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При создании логотипа конференции использован рисунок из книги С.М. Флейшмана «Селевые потоки» (Москва: Географгиз, 1951, с. 51).
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Some characteristics of debris flow hazards in mountain urban areas, China

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Некоторые характеристики селевой опасности для урбанизированных горных территорий в Китае

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Селевые потоки наносят ущерб и угрожают безопасности более 100 городов в горных районах Китая, находящихся в 20 провинциях и административных регионах. Из-за высокой плотности населения, концентрации зданий и других особенностей городов, сели часто приводят к тяжелым жертвам и значительным экономическим потерям и серьезно препятствуют экономическому развитию этих городов и прилегающих к ним территорий.

Debris flows have brought damage to and threatened the safety of over 100 cities and towns in mountain areas of China, which are distributed in 20 provincial-level administration areas and special administrative regions. Due to the high population density, high concentration of buildings and other property in cities and towns, debris flows often result in heavy casualties and huge loss of properties and seriously hamper the economic development of the affected cities and towns and their surrounding areas.

1 Introduction

Debris flow hazards occurred in quite a number of urban areas in the world's mountainous countries. Debris flow caused damage to at least 50 cities in the former Soviet Union (Fleishmann, 1978), including Alma-Ata, Ailiwen, Dushanbe, Tbilisi, Bishkek and Ashkhabad et al. There are also serious debris flow hazards in urban areas in many other countries as USA, Guatemala, Peru, Venezuela, Colombia, Swiss, Austria, Italy, etc. Tens of thousands of people were killed during several big debris flows in 1970's, 1980's and 1990's in Peru, Colombia and Venezuela, often with the whole cities totally demolished (Rapp, Li & Nyberg, 1991; Wei, Xie, & Lopez, 2000; Jacob & Hungr, 2005). As a mountainous country, China has a serious problem of debris flow and the disaster situation is rather grave (Tang, Zhou & Wu, 2000). It is of vital importance to analyse the characteristics of debris flow in strengthening the prevention and controlling of debris flows in the mountainous urban areas.

2 Distribution of debris flow

According to recent statistics, 20 out of the 34 provinces, provincial level cities, autonomous regions and special administrative regions in China, accounting for 58.82% of the total in number, have cities or towns with the presence of the debris flow hazards. Over

100 of these cities and towns are the headquarters of local governments at or above the county level (Fig. 1), including such big cities as Hong Kong, Taiyuan, Xining, Lanzhou, Guiyang Lhasa, etc. With reference to historical records, many cities and towns in mountainous areas have suffered from debris flow hazards in a varying degree. For example, from 1950 to 1976 in Lanzhou city, the capital of Gansu, over 300 people were killed in several occurrences of debris flows. According to incomplete statistics, close to 4100 people have been killed by debris flows in the cities or towns in China ever since 1949 (Xie & Zhong, 2000).

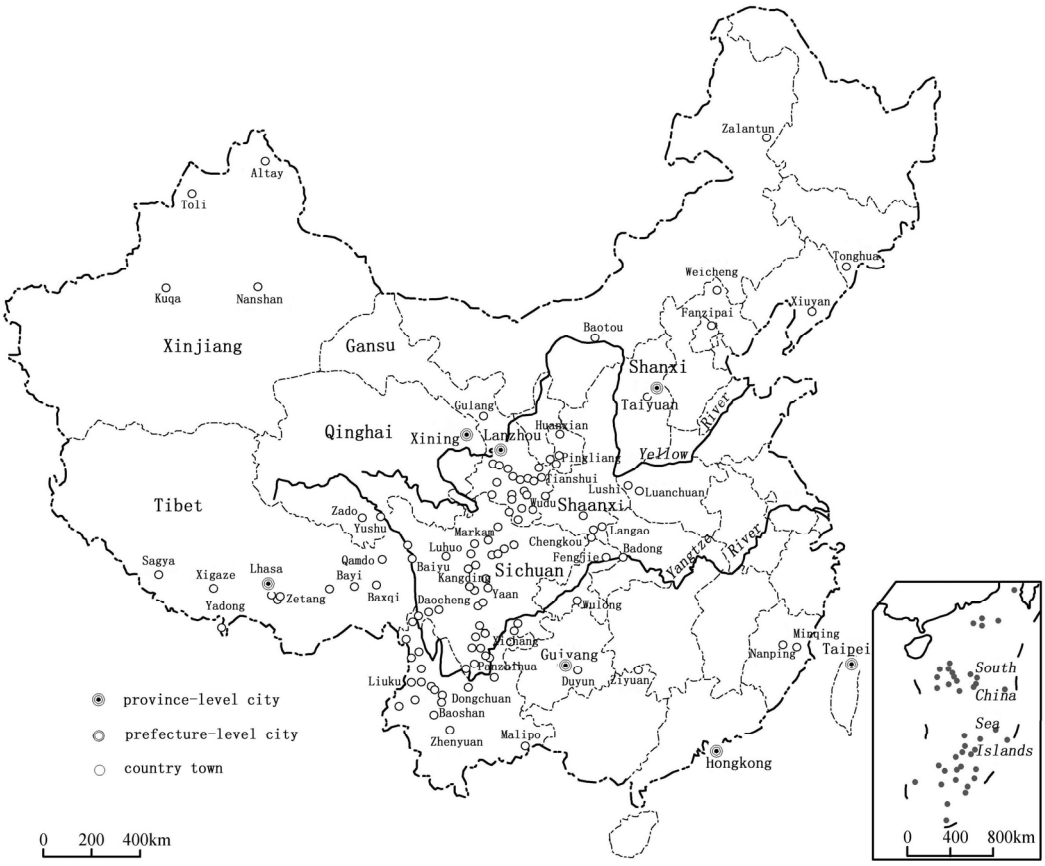

Fig. 1. The sketch of cities and towns in mountain area endangered by debris flow in China.

3 Characteristics of debris flow hazards in mountain urban areas

3.1 Heavy casualties and huge property damages

With the basic characteristics of dense population and all kinds of construction, cities and towns often suffer heavy human injuries and property damage when debris flows occur (Xie & Zhong, 2000). Since 1949, the cities and towns in mountain areas above county level that suffered from debris flow hazards in various scale amounts up to 107 (Table 1). Due to dense population in cities and towns, the debris flow hazards frequently caused death or injuries in great number. Only according to the incompletion statistic data collected in the recent 200 years, the number of casualties resulted from debris flows reached over 4210 in cities and town of China, among which 4100 people got killed (Cui, Wei & Xie, 2003).

The property damage is also serious from the debris flow hazards. On August 4, 1996, the debris flows from three gullies at Taiyuan, the capital of Shanxi, destroyed the residential buildings up to 3 455 and the direct economic losses added up to 286 million dollars. Usually the debris flow hazards could cause damage in millions dollars just for one time and in some cities the direct economic losses were up to 100 million dollars or more. The indirect economic loss is very difficult to calculate. This is one of the main reasons that it is very difficult to develop economy in the mountainous regions which are harassed by debris flow hazards.

3.2 Debris flows are always with high occurrence rates

Debris flows endangering cities and towns in mountainous area mostly originates in the river basins with areas arranging from several to scores of square kilometres, some even smaller than 1 square kilometre and with length of the gully mostly from hundred meters to several kilometres. Mostly with a big gradient of slope at 10% to 40%, the debris flow route is short along the valley and it breaks out very suddenly with huge destructive force. Therefore, it has the feature as dashing fiercely and greater wreck strength, so the occurrence rates of the debris flow is very high.

Table 1. County towns and cities endangered by debris flow in mountain area of China since 1949

Provincial administrative region	Towns and cities suffered debris flow hazards
Sichuan	Kangding, Luding, Danba, Derong, Baiyu, Daocheng, Mao, Barkam, Jiuzaigou, Jinchuan, Songpan, Heishui, Xiaojin, Xichang, Dechang, Ningnan, Xide, Puge, Panzhihua, Yaan, Baoxing, Hanyuan, Gaoxian
Chongqing	Fengjie, Old Yunyang
Yunnan	Dongchuan, Nanjian, Yunlong, Liuku, Gongshan, Fugong, Malipo, Lianghe, Baoshan, Zhenyuan, Lanping, Deqin, Weixi, Qiaojia
Guizhou	Guiyang, Duyun
Tibet	Lhasa, Zetang, Bayi, Baxqi, Bomi, Qamdo, Xigaze, Longzi, Yadong, Sagya, Markam, Zhag'yab
Shaanxi	Ningshan, Huangling, Foping, Pingli
Gansu	Lanzhou, Wudu, Wenxian, Dangchang, Xihe, Lixian, Liangdang, Kangxian, Zhuoni, Zhouqu, Diebu, Tianshui, Wushan, Gangu, Qingshui, Zhangxian, Pingliang, Chongxin, Zhuanglang, Huanxian, Zhenyuan, Kangle, Hezheng, Gulang
Qinghai	Xining, Yushu, Zaduo
Xinjiang	Altay, Toli, Kuqa, Nanshan, Urumqi, Fukang
Shanxi	Taiyuan, Baode
Henan	Loushi, Yiyang, Luanchuan
Inner Mongolia	Baotou, Zhalantun
Liaoning	Xiuyan
Jilin	Tonghua
Hubei	Badong, Xingshan
Guangdong	Shenzhen
Guangxi	Ziyuan
Fujian	Minqing, Nanping
Hebei	Weicheng
Taiwan	Taipei
Hong Kong	Kow Long

Constructed along the mountain slopes, Altay in Xinjiang has been harassed by debris flows from Jiangjungou, Yuanyigou and other gullies for over 10 times since 1949 and each time a great deal of damage was brought about at various scales. Especially it was true in the year of 1959, 1984, 1989, 1990, 1993, the occurrence rates at 100%. On the basis of the incomplete statistic data from 1951 at Lanzhou, Tianshui, Pingliang, Wudu, Wushan, Zhuoni, Lixian, Huanxian, Dangchang, Wenxian and Diebu of Gansu, the debris flow happened 209 times, 153 times of which turned out to be a disaster. The average occurrence rate of the debris flow is up to 73.2%.

3.3 Debris flow hazards are usually confined within part of the cities and towns

Confined in the circulation and accumulation area of debris flows, debris flow hazards are mostly at the lower position of the city. Therefore, the hazards are only confined to the debris flow gully bed, its two flanks and deposition fan (Figure. 2). Nevertheless, in some case the debris flow might destroy the entire city (Figure 3), even though this case just happened at the extremely low possibility. For most of the city, the debris flow mainly causes the direct hazards in partial locations. Compared with the earthquake or flood, the hazards scope is little bit smaller from the debris flow.

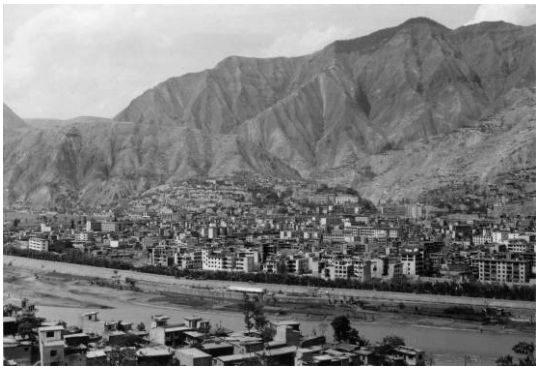

Fig. 2. More than 10 debris flows endangered Wudu city in southern Gansu, which suffered dozen debris flow hazards since the year of 1368

Fig. 3. The Wasi Gully broke out debris flow in June 15 and July 7, 1995 respectively, most of the Kangding city in Sichuan was destroyed, the total economic losses reached 500 million dollars.

4 Seriously restraining the economic development of the cities and the neighbouring area

The towns and cities for the headquarters of local governments at or above county level are often the regional centres of politics, economy, culture, transportation, commercial trade. As a result, debris flow hazards not only lead to serious losses for the city itself, they also threaten the social stability and bring about lots of side effects to the neighbouring areas, which hinder regional economic development. For example, Dongchuan in Yunnan was a new industrial city. The average expenses on economic loss, emergency, rescue, hazards renovation charges by debris flows amounted up to 2.5 million per year in the past years, but the total industry output value was about 122.74 million, which made up 2 per cent of the total. The debris flow hazards left a heavy burden for Dongchuan, and greatly restricted the development of the city, and at the same time, the economic development in its affiliating towns was also affected seriously (Tang et al., 2000).

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