

## Brief Introduction to the Features of Karst Geology in Hunan Province

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### Abstract

Basic features about karst geology in Hunan are briefly discussed with particular emphasis on (1) showing the distribution of the mountains higher than 1300m; (2) summarizing the types of the basins formed in the late of Mesozoic era and in Cenozoic era; (3) studying the relationship of structural movements with the magmatism and the metamorphism there; The climate and water system, the types of carbonate rocks, and the topography characterizes are also dealt with for the purpose of stating the factors controlling the processes of karst and their properties.

**Keywords:** Geology; Hunan Province; Mountains

There are many typical karst regions in China. Hunan province is one of them. 26 geologic parks have been built up. Among them, 17 geologic parks have excellent and very special karst phenomena, such as Wanhuan karst geologic park, Miaoqian karst geologic park, and Meijiang karst geologic park.

People are much concerned with karst phenomena, for they have great influence on human civilization, agriculture, industry, engineering, and disaster [1-3]. Much more attention has been paid to in karst formation and evolution [4,5].

Morphology, landform have obvious control on the karst development [6,7]. Faults and fractures are also very important at the same time [8]. What is more about the matter signifying karst features, altitude and its variation. All these will be taken into account for karst study in Hunan.

### The mountains and the basins the topography

Hunan province locates in the central area of China, with an area of 218,000 km<sup>2</sup>. It is surrounded by mountains from three directions. Wuling mountains, the mountains of Yunnan-Guizhou plateau, Nanling mountains, and Luoxiao mountains extend into

north-west, west, south, and east of Hunan respectively. The mountains higher than 1300m in Hunan province are shown in figure 1.

**Figure 1:** The distribution of main mountains in Hunan.

In figure 1, the peaks of No. 1 to No. 11 and No 12 to No. 33 belong to Wuling mountains and Xuefeng mountains (in Yunnan-Guizhou plateau) respectively. The peaks of No. 34 to No. 61 and No. 62 to No. 77 belong to Nanling mountains and Luoxiao mountains accordingly. The peak of No.78 is Zhurongfeng, which is the highest peak of Hengshan.

In the northern boundary of hunan province lies Dongting lake, where the altitude is very low. There are many small lakes in the area of Dongting lake, such as Huanggai lake. The lowest point is in the west bank of Huanggai lake, where the altitude is only 24m. In hunan province, the highest point of Hupingshan is 2098.7m.Then the altitude difference of about 2074.7m.

The remarkable geomorphic features of Hunan province is that the area of mountain region is very big ( $108,472 \text{ km}^2$ ), and the area of hilly land is quite small ( $32,522 \text{ km}^2$ ). The area of basins is just  $29,412 \text{ km}^2$ , and the area of plain is only  $22,786 \text{ km}^2$ . The area of the mountain region occupies the 52.4% of the whole area, the percentage is very high.

There exist many basins developed in late time of Mesozoic and Cenozoic era. These basins developed in Cretaceous period, Jurassic period, in Paleogene period or in Quaternary period. The basins locate in the north, the central, southeast, northeast of Hunan and occur between wuling mountains and Xuefeng mountains.

#### Climate, rivers and topography

The climate in Hunan province belongs to semi-tropics, rainfall is abundant, and rain comes in with heat in the same season. There are great number of rivers in Hunan. The rivers with the length of longer than 5,000m are as many as 5341, and the total length of the rivers in Hunan is 90,000,000m. The number of the rivers with the drainage area of larger than  $55,000 \text{ m}^2$  is 11,117. Xiangjiang, Yuanjiang, Zishui, and Lishui are four large rivers in Hunan. Almost all the rivers belong to drainage systems of these four rivers, except for very small amount of the rivers which owe to the drainages of Ganjiang or Zhujiang. All the water of these four rivers flows into Dongting lake, from where the water goes out into yangtze river further.

The topographic height difference is very big, especially in high mountainous regions. There are many waterfalls in the source areas and on the banks of the large rivers. For example, Maoyan river belongs to the upper reach of Lishui, with the height difference of up to 1,600m. Maoyan river is longer than 50 km with many clffs on its banks. You can see many dangerous beaches, torrents, and waterfalls along sangzhi river (Figure 2).

a. Cliff, water-level mark

b. Waterfall, valley

c. Waterfall

**Figure 2:** The cliffs, torrents and waterfalls of Maoyan river.

#### Stratigraphic divisions and types of soluble rocks

Strata from middle Proterozoic to Cenozoic era may be observed in Hunan, concerning two stratigraphic divisions and six stratigraphic subdivisions. The stratigraphic divisions are Yangtz stratigraphic division and south China stratigraphic division. Northwest Hunan subdivision is in Yangtz stratigraphic division. South China stratigraphic division include five subdivisions (Xuefengshan, northeast Hunan, central Hunan, south Hunan, southeast Hunan subdivision), see figure 3. There are more than 15 types of soluble rocks in Hunan such as limestone, dolomite, gypsum, salt rocks, and so on. The most important soluble rocks are carbonates rocks (various limestone and dolomite).

There are two systems of strata which are rich in carbonate rocks in Northwest Hunan stratigraphic subdivision, they are the strata of from Sinian system to Ordovician system (Z-O) and from upper carboniferous series to middle Triassic series (C3 - T2). You may also see carbonate rocks in the strata of upper Devonian series to lower carboniferous series (D3 - C1) and in Jurassic system (J). There are also two systems of strata rich in carbonate rocks in Xuefengshan stratigraphic subdivision and Northeast Hunan subdivision, they are from Cambrian to Ordovician system and from upper carboniferous series to lower Triassic series (C3 - T1).

**Figure 3:** Stratigraphic division of Hunan province.

Other strata containing carbonate rocks are in Paleogene system (E). Central Hunan subdivision has one series of carbonate rocks which is from Devonian to Permian system (D-P), in addition to the carbonate rocks appearing within upper Proterozoic (Pt31), Sinian (Z), Cambrian (€) lower to middle Tertiary (T1-T2), and Paleogene system (E). There exists only one strata system rich in carbonate rocks of from Devonian to Permian system (D-P) in south Hunan subdivision and southeast Hunan subdivision. Of course, carbonate rocks may also be seen in Triassic system (T).

As the whole, the thickness of the carbonate rocks is the biggest in Northwest Hunan subdivision, and becomes smaller and smaller through Xuefengshan, central Hunan, south Hunan to southeast Hunan subdivision.

#### **Structural movement, magmatism, metamorphism**

Fractures, Faults and folds are the basic results of tectonism. Usually, fault often appears as fault belt, composed of many faults in small scale, and so does as the fracture. Since middle Mesoproterozoic era.

Hunan has experienced four structural development stages, three times of regional epeirogenesis movements, eight structural periods, and eleven structural movements, resulting in many regional angular unconformities. Structural movements are the major cause for all the other geological processes. Under the control of

the multiple tectonism, magmatism and metamorphism may take place, forming magmatic rocks and metamorphic rocks. Almost all of the magmatic rocks are intrusive rocks, though effusive rocks outcrop may be seen. All types of intrusive magmatic rocks may be seen there, including ultra-basic, basic, neutral, acidic and so on. But the main type of the magmatic rocks is intrusive rocks, with granites as the most common kind, which formed mainly in Caledonian movement (r3) and Indosinian - Yanshan movement (r5). The magmatic rocks spread out only in south China stratigraphic division. From figure 4, you may see that granites (r5, r5, r51, r52, r53), formed in Indosinian - Yanshan period, concentrate in a belt in NNE strike, representing the feature of the regional structures in China.

**Figure 4:** The distribution of the magmatic rocks in Hunan.

The types of the metamorphic rocks in Hunan are slate, Carbonaceous slates, metamorphic feldspar quartz sandstones, metamorphic sandstones, metamorphic fine sandstones, metamorphic sandstones and sandy slate. The geological time units are of Ordovician, Cambrian, Zinian periods, and middle Mesoproterozoic era.

There are great differences in intensity, quantity, and in geologic time about the metamorphic rocks in Hunan, as shown by table 1. In west Hunan, the metamorphic rocks only appear in the strata of middle Mesoproterozoic era. They appear in the strata of from middle Mesoproterozoic era to Cambrian period in Xuefeng mountain, middle Hunan, and south Hunan. They distribute in the strata from Mesoproterozoic era to Ordovician period. So, you can see that the metamorphic rocks become more and more in amount from west Hunan to southeast Hunan, and that the strata containing metamorphic rocks become younger and younger from west Hunan to southeast Hunan also.

Magmatism and metamorphism influence the solubility of carbonate rocks. The more intense of the magmatism and metamorphism are, the lower the solubility of the carbonate rocks. Take these phenomena into account, we get the distributive outline of carbonate rocks contained in the strata which do not contain metamorphic rocks (Figure 5). The carbonate rocks concentrate mainly in three areas, which are west Hunan, central Hunan, and southeast Hunan. The thickness is the largest in west Hunan, and it is smallest in southeast Hunan. So is the area of these three regions.

**Figure 5:** Carbonate rocks distribution in Hunan.

### Geologic parks and karst phenomena

There are 27 geologic parks in Hunan (1 world geologic park, 12 national geologic parks, and 14 provincial geologic parks). Zhangjiajie geologic park is a world one, and it is a national geologic park at the same time. National and provincial geologic parks which are relevant with carbonate karst are up to 17.

Among these geologic parks, 2 of them are closely related and are directly named as karst geologic parks (Wanhuayan and Meijiang), shown by blue color. And 13 of the parks in table 2 are related with karst phenomena, shown by red color in the table. Another 2 of the parks are more or less related with karst, Chaling yunyangshan and Suining huangsang, shown by green color. The building of (karst) geologic parks gives great convenience for field karst phenomena investigation. We have finished karst geologic investigation of 26 sites.

In these investigation sites, four (No 1-4) are in southeast Hunan, five (No. 5-9) are in central Hunan, and 16 (No. 11-26) are in west Hunan. In the site (No. 10), there are many swallow holes (sink holes, ponors) which are formed in recent years. More than

half of the sites lying in west Hunan shows that west Hunan is the richest in karst phenomena. In the meantime, central Hunan and southeast Hunan are two very important areas for karst development and distribution.

In these three areas, the strata of the carbonate rocks are thick and widespread [9], the water is enough and very active owing to the humid and hot climate, the topography is high and has huge elevation differences, and the faults and fractures are quite permeable [10]. That is why the karst phenomena are so concentrated there [11].

### Conclusions

Karst phenomena are very important to geologic parks. Karst development depends on soluble rocks. Generally speaking, the more the soluble rocks, the more and the larger the karst products. Carbonate rocks are main type of soluble rocks. In northwest Hunan, the thickness of the strata rich in carbonate rocks is the biggest. So, the karst is the richest there. The formation and evolution of karst need great amount of water. The semi-humid and hot climate gives very good conditions for water coming. There is huge quantity of rivers in Hunan. So, the water is enough.

Great difference in altitude is vital for water flowing actively and producing karst in soluble rocks.

Only the active water can solve the rocks effectively. High places, such as mountain regions, have obvious height difference. It is impossible for the low places to have great change of up and down in topography. Lots of faults and fractures which are permeable give outstanding help for water circulation on the earth surface and underground.

Therefore, we summarize the relationship of basic factors controlling karst and their favorable properties as in figure. For karst and karst geologic parks in Hunan, carbonate rocks and water are two fundamental factors.

Strata must be thick and widespread. Water has to be enough and active. Excellent Climate supply enough water. Active water attends with the circumstance with high altitude, enormous height difference, permeable faults and fractures.

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