain the solid substances existing in the debris flow; construct a drainage guide channel in the lower stream of the broad valley, and it is also possible to plant vegetations to reduce the hydraulic power of the debris flow. Second, aimed at the unstable debris flow on the accumulation fan of the broad valley, it is possible to set single-side protective dam or drainage guide channel for beam control. Third, construct protective project in the section with higher accumulation of debris flow to prevent the slurry washing to the road in case of debris flow. According to the development status of the debris flow and the analysis on its influence on the proposed migration site, and in combination with the characteristics of the washing gully valley, for the possible debris flow or flood flow, it is suggested to adopt two comparable plane, namely sand (retaining) dam or changing the gully to drainage guide. Based on the importance of the migration site, in combination with relevant experience of debris flow control project in China, the standard of the engineering control is designed based on the peak value of debris flow formed by flood with a return period of 50 years and checked based on the peak value of debris flow formed by flood with a return period of 100 years.

CONCLUSION

With the joint action of natural condition and artificial condition, the occurring rate of natural disaster is increasing year by year, and a lot of debris flows are generated in some special regions. The development of debris flow greatly influences people's life and life and property. According to the actual case in this paper, the development characteristics of debris flow are analyzed, and the hazards of debris flow are also analyzed; finally, aimed at the hazards, the corresponding control measures are given. Besides, people should also strengthen control of debris flow in daily life. it is possible to reinforce facilities and control the unreasonable activities for comprehensive treatment, so as to reduce the occurring rate of debris flow.

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