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20世纪以来中国的大型滑坡及其发生机制

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摘要 中国是一个滑坡灾害极为频繁的国家，其中大型和巨型滑坡占有突出重要的地位，尤其是在中国的西部地区，大型滑坡更是以其规模大、机制复杂、危害大等特点著称于世，在全世界范围内具有典型性和代表性。收集20世纪以来发生在中国大陆的典型大型滑坡灾害实例，并重点对其中的11例进行深入的分析和讨论；这些大型滑坡涉及到不同的地质环境条件和坡体地质结构，具有不同诱发机制和触发因素。分析结果表明，中国大陆大型滑坡发育最根本的原因是具有有利的地形地貌条件，约80%的大型滑坡发生在环青藏高原东侧的大陆地形第一个坡降带范围内。同时，该地区也是世界上板内构造活动最为活跃的地区，其地壳内、外动力条件强烈的交织与转化，促使高陡边坡发生强烈的动力过程，从而也促进大型滑坡灾害的发育。强震、极端气候条件和全球气候变化构成大型滑坡发生的主要触发和诱发因素：中国南方暴雨强度达到200～300 mm/d时就易于触发大滑坡的发生；中国西北地区春季冻结层的融化，也是大规模黄土滑坡发生的诱因。近年来全球气候变化导致气温上升、雪线上移、冰川后退、冰湖溃决，也都成为特定地区大型滑坡灾害发生的诱发和触发因素。另外，70%以上大型滑坡发生与人类活动有密切的关系。滑坡机制分析结果表明，中国的大型滑坡通常具有复杂的生成机制：总的来看，大型滑坡发生的岩土介质主要有以下3类，即岩质滑坡、土层滑坡和松散堆积层滑坡。除松散堆积层滑坡，前两者都涉及复杂的演化机制及过程，其典型的地质－力学模式包括：滑移－拉裂－剪断“三段式”模式、“挡墙溃决”模式、近水平岩层的“平推式”模式、反倾岩层大规模倾倒变形模式、顺倾岩层的蠕滑(弯曲)－剪断模式等。每一类模式都具有其对应的岩体结构条件和特定的变形破坏演变过程。通常大型岩质滑坡的发生一般都伴随有滑动面上“锁固段”的突发脆性破坏，“锁固段”在岩质边坡的变形控制和稳定性机制中具有重要地位，也是边坡地质灾害评价与控制的关键。实践结果表明，查明边坡(滑坡)变形破坏的地质力学模式是滑坡地质灾害防治的基础所在。

关键词 边坡工程；大型滑坡；实例研究；发育规律；形成机制

分类号

LARGE-SCALE LANDSLIDES AND THEIR SLIDING MECHANISMS IN CHINA SINCE THE 20TH CENTURY

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Abstract

The landslides occur frequently in China. In particular，large-scale landslides are dominant and extremely important. In West China，the large-scale landslides are notable for their scale，complex formation mechanism and serious destruction，which are typical and representative in the world. Data were collected from some typical large-scale landslides occurred in mainland of China since the 20th century. Among these cases，nine landslides were comprehensively analyzed and discussed. These cases represent different geological conditions，different triggering mechanisms and induced factors. This study shows that the fundamental cause for large-scale landslide in China is due to the topographical and geomorphological conditions. About 80 percent of large-scale landslides

were found in the first slope-descending zone of the mainland topography around the eastern margin of Tibet plateau. Moreover，this area is the most active area of the plate tectonic activities. The intensive interactions between the endogenic and epigenetic geological process cause serious dynamic change of the high steep slope，which are resulted in the development of large-scale landslides. Strong earthquake，extreme weather conditions and the global climatic change are the main triggering factors of large-scale landslides. In South China，it is easy to trigger large-scale landslides when storm causes 200–300 mm/d of heavy rainfall. In Northwest China，the thawing of the frozen layer in spring is the main cause of large-scale landslides in loess region. In recent years，global warming causes the temperature to rise，snow line to shift，glacier recession and glacier lakes to collapse. These factors are also the triggering factors of large-scale landslides in some areas. In addition，the causation of more than 70 percent of large-scale landslides is closely related to the human activities. Detailed analyses of the cases show that the mechanisms of large-scale landslides in China are complex. The large-scale landslides can be summarized into three types：rock landslides，soil landslides and landslides in debris. The typical geomechanical models of large-scale landslides in rocks are shown as following：the “three sections” model(i.e. sliding-tension cracking-shearing)，“retaining wall collapse”model，“horizontal-pushing”model in horizontal strata，large-scale toppling model in anti-dip strata，and the creep-bending-shearing model，etc.. Each model corresponds to some specific rock structure conditions and deformation processes. When large-scale rock landslides occur，they are generally accompanied by the suddenly brittle failure of the“locked section”along the potential sliding surface. The“locked section”is extremely important to the deformation control and stability of the rock slope，which is also the key factor for the assessment of slope geohazard and for the development of control methods. It is shown in engineering practice that the correct understanding and using of geological and mechanical model are the fundamental keys for the prevention of large-scale landslides.

Key words slope engineering；large-scale landslide；case study；development rules；formation mechanism

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