Geological tourist route planning of Henan province based on geological relics zoning

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**ABSTRACT**

Henan province has abundant geological relic resources. According to their distribution characteristics, following the principles of hierarchy and continuity, divided them into five geological relics regions and calculated the regional comprehensive density of geoparks. It is found that: the geoparks regional comprehensive densities of the South Taihang Mountain Region, Xiao Mountain -Songji Mountain Region, Xiaoqinling-Funiu Mountain Region, Tongbai Mountain-Dabie Mountain Region are higher and suitable for the geological tourist route planning and then respectively proposed systematic geological tourist routes planning. This study has the positive significance on promoting the geoparks of the same region to strengthen contact and develop classical geological tourist routes, improving the quality of the whole geological tourism in Henan province.

**KEYWORDS**

Geological relics zoning; geopark; regional comprehensive density; geological tourist route planning

1. Introduction

Geological tourism resources in Henan province are rich and the construction of geoparks has been walking in the forefront in China. But geoparks are relatively independent and geological tourism resources are scattered, which cannot bring tourists complete geological knowledge system or deep impression (Mu & Wan, 2005; Wang et al., 2008; Li, Wang, & Wang, 2013). Therefore, it needs to plan the geological tourist route in Henan province. The common methods of travel planning mainly include two kinds, one is from the angle of the travel agency, the other from tourism resources area (Farsani, Coelho, & Costa, 2004; Fang, Zhang, & Zhang, 2014). Because geological tourism is a new way of tourism, data from the travel agency is limited. From the angle of regional tourism resources, this research divided the geological tourism resources of Henan province into five regions and calculated the regional comprehensive density of geoparks and then planned the geological tourist route (Gao & Gao, 2016).

2. Geological relics zoning of Henan province

By collecting and analyzing the data, screening the geological relics point, evaluating the important geological relics, interpreting the remote sensing, investigating the field and other methods, found out the geological relics' type, distribution, scale, shape, number, material composition, origin, evolution, combination relationship, preservation and protection conditions, and so on in Henan province (Ha, 2016; Ma, Jiang, & Yu, 2016).

According to the Geological Relics Survey Technical Requirements (Provisional) Scheme, geological relics types are divided into 3 genera, 9 classes and 33 subclasses. After investigation, the important geological relics have 335 points in Henan province, among them, the stratigraphic section is 156, the important fossil origin is 24, the structural section is 24, rock profile is 26, the important rock ore origin is 30, the geotechnical engineering landform is 37, the tectonic geomorphology is 6, the water landscape is 27 and 5 points of other geological disasters. Twenty-two points are world-class, 137 points are national level, and 176 in the provincial level (Wang, 2016). One hundred and eighteen points are in geoparks, accounting for 35.22% of the total, including 69 points in the world geoparks, 24 in the national geopark, 25 in provincial geopark. Two hundred and seventeen points are not in geoparks, accounting for 64.78% of the total.

2.1. Zoning guiding ideology

According to the actual situation in different conditions of tectonic geological background and landform types forming different geological relics, combining the nature and characteristics of geological relics, the different geological background and landform types of the tectonic
units, geomorphic units, carry on the division of geological relics to provide scientific basis for the management and utilization of geological relics (Fan, 2016).

### 2.2. Zoning standard

#### 2.2.1. The hierarchy principle
Taking the geomorphic unit, tectonic units of the geological relics exposed distribution as the boundaries divide the geological relics (Jahin, 2016). The first-class geomorphic units and tectonic units in Henan are the geological relics regions. The second-class geomorphic units and tectonic units in Henan are geological relics partition and the third-class are geological relics district.

#### 2.2.2. The space continuity principle
The region, partition, district division of geologic relics should guarantee the continuity and integrity of the geological relics distribution space for the overall protection planning and management, reasonable use.

### 2.3. Geological relics zoning results

According to the above zoning principle, geological relics zoning will be divided into three levels and five regions in Henan province. Each district is furtherly divided into different partitions and 5 geological relics district are divided into a total of 18 partitions. And then, some geological relics partitions are divided into geological relics districts, 18 different partitions are divided into 24 geological relics districts. The geological relics regions and partitions are as follows: (1) South Taihang Mountain Region includes South Taihang Partition, Wangwu Mountain Partition, and Tangyin Mesas Partition; (2) Xiao Mountain–Songji Mountain Region includes Sanmenxia Basin Partition, Xiao Mountain Partition, Luoyang Basin Partition, and Songji Mountain Partition; (3) Xiaoqinling–Funiu Mountain Region includes Xiaoqinling Partition, South Yanyuan Partition, Xionger Mountain Partition, Funiu Mountain Partition, and Nanyang Basin Partition; (4) Tongbai Mountain–Dabie Mountain Geological Relics Region includes Tongbai Mountain Partition and Dabie Mountain Partition; (5) Huanghuaihai Plain Geological Relics Region includes Haihe Plain Partition, The Yellow River Alluvial Plain Partition, and Huaihe Alluvial Plain Partition.

### Table 1. Cities and geoparks in each region.

| Including cities | Including geoparks |
|------------------|--------------------|
| South Taihang Mountain Region | Anyang, Jiaozuo, Xinxian, Jiyuan, and Hebi |
| Xiao Mountain–Songji Mountain Region | Pingdingshan, Luoyang, Mianchi, Yima, Dengfeng, Gongyi, and Yuzhou |
| Xiaoqinling–Funiu Mountain Region | Hubin district, Shanxian county, Lushi county, and Lingbao county of Sanmenxia, Nanyang |
| Tongbai Mountain–Dabie Mountain Region | Xinyang |
| Huanghuaihai Plain Region | Shangqiu, Kaifeng, Zhengzhou (except Dengfeng, Gongyi), Zhoukou, Luohe, Xuchang (except Yuzhou), and Zhumadian, Puyang |

By the end of 2016, in Henan province, four world geoparks have been established—Song Mountain, Yuntai Mountain, Funiu Mountain, Wangwu Mountain-Daimei Mountain. Fifteen national geoparks and 17 provincial geoparks have been established or got construction qualification.

### 3. Regional comprehensive density of geoparks in Henan province

3.1. The cities in each geological relics region

On the basis of the above geological relics zoning results, the cities and geoparks in each region are shown in Table 1. Here, we can see that South Taihang Mountain Region includes the cities of Anyang, Jiaozuo, Xinxian, Jiyuan, and Hebi; Xiao Mountain–Songji Mountain Region includes the cities of Pingdingshan, Luoyang, Mianchi, Yima, Gongyi, Dengfeng, and Yuzhou; Xiaoqinling–Funiu Mountain Region includes Hubin district of Sanmenxia city, Shanxian county, Lushi county, Lingbao county, and Nanyang city; Tongbai Mountain–Dabie Mountain Geological Relics Region only includes Xinyang city; Huanghuaihai Plain Geological Relics Region includes the cities of Shangqiu, Kaifeng, Zhengzhou (except Dengfeng, Gongyi), Zhoukou, Luohe, Xuchang (except Yuzhou), Zhumadian, and Puyang.
3.2. The measurements and results of regional comprehensive density

Regional comprehensive density is a usual measurement to measure a point concentration within a region. Its computation formula is:

\[
D = \frac{Q}{\sqrt{SP}}
\]  

(1)

\(Q\) is the number of regional geoparks, \(S\) stands for regional area (million square kilometers) and \(P\) as the regional population (one million people), \(D\) stands for regional comprehensive density. \(Q\) is obtained by collecting, \(S\) and \(P\) are obtained from the Statistical Yearbook of Henan province.

The world geoparks are composed of multiple parks and independent park which is also a national or provincial geopark, so the national geopark or provincial geopark can only be calculated to avoid double-counting. By the end of 2016, there are a total of 32 national or provincial geoparks in Henan province, the province's land area is 16.59 km², and the total population is 107.22 million. Bring the data into the formula, the calculated regional comprehensive density are shown in Table 2.

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The Xiao Mountain–Songji Mountain Region has 10 geoparks and it is most in 5 geological relics regions, but its population and area is moderate, so its regional comprehensive density is the biggest, 1.51. Tongbai Mountain–Dabie Mountain Region only contains Xinyang city and its population and area are the minimum, so its comprehensive density 1.49 is the second in descending order. The third is South Taihang Mountain Region and the fourth is Xiaoqinling–Funiu Mountain Region, their values are respectively 1.08 and .72. The last is Huanghuaihai Plain Region, .23, significantly lower than other regions. The first four geological relics regions' comprehensive densities are all higher than that of Henan province and the Huanghuaihai Plain Region is lower than the average level of Henan province .68. Therefore, the value of planning Huanghuaihai Plain Region is not big and it only needs planning geological tourist routes for the other four major regions in detail.

4. Geological tourist route planning

4.1. The geological tourism route of South Taihang mountain region

4.1.1. Wangwu Mountain, Daimei Mountain – The most magical place of the Yellow River

Wangwu Mountain and Daimei Mountain, on each side of the Yellow River, on the whole (the landscape) constitute a beautiful and splendid picture. The geological landforms and geological structure is the major, geological section and water landscape is the auxiliary pole, ecologic alternates with culture. Ancient Wangwu Mountain recorded the transition process to land from ocean of 2.5 billion years. The beautiful Daimei Mountain witnessed the cutthrough and the formation of The Yellow River and the rise or fall of the Chinese civilization history. Geology and culture get the seamless docking here.

4.1.2. Yuntai landscape – The soul of South Taihang tectonic block mountain

Yuntai landscape, taking the Yuntai Mountain landscape as the typical case, is the soul of the south taihang tectonic landforms. This landscape is a special landscape and it is based on horizontal strata, with the characteristics of various of canyon group and the single side walls, mesa and stone pillars, with the mechanism of collapse erosion. It is different from the southern landscape and has an extremely high tourism value.

4.2. The geological tourism route of Xiao Mountain–Songji mountain region

Songshan stratum has five generations, here the oldest stratum is 3.9 billion years old. The important geological periods of formation are all recorded here, through Dengfeng city from north to south. You can see the important geological relics since three billion years ago, according to the clues of the geological relics left, think about the ancient geography, environment, and walk across three billion years of geological time and space.

| South Taihang Mountain Region | Xiao Mountain–Songji Mountain Region | Xiaoqinling–Funiu Mountain Region | Tongbai Mountain–Dabie Mountain Region | Huanghuaihai Plain Region |
|-------------------------------|------------------------------------|----------------------------------|---------------------------------------|--------------------------|
| Q 7                           | 10                                 | 5                                | 6                                     | 4                        |
| S 2.3767                      | 2.8292                             | 3.5421                           | 1.8819                                | 5.96472                  |
| P 17.73                       | 15.4074                            | 13.4874                          | 8.6                                   | 50.77                    |
| D 1.08                        | 1.51                               | .72                              | 1.49                                  | .23                      |
4.3. The geological tourism route of Xiaoqinling–Funiu mountain region

4.3.1. Dinosaurs – The master of Mesozoic
With dinosaurs as the main line of geological tourism are mainly distributed in Mesozoic basin of north and south Funiu, including RuYang Basin, Luanchuan Basin, and Nanyang basin. Here had the world’s biggest dinosaur - Ruyangosaurus Giganteus – the world's largest dinosaur egg origin, Nanyang Basin. Besides, here had Zhongyuan Nodosaurus, Nanyang ZhugeLong, Luanchuan Anraptor, and so on.

4.3.2. Gold ore of Xiaoqinling
Xiaoqinling gold deposits has a glorious history in the Chinese and is still the second now. Xiaoqinling is covered with gold mine and different periods of mining site, smelting ruins can be seen everywhere.

4.4. The geological tourism route of Tongbai mountain–Dabie mountain region
Here is orogenic belt geological tourist route of Shangcheng–Xinxian county. This is the core area of reflecting the formation of Qinling–Dabie Mountain orogenic belt. Jingangtai volcanic rocks, known as the proud of Dabie Mountain and the eclogite of Lashutang, Xinxian county, a kind of ultrahigh pressure metamorphic rocks, are all the process records of orogenic belt. At the same time, it is also a famous red tourist destination of Xinyang city.

5. Conclusion
Henan province has abundant geological relic resources and divided it into South Taihang Mountain Geological Relic Region, Xiao Mountain–Songji Mountain Region, Xiaoqinling–Funiu Mountain Region, Tongbai Mountain–Dabie Mountain Region, and Huanghuaihai Plain Region. Among them, the geoparks regional comprehensive densities of the first four geological relics regions are higher and suitable for the geological tourist route planning. Combining with the natural landscapes and human landscapes of the first four geological relics regions, planed the characteristic geological tourist route. Through planning, on the one hand, can promote the geoparks in the same region to strengthen the contact and jointly create a classical geological tourist routes in their area. On the other hand also promote the quality of the whole geological tourism in Henan province, make the geological tourism industry development more reasonable and perfect.

Disclosure statement
No potential conflict of interest was reported by the authors.

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