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To cite this article: Fengying Sun *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **592** 012191

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Karst Landscape and Development Features of the Cambrian Ordovician Period in Huainan Region

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Abstract. Huainan is located at the boundary between north and south of China. Due to its unique geotectonic location and long geological evolution history, Huainan has formed a special karst landform. The karst landscape and karst development process of the Cambrian Ordovician in this area are analyzed from the aspects of stratigraphic distribution, crustal movement evolution and groundwater recharge conditions. It is concluded that large karst caves are developed in the karst multi-shun layer in the study area, in carbonate rocks. The surface development of the joint fissures is mostly filled with calcite, the erosive gully is developed in the concentrated area of the flowing water, and the karst landscape such as the beaded karst is developed near the fault zone.

1. Introduction

Karst landscape distribution and hydrogeological conditions are strictly controlled by stratum, lithology and geological structure. Karst workers at home and abroad have done a lot of analysis and research on the karst development characteristics of carbonate rocks, especially in the southern and northern inland areas of China ^[1-5]. However, as the southern margin of the North China Platform on the north-south border of China, the karst development has its particularity, which is different from the dissolution karst in the south and the structural karst in the inland area of the north. The main reason for karst development in the area is not due to the chemical changes involved in water, but mainly physical factors such as fracture, collapse, and erosion of water. The surface is mostly karst dry valley, dissolved pores, dissolved trenches, caves, and gaps. Karst landscape morphology. Most of the previous studies in this area have been devoted to special studies such as karst water inrush and surface karst collapse in mining areas ^[6-10]. This paper systematically explores the distribution and development characteristics of karst landscapes in the study area, and discusses the regional characteristics.

2. Distribution of karst landscape

The study area is located at the edge of the North China Platform. It is controlled by the deep and large faults in the north and south. The main structural traces are NWW-distributed, and the Dingyuan fault in the south of Shouxian County reaches the Dingyuan and reaches the NNE-oriented fault zone. The fault structure controls the main vein of groundwater runoff and the transmission channel of rainfall recharge. The NWW to the tectonic line and the EW to the stratigraphic formation constitute the distribution characteristics of the karst landscape in the whole area (Figure. 1).





Figure. 1 Distribution map of karst landscape in the study area

The karst development intensity is larger than the fault tipping junction at the intersection of the water-conducting fault. In the section where the fault structure is not developed, the same-level aquifer has a uniform water level line, and the hydraulic connection tends to be close along the rock stratum. The ground and shallow karst of the inverted steep stratum are developed strongly, and a large number of bedding karst collapse pits and karst fissures appear in the rock strata (Figure. 2 A, B).

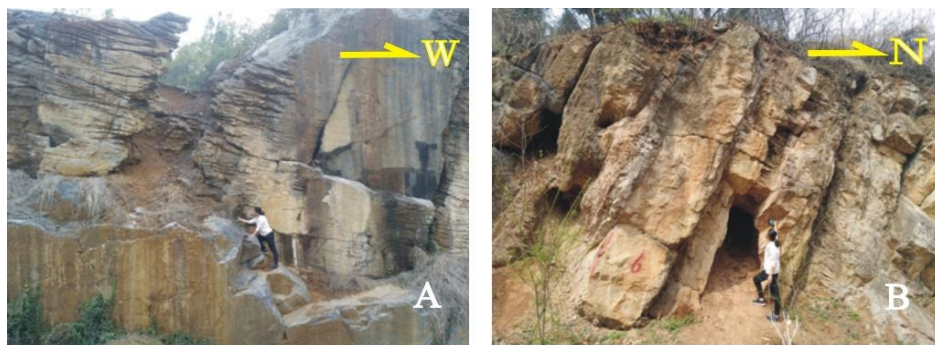


Figure. 2 Karst collapse and sinkhole

Although the thickness of the Ordovician carbonate rocks is large, the limestone and dolomite are distributed interchangeably among many groups. Besides, there are significantly differences between the composition and solubility of the rocks among many groups, which affects the uniformity of karst development in the area. As a result, the geomorphology forms such as pores and caves are dominant (Figure. 3 A, B).

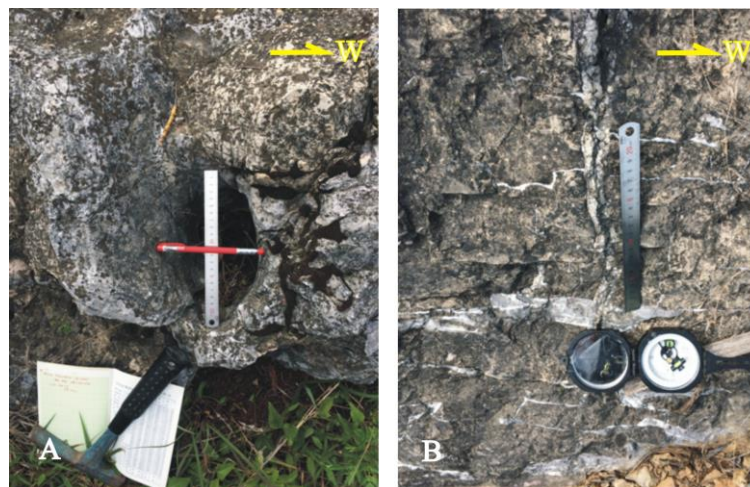


Figure. 3 Calcite veins and karst spring group

The Cambrian Gushan Formation is an irregular interbedded layer of light gray thick siliceous dolomite and khaki thin argillaceous limestone. The former is sturdy and the latter structure is loose and easy to weather. At the junction of hard and soft rock layers, the southern slope of the hill is slashed. Straight layer fissures and sinkholes have developed. The Fascinating Wolf Land Valley is actually formed by karstic geomorphological landscapes in the form of closely-linked network structures. They are developed on the southern slope of Mt. Three Sisters, covering an area of 1 km². Owing to dissolution or corrosion, karstified geomorphological features such as small numbers of stone teeth, lapiaz, corroded groove, light through cave, naturally-grown bridge are developed on the surface of gully crevices.

Precipitation in the area is mainly concentrated in summer and autumn, and continuous rainfall often occurs, and the rainfall is mostly 60mm/d. The development of fissures and gaps in the area is conducive to the infiltration and recharge of atmospheric precipitation, and the capacity of water-bearing is rich in the aquifer. After being blocked by the Cambrian section of the Cambrian Maozhuang Formation and the Shantou Formation, intermittent cooling springs are often formed. The Shungeng Mountain fault runs through the Shantou Formation, the Maozhuang Formation and the Xuzhuang Formation limestone from the east to west, and there are a large number of pores, fissures and karst caves. A number of fault-rise springs are exposed on the south side of the Pakung Mountain (Figure. 4 A, B). The hydrochemical types belong to the HCO₃-Ca·Mg type and reflect the active circulation of karst spring water (Table. 1).



Figure. 4 Karst spring photos

Table. 1 Characteristics of main karst springs in the study area

Spring name	Outcropped strata	Genetic type	discharge (L/S)	temperature (°C)	water chemotype
Han spring	E _{1mz}	fault spring	103.5	20	HCO ₃ -Ca·Mg
Xiyun	E _{1mz}	Erosion spring	4.8	17	HCO ₃ ·SO ₄ -Ca
Zhenzhu	E _{2zh}	Ascending spring	5.6	19	HCO ₃ -Ca·Mg
Yuxie	E _{2zh}	Gravity spring	50.4	17	HCO ₃ -Ca
Yulou	E _{3g}	fault spring	3.8	19	HCO ₃ -Ca·Mg
Xiangshui	O _{1m}	Erosion spring	16.5	17	HCO ₃ -Ca·Na
Laolongyan	O _{1m}	Gravity spring	2.9	16	HCO ₃ -Ca

3. Karst development characteristics and formation mechanism

The basement in the study area is the Archean and Early Proterozoic deep and mid-deep metamorphic rocks and the Mesoproterozoic metamorphic rocks, and then entered the developmental stage of the Early Paleozoic up to 132 Ma carbonate caprock. In the Cambrian, thick limestone was deposited mainly

in the open platform and oxidation environment. The Ordovician was converted from the limited platform to the evaporation platform, and the medium-thick gray dolomite was deposited. However, due to the sea migration and sea receding frequently during the sedimentation process, small sedimentary discontinuities and fresh water mixing and transformation, it is possible to develop sedimentary karst.

The Late Ordovician crust was uplifted, and the carbonate caprock was weathered and leached by nearly 140 Ma after the Silurian and Devonian until the Early Carboniferous. Atmospheric precipitation infiltrates and mixes with the original connate sedimentary water, accelerating the dissolution of carbonate rocks. Since the beginning of the Carboniferous World, the North China platform has declined overall, accepting coal deposits from the Late Carboniferous to the Permian. The organic matter in the coal series produced a large amount of CO₂ during the hydrocarbon formation pyrolysis process, and continued during the diagenetic compaction process. The sedimentary water release caused the Early Paleozoic carbonate rock to be in the vertical dissolution of the buried groundwater acidic groundwater. The Ordovician rock formations in the area are relatively thin, easily penetrated, and continue to develop and dissolve to the Lower Cambrian limestone, so water-induced karst is developed in the carbonate rocks of the coal floor.

Indosinian movement initiated by the Triassic, the North China platform collided with the Yangtze platform, forming the Qinling-Dabie orogenic belt, and the sedimentary caprock of the southern margin of the North China Platform was deformed by folds and formed a NWW thrusting thrust. Fault. In the early Jurassic Yanshan movement, the Pacific plate subducted from the low-angle obliquely below the East Asian continent, and a large number of NNE-to-left translational fracture systems were formed in the area. In the late Cretaceous Yanshan movement, the regional stress was transformed from a compression-torsion force to a tensile force, which caused the early fracture to resurrect and transform into a tensile normal fracture with multi-stage magma eruption. The local anticline or bulge was strongly denuded, causing some of the exposed surface of the Early Paleozoic carbonate rock to undergo leaching. This period lasted nearly 243 Ma, which belongs to the karst period of the fault zone.

Since the late Cretaceous, the tectonic activities in the southern margin of the North China Platform have been relatively stable, and the major tributaries and lakes of the Huaihe River have formed and deposited thinner Cenozoic strata. The Huaihe River flows from the west to the east through the study area. Near the Maoxian Cave, the Bagong Mountain, located on the bank of the river, has aggravated the cracking and erosion of carbonate rocks and formed river water erosion karst due to rapid lateral erosion (Figure. 5).

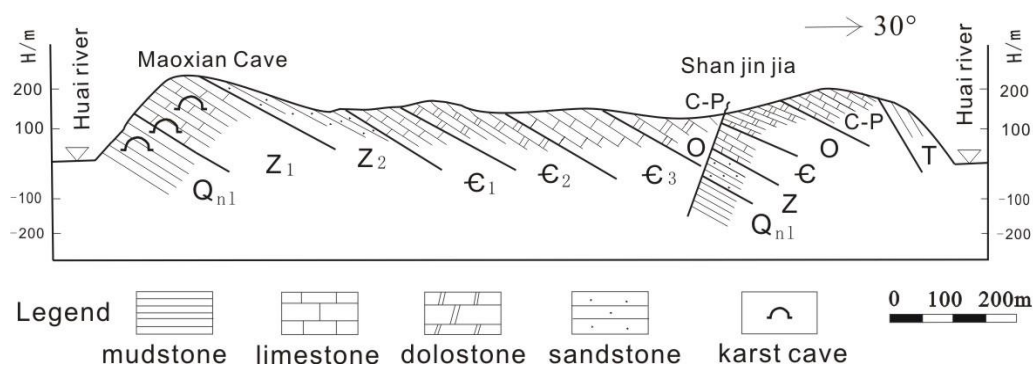


Figure. 5 Erosion karst of Maoxian Cave located on the Huai river concave bank

4. Conclusion

1. The karst groundwater in the area mainly relies on the mountain to receive atmospheric precipitation, with an annual precipitation of 970 mm and an infiltration coefficient of 15.24%. Due to the large amount of artificial drainage in the mining area, the original plugged channels will be destroyed, the rock mass permeability will be increased, the mixing of different water flow systems will be connected, the water dissolution capacity will be enhanced, and human activities will aggravate the karstification.

2. From the analysis of stratigraphic distribution, crustal movement evolution and groundwater recharge conditions, it is concluded that large karst caves are developed in the karst polysaturated layer in the study area, and joint fissures are developed in the surface of carbonate rock and are mostly filled with calcite. Sexual dissolution ditch, karst landscape such as beaded caves developed near the fault zone.

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