《桂林岩溶地质》之九

桂林环境工程地质

● 中国地质科学院岩溶地质研究所

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涂水源　张伯禹　谢代兴　李兆林
韦复才　廖如松　王　珽　卑占崑
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ENVIRONMENTAL ENGINEERING GEOLOGY IN GUILIN

Tu Shuiyuan Zhang Baiyu Xie Daixing
Li Zhaolin Wei Fucai Liao Rusong
Wang Ting Bei Zhankun

Institute of Karst Geology, Chinese Academy of Geological Sciences

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内容简介

《桂林环境工程地质》系根据国家重点科研项目“桂林市环境工程地质”研究报告编写而成。全书共分七章。系统地阐述了桂林市的环境工程地质条件，深入研究了第四系的成因类型、时代和岩性特征，对岩土体工程地质、岩溶塌陷、人工地下洞室稳定、石山边坡和河岸岸坡稳定分别作了论述，并划分了环境工程地质区。

本书可供从事环境工程地质、水文地质、岩溶地质、第四纪地质、城市工程地质、城市规划与建设、工业民用建筑与设计、环境保护工作者及有关大专院校师生参考。

前　言

随着科学技术的发展，人类工程—经济活动日益加剧，对自然环境的影响和破坏也愈来愈大，因此合理地利用环境，判定和缩小地质灾害，已引起世界各国的普遍重视。不少国家已把环境工程地质工作作为国民经济建设中一项不可缺少的前期性基础工作，在地震区、矿区、都市区等不同地区开展了大量环境工程地质工作。

1982年，我国首次召开了环境工程地质专题座谈会，总结了建国以来所发生的重大环境工程地质问题或灾害，提出了开展环境工程地质工作的重要性和迫切性，其中包括对大城市和重点旅游区环境工程地质的研究。

桂林市是一座古老城市，位于热带岩溶区，山青、水秀、洞奇、石美而著称于世，是我国重点旅游城市之一。近年来，市政建设发展迅速，建设规模日益增大，因此总结和研究其环境工程地质条件，探讨各类地质灾害（环境工程地质问题）的形成、发展及分布规律，对场地建筑的适宜性进行预测评价，在实践和理论上都十分必要。

桂林岩溶及岩溶地貌的研究已有久远的历史，近来各单位又作了大量水文地质工程地质勘察与研究，特别是地质矿产部岩溶地质研究所先后对桂林岩溶区开展了地质构造、碳酸盐岩、岩溶地貌与洞穴、岩溶水资源和环境水文地质等专题研究，所有成果，为桂林市环境工程地质研究奠定了基础。

在研究桂林市环境工程地质过程中，得到了中国科学院贵阳地球化学研究所、广西农学院、桂林地区地质队、地质矿产部水

文地质工程地质研究所、中国有色金属总公司地质矿产研究院等协助完成了有关勘探试验，在此表示感谢。

本书是首次开展岩溶地区城市环境工程地质研究的成果总结，有不妥之处，望读者批评指正。

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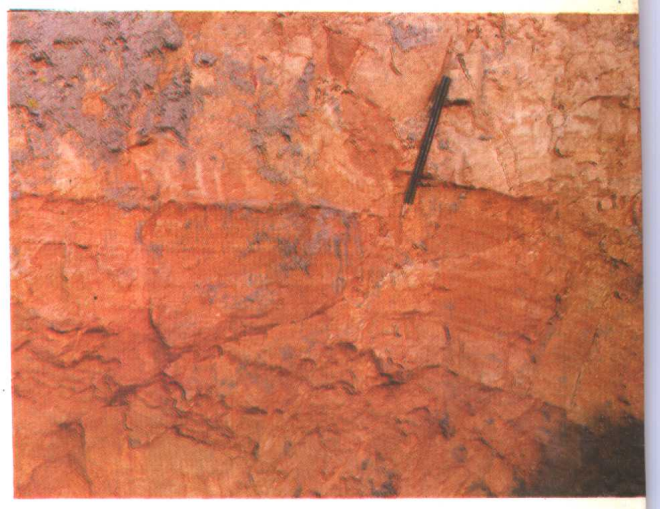

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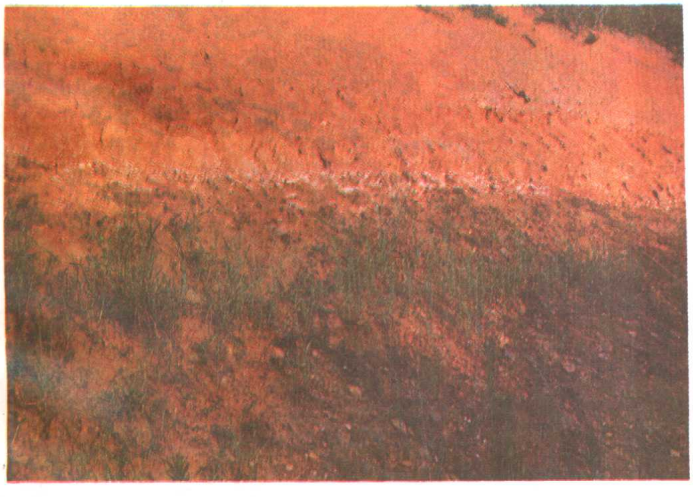

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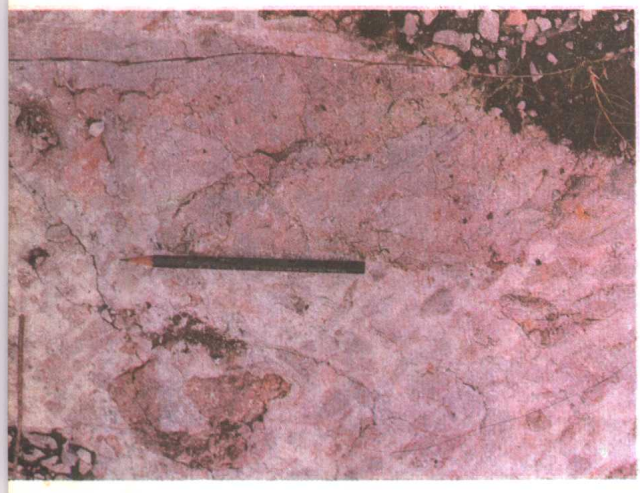

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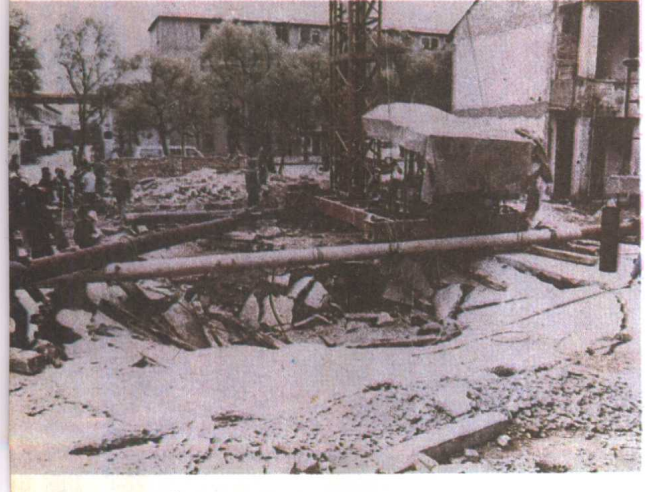

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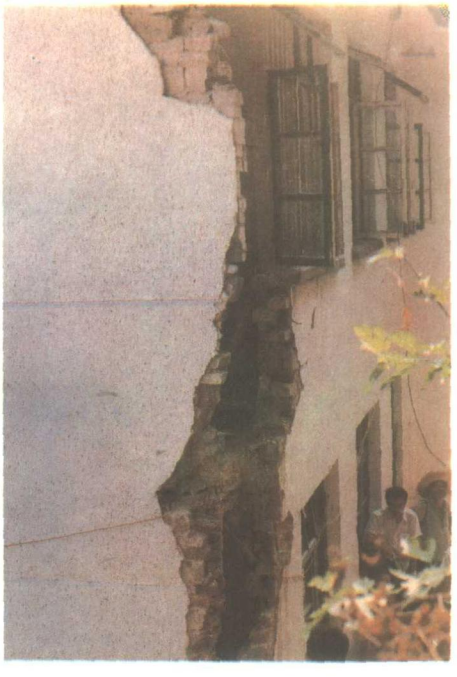

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Abstract

Guilin City is situated in northeastern Guangxi, in the Lijiang River valley basin. The ground elevation of the basin is 145—160 m and the elevation of the mountainous areas surrounding the basin is 400—900 m. The strata in the city are mainly represented by Middle Devonian-Lower Carboniferous carbonate rocks. Only on the margins of the basin are small amounts of clastic rocks exposed. Tectonically the city belongs to the northern side of the arc apex of the Guilin arcuate structure of the Eastern Guangxi meridional tectonic belt, where folds are gentle and fracture structure is well developed owing to polyphase tectonic activity. There are mainly three sets of fracture: the NNE-NE set, the NW set and the near-E-W set. Guilin is a famous karst region in China. There karst of carbonate rocks is well developed, and there are many large-scale karst caves, forming a landscape of peak clusters and peak forest on the ground surface; while at depths of 10—100m caves and karst fissures are also well developed and locally karst passageways are formed besides karren with sharp relief that are formed on the surface bedrocks.

The groundwater may fall into three types: karst water, pore water and fissure water. The pore water mainly occurs in alluvial sand gravels, whereas clays or clayey gravels contain perched water. Karst water is of the widest distribution. It is rich but not evenly distributed. In places it concentrates to form runoff zones; covered by impermeable strata such as clays it tends to occur as confined water. Groundwater is mainly of HCO_3-Ca and HCO_3-Ca·Mg types, with low mineralization. The corrosive CO_2 (89%) is less than 5 mg/l and the pH value mostly ranges between 6.5—7.5%. The

water quality is good. Only in a few places is the industrial or domestic waste water corrosive on concrete.

In the city of Guilin about 60% of the area is covered by alluvial, alluvial-pluvial, eluvial, slope wash-pluvial and lacustrine-swamp sediments as well as artificial accumulation. The lithologies are clays, loams, sandy gravels, clayey gravels and debris-and gravel-bearing clays. The thickness is generally 5—20 m, partly up to 20—30 m and locally more than 30 m. According to their engineering-geological properties, the sediments may be classified into general soil, red clayey soil (red clay), soft soil and artificial accumulation.

(1) General soil is lithologically represented by loams, sandy gravels and clayey gravels. It has relatively stable physical-mechanical properties, is weakly to intermediately compressible, and has a high load-carrying capacity, which is more than 1.2kg/cm² for loams and up to 1.8—3.0kg/cm² for sandy gravels and clayey gravels. So it may serve as a good construction site.

(2) Red clayey soil was formed by "lateritization", i. e. leaching and migration of carbonate minerals and hydrolysis of silicate minerals, in a wet and hot environment. The clay grain content is more than 50%, and minerals are mainly kaolinite, illite, montmorillonite, vermiculite and goethite. It is intermediately to weakly expansible according to its mineral and chemical composition and the distribution and content of F^{+++}. Its moisture content and compressibility increase and the mechanical strength decreases with depth. Its loadcarrying capacity is up to 1.5—2.2kg/cm² in a hard or hard-plastic state, but is less than 1/2 the figure in a soft-plastic or flowplastic state.

(3) Soft soil includes silty clays of lacustrines-wamp facies and soft soil in karren. It is intermediately to strongly compressible, with a low strength, the loadcarrying capacity being generally less than 1 kg/cm². Its engineering-geological properties are very poor.

(4) Artificial accumulation is soft, with a low strength. It is not advisible to use it as foundation of construction.

Earth caves and karst collapses are widespread and numerous in covered karst areas of Guilin City. That is an outstanding environmental

engineering-geological problem and is very harmful to urban construction and industrial and agricultural production. Karst collapses were recorded as early as 1498 A. D. (in the Ming Dynasty). They are mainly concentrated in the peak forest plain and peak cluster valley area where soil overburden is thin (less than 5 m), the groundwater table is low and karstification of carbonate rocks is strong. The collapse dolines in the area make up over 93% of the total number in Guilin, while in other areas they are only present sparsely. The karst collapses can be divided into natural ones and those induced artificially (including those induced by pumping groundwater, overloading or vibration and drainage of waste water). Among other things, those induced by pumping groundwater account for about one half of the total number of the collapses. This suggests that the exploitation of groundwater is an important factor for collapses, so much importance should be attached to. The collapses induced by other artificial factors, though few in number, cannot be neglected either because they mostly happen near factories or along the traffic lines and are most harmful. The application of the "step-by-step discriminatory method" in the quantitative predition of karst collapses not only makes it possible to predict the time and space of the collapses to be produced after the various factors affecting collapses are ascertained, but also is of important significance for making a regional prediction and evaluation of collapses.

A great number of artificial underground caves were excavated in karstified mountains in Guilin. In general, the wall rocks can be divided into the stable type and the basic stable type, and the instability and failure only occur in local place of a few caves. Three types of failure may be distinguished: local rockfall and tensil failure, shear failure and compound failure. The failure mechanisms are mainly controlled by the structures of rock formations, geological structure, karst and hydrogeological conditions. The local rockfalls occur extensively but on a small scale, the tensile failure mainly takes place in the caves where there are limestones with clay-gouged intercalations or thinbedded carbonate rocks, especially the caves with a large span (greater than 10 m). The shear failure and compound failure mainly happen in the cave sections with argillite and loose deposits. They are large in scale and need treatment of complete lining. The seasonal change

zone of groundwater is the locus of karst development, where large karst caves usually originate when influences of other factors are present, thus destroying the stability of the artificial caves and causing the instability and subsidence of the cave floor.

The collapses of karst stone mountains are one of the important environmental engineering-geological problems, to the detriment to the urban construction and personal safety. Stone mountain collapses can be divided into two types: overturn fall and disperse fall (rolling stone). The former type is broad in scale, being generally more than a few dozens to a few hundreds of cu m, but there are only a few occurrences. On the other hand, the latter is small in scale, being generally only a few cu m or even smaller, but it is widespread and tends to happen suddenly. Therefore, investigation and treatment should be made before various structures are consstructed near the hills.

Landslides mainly occur on the mountain slopes made up of clastic rocks. Weathered loose layers and slope washes on the slopes slip down along the bedrock surface. The area of a single landslide may attain a maximum of 500×200 m. In recent years, as stones are excavated in carbonate areas, landslides have also often happened along the excavation surface. Of these the Yegoushan landslide (October 29, 1986) is a larger one, the volume of the landslide mass being up to more than 1600 cu m.

In general, the banks of the Lijiang River in the city of Guilin proper are stable, and only in the Tuemu-Huziyan reach is the bank failure serious, destroying the cultivated land and causing the shelterbelt along the river to be difficult to form. So the reach is a key sector where protection measures should be taken.

According to the geomorphological and engineering-geological conditions and existing environmental engineering-geological problems, Guilin may be divided into three environmental engineering-geological districts, ten subdistricts and six sections as well as three areas with different degrees of stability, the stable, relatively stable and unstable areas.