《桂林岩溶地质》之三

桂林岩溶与地质构造

中国地质科学院岩溶地质研究所

重庆出版社

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桂林岩溶与地质构造

重　庆　出　版　社

1988年·重庆

责任编辑：王镇寰
封面设计：高仲成
技术设计：聂丹英

中国地质科学院岩溶地质研究所
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重庆出版社出版、发行（重庆长江二路205号）
新华书店经销　重庆新华印刷厂印刷

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开本787×1092 1/16　印张8.5　插页6　字数 167 千
1988年7月第一版　1988年7月第一版第一次印刷
印数：1—1,800

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ISBN 7-5366-0187-5/P·13

科技新书目182—293　定价：3.60元

前　　言

《桂林岩溶与地质构造》是"六五"期间由原地质部水文地质局所下达《桂林地区岩溶发育规律及水文地质、工程地质评价》研究项目之一。研究工作自1982—1985年完成。重点工作地段为桂林—杨堤一带，约1600平方公里，外围工作北至兴安，南达阳朔。

当前，国内外对岩溶发育与地质构造关系的研究，多着重在岩溶形态与构造形迹、近期岩溶与新构造运动的关系上，而对于从时间上和空间上全面论述一地区岩溶发育与地质构造的关系则感欠缺。笔者认为：地质构造是岩溶发育的重要条件之一，它在空间上控制着岩溶洼地、洞穴的成生和发展；在时间上控制不同岩溶地貌发育阶段的特征具有相应的时序关系。为弥补上述的欠缺和阐明这些关系，除从形态、形迹的描述外，还必须补充有关岩溶岩系(建造)的研究；除从近代岩溶、构造的分析外，还必须加强对古代岩溶、构造的分析。也就是说，必须把改造与建造结合起来分析构造与岩溶发生、发展的全过程，只有这样，才能更好地阐明岩溶发育的规律性。

根据上述指导思想，研究工作重视有关建造的分析，重视建造、改造、形态等成因联系的探索，取得主要成果如下：地层方面，在前人已确定的泥盆纪、石炭纪地层的基础上，新发现了中生代晚三叠世及晚白垩世的岩溶沉积、堆积。地质构造方面，在前人工作的基础上，进一步完善区域构造格架的建立和地质构造发育阶段的划分，并对区内碳酸盐岩构造岩作了初步系统的研究，进行了成因分类；又将其中受到岩溶交代改造作用的构造岩划分为岩溶交代改造断裂构造岩。岩溶与构造关系方面，通过调研岩溶堆积体381处、岩石薄片鉴定127件、微体化石鉴定 157 块等资料的分析，初步建立各期岩溶岩系（建造）的概念；并以此为据，

进一步从时、空关系上，探讨了地质构造与岩溶地貌发育的时序关系；地质构造控制岩溶洼地、洞穴发生、发展的演化规律。

通过研究工作，总结岩溶地区开展岩溶与地质构造关系的研究，其有效方法可归纳为：从分析构造形迹入手，建立构造发育阶段史；同时研究各相应阶段可能形成的岩溶岩系（建造）的特征及其所反映的地貌环境；用成因联系的观点，探讨岩溶与地质构造发育的时、空关系。

由于本书中有关岩溶地质问题的分析，主要是采用地质学方法，并侧重在构造与岩溶建造资料的分析基础上，因此，虽同时考虑了一些可溶岩岩性和水文地质方面的因素，也难免会有某些不全面之处，欢迎读者批评、指正。

本书第一章由邓自强、张美良执笔；第二、三章由林玉石、刘功余执笔；第四、七、八章由邓自强执笔；第五章由邓自强、魏志民执笔；第六章由林玉石、张美良执笔。最后由邓自强统一审校。

作者

1986年12月

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KARST AND GEOLOGIC STRUCTURE IN GUILIN

(Abstract)

Geological structure is one of the important conditions of karst development. In space it controls the formation and development of karst depressions and caves, while in time it controls the characteristics of different stages in the development of karst landforms. These regularities usually can find expression in the history of geological development, hydrogeological conditions of different stages and characteristics of karst rock series (formations).

I. Stratigraphy

The exposed strata in the area mainly include the Paleozoic, Mesozoic and Cenozoic. Of these, the strata from the Middle Devonian Donggangling Formation to the Lower Carboniferous of the upper Paleozoic consist mainly of neritic carbonate deposits, 4,622 m in thickness. The Upper Triassic and Upper Cretaceous strata of the Mesozoic are represented by continental karst deposits and accumulative conglomerate and silty mudstone, distributed sporadically. On identification, the Upper Triassic contains a fossil assemblage of spores of pteridophytes and pollen of gymnosperms. The Cretaceous contains a fossil assemblage of charophytes, ostrapods and sporo-pollen, and age determinations by the Ru-Sr method on mudstone gave an isotopic age of 145±5 Ma, which can be used for reference. The Tertiary silty mudstone occurs sporadically and is found to contain foraminifer fossils. The Quaternary mainly comprises alluvial, diluvial and flood-plain deposits and glacial tills, 20—60 m in thickness.

I. Geological Structure

Geological structure is classified into basement structure and cover structure. Basement structure is marked by NE-trending synclinoria composed of the lower Paleozoic, while cover structure is made up of the Devonian and Carboniferous, with Indosinian N-S-trending arcuate structures as the main framework, which are superimposed by early Yanshanian NNE-trending Neocathaysian structures and late Yanshanian NW-trending structures. The fractured tectonites formed by structural movements in different stages may be classified into five types and nine subtypes (see the Table of the Classification of Carbonate Tectonites in Guilin). The protoliths of these tectonites are all carbonate rocks. Owing to the activity of karst water in the late stage, the cementing material is often replaced by calcareous and argillaceous substances, thus forming metasomatic tectonites. The study of tectonites in karst areas is of practical value and scientific significance for understanding the nature of the deformation of the protoliths, tracing the history of structural activity and relating structural activity to karst development.

Classification of Carbonate Tectonites in Guilin

Mode of action of crustal stress	Type	Subtype
Tensile and shear	Cataclasite	Cataclasite
Compressive	Cataclasite	Reticulate cataclasite
Tensile	Breccia	Breccia
Compressive and shear	Breccia	"Molasse"
Compresso-shear and shear	Porphyroclasite	Coarse porphyroclasite
Compresso-shear and shear	Porphyroclasite	Fine porphyroclasite
Compresso-shear and shear-compressive	Mylonite	Conglomeratic mylonite
Compresso-shear and shear-compressive	Mylonite	Mylonite
Certain T-P conditions	Recrystallized tectonite	

Although few systematic studies were made on neotectonic movements, a synthetic analysis of available data has shown that differential uplift predominated in the Tertiary, with an uplift amplitude of about 100—150 m. The uplift amplitude in the peak cluster area is a bit larger than in the plain area. As regards the nature of the movements, up to now there has been no evidence of block movements, nor indications of fold movements, only small-scale NNE-trending fractures being seen locally.

Quaternary tectonic movements were dominated by intermittent uplift, with an aggregate uplift amplitude of 40—60 m, which is manifested by conspicuous layering of the caves and terraces in Guilin. The layers are the products of different stages. Although there is a difference in uplift amplitude between the peak cluster area and the plain area, three layers may be roughly distinguished, occurring at elevations 180—200 m (early Oligocene), 150—175 m (middle Late Oligocene) and 130—150 m (Holocene) above sea level, respectively.

II. Relations between Geological Structure and Karst Development

1. Karst rock series (formations)

In the study of the relations between structure and karst development, previously emphasis was laid on analyses of structural features and karst features. Undoubtedly, this shows the spatial relations between structure and karst, but for lack of material grounds, it is difficult to reveal their internal relations and establish the stages of karst development. For this reason, while analysing the relations between structure and karst we have systematically studied deposits in different stages of karst development in order to reconstruct karst landforms in different stages. According to the special textural, structural and association characteristics of these deposits, their usual development in negative landforms such as karst fissures, caves and depressions and their unconformable contacts with bedrocks, we call them "karst rock series (formations)". Through field investigations, we have found 360 outcrops of karst rock series, consisting mainly of solution calcareous conglomerate, calcareous mudstone and calcareous-clastic limestone. According to the lithology, stratigraphic succession, contact relationships, mode of occurrence and different fossil assemblages, the rocks are preliminarily classified into late Hercynian grayish-white karst rock series, Indosinian grayish-green karst rock series, early Yanshanian white karst rock series, late Yanshanian red karst rock series and Himalayan grayish-yellow karst series.

Practice shows that the reconstruction of the environment of the formation of these rocks through analyses of the rock series can provide reliable material grounds for the study of paleokarst.

2. Depression- and cave-controlling structure

Through the study of the above-mentioned geological structure and karst rock series and the analysis of the developmental characteristics of karst depressions and caves, it may be seen that they have a genetic connection with respect to their generation and development, reflecting particular relations in time and space. These relations show that karst depressions and caves are the results of corrosion, erosion, reworking, deposition and remolding of carbonate rocks by karst water along the fractures and fissures of carbonate rocks. The regularities are mainly indicated by the orientation, equidistance, inheritance, layering and morphological relations of the karst depressions and caves.

(1) **Orientation** Karst depressions and caves generally developing along zones of lower-order, associated and/or derivative fractures that have undergone multiple tenso-shear—shear-tensile activity and remolding are poor in healing degree and have a good interconnection. Analysis indicates that the NWW-and NNW-trending fractures were subjected to tenso-shear—shear-tensile superimposition and that the NNE- and NEE-trending fractures underwent tenso-shear remolding in the late stage though they are mainly of compresso-shear origin. They are favourable loci for the development of karst depressions and caves in Guilin. The karst depressions and caves controlled and generated by these fractures exhibit a distinct orientation: trailing NW- and NE-trending fractures and fissures, the karst depressions often occur in the "lambda", zigzag, elongated, "S" or "X" forms; while karst caves are tortuous, extending in the linear, branched or treillis forms.

(2) **Equidistance** The regularity of the equidistant distribution of fractures and fissures has been well known. Accordingly, the karst depressions and caves controlled by these fractures and fissures are also equidistant to a certain degree. For example, strictly controlled by NE-trending fractures and their associated NW-trending fractures and fissures, the depressions north of Hankuang, Lingui, are arranged equidistantly at a spacing of 600—700 m in a NE direction. The caves in Mount Maomaotou (Mount Guangming), Guilin, are also controlled by NE-trending fractures and their associated NW-and NE-trending fractures and fissures

and are in general arranged equidistantly at a ca. 400 m spacing in a NE direction.

(3) Morphological relations The morphologies of karst depressions and caves are usually controlled by fracture and fissure structures of differing nature and attitudes and are often described in plan or section. For example, in plan the morphologies of depressions may be divided into the polygonal, elliptical (rounded), elongated and irregular shapes, and in cross section there are shallow-dish, "V" and "U" shapes, or according to the internal structure the morphologies may be divided into the simple, overlapping, hum and overlapping-hum types. No matter which scheme of classification, their morphologies all have a certain internal connection with structural features. For example, the karst depressions developing along the axial regions of gentle anticlines and synclines tend to trail the NE and NW sets of fractures and fissures and thus assume elongated shapes; those developing along fractures or bed-crossing fissures are usually polygonal, elongated or paternoster-shaped, those developing along the intersection loci of fractures or fissures are rounded, elliptical or irregular; those developing iollong bedding planes or intraformational fissures are elliptical.

Most of the original cave system has not been completely preserved due to multiple remolding and destruction of the caves and filling of deposits in them, so the cave system can be only analysed according to the residual local morphologies. In plan, restricted by cave-controlling structures, the morphologies of the caves may fall into the simple type (rectlinear, irregularly linear and zigzag shapes) and the complex type (feather, branched and net shapes). In cross section, the morphologies of the caves developing along tensile fractures and fissures are irregular; those developing along compresso-shear and shear fractures and fissures are fissure- and valley-shaped; those developing along the intersection loci of fractures and fissures are hall-shaped; those developing along bedding planes are flat and elliptical; those developing along bedding fissures and intraformational fissures are key hole-shaped, zigzag and rectangular. In longitudinal section, the morphologies are commonly stepshaped. As the slope of the cave bottom in different cave segments is different, the gradiant is also different and the main stages of development are not the same either.

(4) Inheritance The karst morphologies formed in a particular stage was usually related to the structures developing at that time; that is to say, the development of karst depressions and caves usually depends on the multi-stage evolution of fracture and fissure structures, and their morphologies and structure also exhibit multi-stage features. The analysis of the regularity of depression- and cave-controlling structures is bound to involve the process of generation and development of these depressions and caves. Except for those new-born depressions and caves in various stages, the regularity finds expression mainly in late-stage inheritance and remolding of the preceding characteristics of development. For example, from above downwards, the depressions become large and their structure changes from the simple to the complex and then back to the simple. This indicates that with stage-by stage uplift of the earth's crust, the high-level depressions generally took shape earlier, which are mainly those of the simple type, and that the lower-level depressions were characterized by inheriting development in the late stage, in which there were often hums or small depression and funnel swarms, forming hum- or overlapping-type depressions. Afterwards, when the earth's crust was in a relatively stable state for a long time, the morphologies of the depressions again became simple.

The inheritance of cave development mainly finds expression in the development from karst fissures in the early stage to karst caves in the late stage. Its space-time model is obviously manifested in the cave system of incised vertical caves or storeyed caves (characterized by a combination of vertical and horizontal caves). In subhorizontal valley-shaped caves, marks of horizontal flow channels of various ages are often seen on the cave walls. This reflects inheriting development of the cave corridor in a particular period of time under the conditions of no vertical circulating water flow, and also implies that as the rate of intermittent uplift of the earth's crust roughly corresponds to the corrosion (erosion) rate the cave corridor was incised stage by stage.

(5) **Layering** As the crustal movements of different stages and nature controlled base levels of corrosion and erosion of different elevations in different stages, the spatial combination of karst morphologies is bound to show the characteristics of layering at different elevations. According to the statistics of the elevations above sea level of the bottoms of 1, 204 depressions in the Guilin-Yangti area, the peak values are about 330-380 m, 230-280 m and 180 m respectively; according to the elevations above sea level of 456 horizontal caves, the peak values are about 300-330 m, 240 m and 170 m respectively. The peak values of both statistics are essentially comparable though there is a slight difference. Besides, there are deposits of Late Cretaceous karst rock series (formations) in some high-level depressions

and caves at an elevation of over 300 m above sea level, while corroded-incised karst rock series are mostly observed in middle- and lower-level depressions and caves. This indicates that they were formed by stages. On this basis, three layers may be largely distinguished in the area in relation to the karst morphologies, i.e.: (1) the layer with an elevation of greater than 300 m above sea level, mainly formed in the Mesozoic; (2) the layer with an elevation of 230—280 m, mainly formed in the Tertiary; and (3) the layer with an elevation of 140—180 m, formed in the Quaternary. As the intermittent uplift movements were pronounced in the Quaternary, the third layer may be further divided into three sublayers, which are the products in different times of the Quaternary.

3. Time sequence relationship between geological structure and karst development

According to the data of the above-mentioned structure, formations and karst and from an analysis of their genetic and time-space relations, it may be seen that different structural stages controlled different stages of karst development, while karst rock series formed in each individual stage of karst development reflect the karst landscapes in that stage. So there is a distinct time sequence relaitonships. The concrete manifestations are as follows; (1) the uplift of the sea basin and emergence of land in late Hercynian time——the stage of karren development; (2) the formation of arcuate fold structure in Indosinian time——the stage of corroded depression development; (3) intense activity of the NNE-trending Neocathaysian system and the NW-trending fractures in Yanshanian time——the stage of peak cluster-depression (valley) development; (4) the predominance of intermittent uplift movements in Himalayan time——the stage of planation of part of peak clusters and forest.

To sum up, there exist a close genetic connection among structure, formations and karst, which finds expression in their spatial distribution and time sequence relationship. Therefore the study of the relations of the above three is a reliable way for the study of the history of karst development.