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Study on the Types and Risk Assessment of Geological Hazards in a Certain Mountain Area

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Abstract: Among numerous natural disasters, earthquakes generally cause the greatest damage and have the widest impact, and secondary geological disasters caused by earthquakes can also pose a significant threat to people's lives and property safety. By collecting data and comparing and analyzing the changes in the degree and quantity of various types of geological disasters in the local area after a certain earthquake, the research results show that the areas with the highest probability and quantity of geological disasters are medium and high mountain areas, slightly followed by deep and medium hill areas, and the areas with flat dams and shallow hills that are basically free from geological disasters; Among various geological disasters, the increase in collapse and unstable slopes (landslides) is the largest, with small scale being the main increase in geological hazard hazards, accounting for 79% of the total. Large scale and medium-sized scale account for 0% and 21% respectively; Before and after the earthquake, there was a significant increase in the number of geological hazards such as collapses, landslides, unstable slopes, and collapses within the VIII degree area. The VII degree earthquake intensity area had a significant increase in the number of collapses, with an increase of nearly 69%. 15% to 30% were the increase in the number of geological hazards such as collapses, unstable slopes, and landslides before and after the earthquake. The VI degree earthquake intensity area had a relatively small increase in the number of collapses, with only 9%, before and after the earthquake, geological hazards such as collapse, unstable slopes, and landslides have not increased significantly.

1. Introduction

One of the provinces with the highest frequency of geological disasters in China is Sichuan Province, which has the characteristics of wide distribution, multiple disaster points, and long duration [1]. Among numerous natural disasters, earthquakes generally cause the greatest damage and have the widest range of impact, and secondary geological disasters caused by earthquakes can also pose a significant threat to people's lives and property safety [2]. Therefore, it is crucial to understand the types and degrees of secondary disasters that occur locally before and after earthquakes, and to predict the trend of geological disasters after earthquakes is also an important issue that needs to be addressed [3]. Wu Haochen analyzed the trend of geological disasters in

Lushan, Sichuan after a certain earthquake using airborne radar, drones, and other methods [4]. Gao Huihui analyzed and statistically analyzed the development of debris flows and landslides in various intensity areas after the Wenchuan earthquake, and summarized the evolution and distribution characteristics of debris flows and landslides [5]. Wang Jiayun analyzed the geological disasters caused by the Yushu earthquake and studied the mechanisms and main influencing factors that affect the development of geological disasters in the earthquake area [6].

Based on this, in order to gain a deeper understanding of the impact of earthquake intensity on local geological disasters, a comparative analysis was conducted on the types and trends of geological disasters in a certain area after an earthquake, providing guidance and reference for the formulation of relevant earthquake prevention and rescue measures.

2. General Situation

This study area is a geographical area in Sichuan that can experience moderately strong destructive earthquakes, with strong development of fault structures. In history, the region has experienced multiple earthquakes in the past few decades, with earthquake intensities ranging from 5.0 to 5.5. According to the judgment of the National Seismological Bureau, there is a certain probability of a 6.0 magnitude earthquake occurring in the region. Due to the great threat of earthquakes in this area, it has been designated as a key earthquake monitoring and defense area by the Sichuan Provincial Government. The overall terrain trend of this area is low in the north and high in the south, with hills, medium, and low mountain landforms occupying most of the area. In addition, sedimentary rock is the main stratum type in this area, which can be traced back to Cambrian of Paleozoic. The northeast and southwest are two different geomorphic units within the study area. The hilly area is the main landform in the northeast, with a small dip angle of the rock layers. The overall terrain is relatively flat, with small fluctuations, and more red strata of the Jurassic and Mesozoic Cretaceous are exposed; The middle and low mountainous areas are the main landforms in the southwestern region, with complex structures, strong fissure development, easy rock fragmentation, and significant mountain undulations. The region is mainly characterized by karst landforms. The Gushanzi dam information in this area is shown in Table 1.

The occurrence of seismic geological disasters is affected by a variety of factors, mainly including seismogenic structure, human activities, tectonics and other factors. At the same time, the interaction between various influencing factors will increase the probability of earthquake disaster in the region to a certain extent. The types of geological hazards in this area mainly include collapses, landslides, and collapses, as well as disasters such as mudslides, ground fissures, and ground subsidence. Referring to the earthquake disaster data over the years, it is found that the risk of geological disasters in this region is showing an increasing trend, and it is necessary to strengthen the monitoring and control of this region.

Table 1: Information of Gushanzi Dam

Dam scale	Basin area/km^2	Maximum dam height /m	Dam type	dam length /m
Small Type I	39.1	31.05	Clay core wall	168

3. Main Types of Secondary Earthquake Disaster in the Region

3.1. Landslides on Unstable Slopes

Most of the soil masses with landslide geological disasters in the area belong to colluvial and residual slope deposits, with relatively loose structures and strong permeability, while low cohesion. Especially after rainfall, a large amount of water seeps into the soil, greatly reducing the shear strength of the soil and increasing the self-weight of the soil. In this case, the upper soil mass is prone to sliding along the contact zone. When an earthquake occurs, it damages the structure of the rock and soil mass, increases pore water pressure, reduces the shear strength and effective weight of the soil mass, and is subjected to horizontal seismic action, resulting in unstable slopes and landslides. As shown in Figure 1, landslides occurred in the region after a certain earthquake.

Figure 1: Overall View of Landslides after Small Earthquakes

3.2. Dangerous Rock and Collapse

Most of the collapses in the area occur on gently sloping slopes and steep cliffs, with heights as low as ten meters and as high as several hundred meters. At the top of the slope, unloading cracks are prone to occur, and concave rock cavities are easily formed at the contact surface. The rock mass is simultaneously divided into blocks by the action of cavities, unloading cracks, and structural cracks, and gradually separates into dangerous rocks. Therefore, when an earthquake occurs, the stability of the rock mass rapidly decreases and collapses occur. The length, width, and thickness of a certain collapse in the research area are approximately 83m, 95m, and 10m, respectively × 10m3 is its approximate volume, which is formed by incubation in dolomitic limestone. When an earthquake occurs, the seismic action and vibration expand the unloading cracks, increase the degree of rock deformation, and cause the lower rock mass to be broken and toppled, with 125 being the main direction of collapse.

3.3. Ground Cracks, Ground Subsidence

Ground subsidence mainly includes non karst subsidence and karst subsidence. Ground fissures and conical karst collapses were formed during a certain earthquake. The direction of the ground fissure in a certain village is 322, with a width range of 5-25cm, a length of 46m, and a visible depth range of 0.33-1.21m. No significant dislocation of plant roots was observed from the fissure.

4. Comparing the Distribution Characteristics and Development of Geological Disasters Before and After Earthquakes

4.1. Distribution Characteristics

For the distribution of stratigraphic lithology, most ground collapses occur in the Triassic and

Permian strata in the south. Most of the collapses occur in the northern Cretaceous and Jurassic sandstones, as well as in the Triassic and Permian limestone formations in the south.

Landslide like geological disasters are prone to occur in slope areas (with slopes ranging from 15 to 40). However, when the slope of the area does not exceed 15, the probability of geological disasters occurring is relatively low because the bottom layer is relatively stable. However, when the slope of a region exceeds 40, geological disasters such as collapse usually occur, and collapse generally occurs in steep cliffs with slopes exceeding 40 in the region. In addition, the areas with the highest probability and quantity of geological disasters are medium and high mountain areas, slightly followed by deep and medium hill areas, and flat and shallow hill areas are basically free from geological disasters.

For the distribution of human activities, the gradual increase in human activities is also an important reason for the occurrence of geological disasters, and the probability of regional disasters will increase with the increase of human activities. Especially in industrial and mining construction areas, urban construction areas, along highways, over cultivated areas, as well as hydropower, water conservancy, and engineering construction areas.

4.2. Analysis of the Development Characteristics of Geological Hazards in Different Seismic Intensity Zones

Distribution and Development Characteristics of Geological Hazards in Different Seismic Intensity Zones Changes in the Development of Geological Hazards before and after Earthquakes

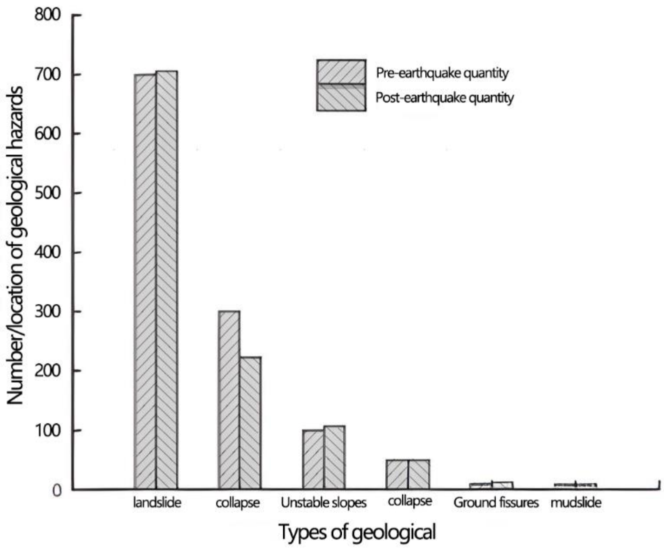

Figure 2: Change trend of geological hazard hidden danger points before and after earthquakes

Most of the geological types in the study area are Cretaceous, Jurassic, and Mesozoic Triassic. The rock surface is fragmented, with low strength and cracks. At the same time, many engineering projects have been carried out in this area, so geological disasters in this area are more developed after a certain earthquake, and the degree of geological disasters such as landslides and collapses has increased. Among various geological disasters, the increase in collapse and unstable slopes (landslides) is the largest, with slight increases in mudslides, ground fissures, and ground subsidence. In addition, after the earthquake, there were a total of 35 geological hazard points with increased deformation. Specifically, it includes 2 ground fissures, 24 collapses, 6 landslides, and 7 unstable slopes. As shown in Figure 2, the comparison results of the changes in geological hazard hazards before and after the occurrence of an earthquake are presented. From Figure 5, it can be seen that after a certain earthquake, the main increase in the scale of geological hazard hazards is the small scale, accounting for 79% of the total, while the large scale and medium-sized scale account for 0% and 21%, respectively.

5. Analysis of the Development Characteristics of Geological Hazards in Different Seismic Intensity Zones: Distribution and Development Characteristics of Geological Hazards in Different Seismic Intensity Zones

VIII is the maximum intensity of this earthquake, with 2263km2, 437 km2, and 85 km2 respectively representing the areas of VI, VI, and VIII regions. The northwest direction is the major axis of the isoseismic line, while 54km and 72km are the short axis and major axis lengths, including 6 counties and districts.

5.1. Analysis of the Development Characteristics of Geological Hazards in Various Seismic Intensity Regions

Referring to the geological disaster data and seismic intensity map of the region after the earthquake, 35 deformation increased geological hazard points and 65 new geological hazard points were statistically divided. The results showed that the area with the smallest area was the VIII degree area, but there were 32 more geological hazard points in this area, accounting for about 50% of the total increase; Next is the I degree zone, where 29 hidden danger points have increased, accounting for approximately 45% of the total increase; The distribution density of 37/100 km2 geological hazard hidden danger points in the VIII degree area is approximately 5.4 times that of the I degree and VII degree areas, which is 300 times. At the same time, the VII and VIII degree zones are also areas of increased deformation, with approximately 60% of the areas experiencing increased deformation, as shown in Figure 3. The common feature of different seismic intensity zones is that the points of increase and increase in deformation are mainly landslides and collapses, accounting for over 90%.

5.2. Comparative Analysis of the Development of Geological Disasters before and After Earthquakes

Based on the above analysis, a comparative analysis of the characteristics of geological hazard hidden danger points in each seismic intensity area before and after the earthquake can be found: there is a significant increase in geological hazard hidden danger points such as collapse, landslide, unstable slope, and collapse in the VIII degree area before and after the earthquake, close to a multiple relationship, as shown in Figure 4. The area with a significant increase in the number of collapses is the VII seismic intensity zone, with an increase of nearly 69%. 15% -30% is the increase in the number of geological hazards such as collapses, unstable slopes, and landslides before and after the earthquake, as shown in Figure 5. The area with a relatively small increase in the number of collapses is the VI seismic intensity zone, which is only 9%. However, there is basically no increase in geological hazard points such as collapses, unstable slopes, and landslides before and after the earthquake.

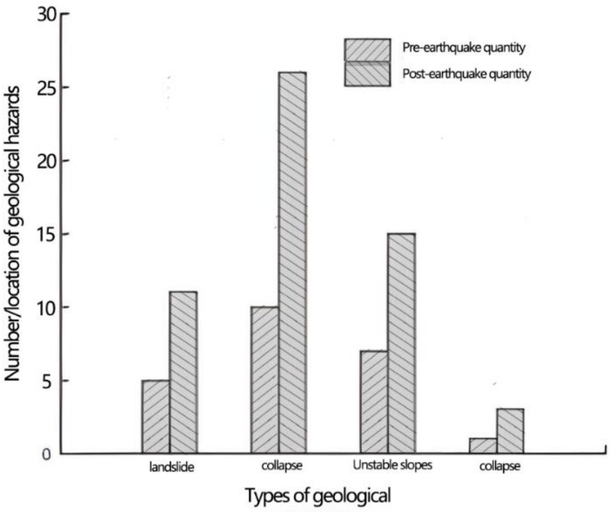

Figure 3: Comparison Results of the Number and Severity of Geological Disaster Points in Different Seismic Intensity Zones

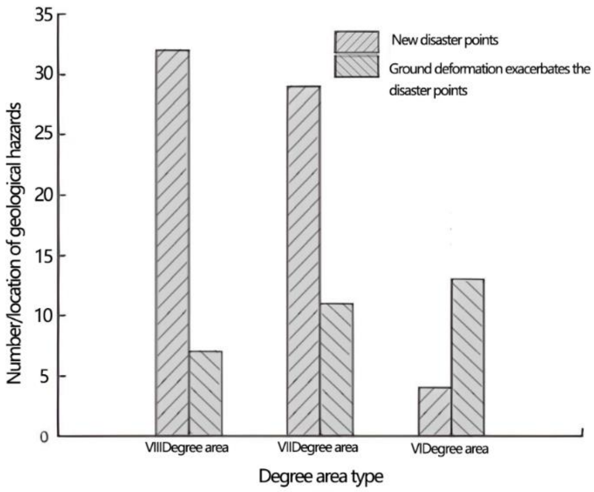

Figure 4: Change trend of various geological hazard points in VIII seismic intensity areas

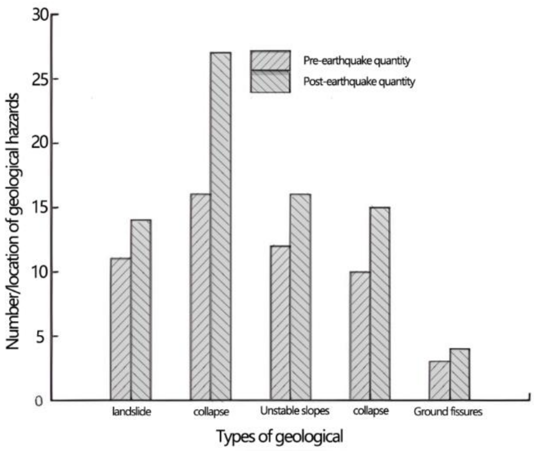

Figure 5: Change trend of various geological hazard points in the VII degree earthquake intensity zone

6. Conclusion

In order to better understand the impact of local earthquakes on geological disasters and provide guidance for the development of seismic prevention measures in the future, the following conclusions are drawn by comparing and analyzing the changes in the degree and quantity of various types of geological disasters in the local area after a certain earthquake:

1) In the slope zone (with a slope of 15 to 40), landslides are prone to geological disasters. When the slope of the area does not exceed 15, the probability of geological disasters occurring is relatively low. But when the slope of a region exceeds 40, geological disasters such as collapse usually occur. The areas with the highest probability and quantity of geological disasters are medium and high mountain areas, slightly followed by deep and medium hill areas, and the areas with flat dams and shallow hills that are basically free from geological disasters.

2) Among various geological disasters, the increase in collapse and unstable slopes (landslides) is the largest. After an earthquake, there are a total of 35 deformation and increased geological hazard hidden points. Small scale is the main scale of increased geological hazard hidden points, accounting for 79% of the total, while large scale and medium-sized scale account for 0% and 21% respectively.

3) The area with the smallest area is the VIII degree area, but the number of potential disaster points in this area has increased by 32, accounting for approximately 50% of the total increase; Next is the I degree zone, where 29 hidden danger points have increased, accounting for approximately 45% of the total increase; The distribution density of geological hazard hidden danger points in the VIII degree area is about 5.4 times that of the I degree and VII degree areas, which are 300 times higher. Different seismic intensity areas have a common point that deformation increase points and new points are mainly landslides and collapses, accounting for over 90%.

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