Characteristics of the Geological Tourism Resources in Hainan Island, China

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Abstract. In order to deep mine Hainan geological tourism resources, based on remote sensing, geology, geography and field investigation, a Hainan geological tourism resources evaluation method was established, which included data collection, data preprocessing, geological tourism monomers extraction using remote sensing imageries. According to the national standard of classification, investigation and evaluation of tourism resources (GB/T18972-2003), 146 geological tourism monomers in Hainan Island were firstly evaluated. The results showed that there were 13 geological tourism resource types in Hainan Island with the characteristics of large quantity, high quality, long travel time and convenient transportation. Finally, the future development of Hainan geological tourism was suggested to further strengthen on the geological environment stability to provide references for geological tourism economy development in Hainan Island.

1. Introduction
Geological tourism resources are fossils, rock masses, structural features, ore deposits, geomorphic landscapes and other scenes preserved in the rock stratum due to crustal tectonic changes, magmatic activities, paleogeographic environment evolution, paleontological evolution and other factors in the long evolution process of the earth. They have the value of scientific research, universal education, and attractions to tourists. Geological tourism is a tourism that enables people to understand the knowledge of geology, geography and other related disciplines by visiting and investigating a series of geological heritages and landscapes [1-3].

At present, investigations of tourism resources in Hainan are mostly focused on the analysis on its natural and humanistic characteristics [4-6], investigation and evaluation systems [7-10], and development strategic planning, etc [11-12].

However, there are few studies on the characteristics of the geological tourism resources in Hainan Island. In order to further explore the geological tourism resources, this paper combined remote sensing, geology, geography and field investigations to establish a Hainan geological tourism resources evaluation method. The results are expected to provide a reference for the development of geological tourism economy in such areas as Hainan Island.
2. Study area
Hainan Island is the largest tropical island in China. With the land area of 33920 km², its coordinate is 108°37′-111°03′ E and 18°10′-20°10′N and has convenient traffic networks, such as the "three vertical" highway (Haiyu east line, Haiyu middle line and Haiyu west line), Huandao expressway, Eastern Ring Railway, western line railway and Western Ring Railway. In addition, Haikou Meilan International Airport, Sanya Phoenix International Airport, Haikou Port, Sanya port, Basuo port, Qinglan port and Yangpu Port are connected at home and abroad.

Hainan Island has a tropical monsoon marine climate. The annual average temperature is 23.8 ℃. In which, January is the coldest, with an average temperature of about 18.0 ℃. Frost can occur in the central mountainous areas, and the extreme minimum temperature is 0.1 ℃; July is the hottest month, with an average temperature of 28.2 ℃ and an extreme maximum temperature of 39 ℃. The rainfall of Hainan Island varies greatly from place to place, and is controlled by seasonality. The rainy season lasts from May to October, accounting for 75.5% ~ 90.0% of the annual rainfall; The dry season is from November to April, and the rainfall accounts for only 10.0% ~ 24.5% [13].

Terrain of Hainan Island is high in the middle and low in around. Landforms of the study area are composed of mountains, platforms and plains. In which, with an elevation of 500-800m, mountains are main landforms and distributed in the center of the island, which account for 38.7% of total area.

There are 154 rivers in the study area, most of which originate from the central mountainous and 38 rivers have a catchment area of more than 100 km². Nandu River, Changhua River and Wanquan River are the three major rivers in Hainan Island, with a catchment area of more than 3000 km², and their drainage areas account for 47% of the whole island. It is these rivers that form beautiful waterfalls in mountains and become an important part of geological tourism resources.

With oceans, mountains, rivers, lakes and coastal zones, Hainan island has formed more than 100 famous scenic spots. Among them, there are 1 World Geopark, 2 National Geoparks, 6 scenic spots with 5A grade, 21 scenic spots with 4A grade, 10 national protected areas and 23 provincial protected areas.

3. Methodology
Shown in the Figure 1, the method mainly includes four steps: data collection, data preprocessing, extraction of geological tourism monomers using remote sensing imageries and evaluation on geological tourism resources based on field investigations [14].

(1) Data collection
Remote sensing images, geological, topographic and other basic geographic information data of Hainan Island were collected to form a priori background knowledge database.

(2) Data preprocessing
After collecting data, they are registred using a unified projection to make an target on different maps in a same location. Then, they are put together to form a database.

(3) Geological tourism monomers extraction using remote sensing imageries.
Various geological tourism monomers in Hainan island, such as coasts, islands, valleys, rivers, caves, etc., are extracted from remote sensing imageries. Their characteristics on true colored remote sensing images were shown in table 1. From which, we can extract different geological tourism monomers respectively.
Table 1. Characteristics of geological tourism monomers on true colored remote sensing images

| Geological tourism monomers | Characteristics on true colored remote sensing images |
|-----------------------------|-----------------------------------------------------|
| Coasts                      | One side is land with white or green colors, the other is sea with blue or black colors. |
| Islands                     | Small land with white or green colors in the sea whose color is blue or black. |
| Rivers                      | Curved shapes with black or blue colors. |
| Caves                       | Round shapes with black colors. |
| Beaches                     | In land with belt shapes and white colors near to sea. |
| Hills                       | Higher altitude to backgrounds with green vegetation. |
| Volcano and lavas           | Round shapes with green vegetation. |
| Hot springs                 | Higher temperature to backgrounds with poisonous vegetation whose color is slightly yellow. |
| Valleys                     | Long and narrow shapes with black or blue colors. |
| Waterfalls                  | Higher elevation difference along rivers. |
| Lakes                       | Round shapes filled by water with black or blue colors. |
| Ore accumulations           | Round shapes caused by artificial activities with white, blue or red colors. |
| Meteorite craters           | Round shapes caused by meteorite activities with green vegetation. |

(4) Evaluation on geological tourism resources based on field investigations

According to the standard of classification, investigation and evaluation of tourism resources (GB / t18972-2003), from the aspects of geographical location, structure, composition, genetic mechanism and evolution process, scale and volume, environmental backgrounds, regional access conditions, protection and development status, etc., field investigations were carried out on each Hainan
geological tourism monomer in terms of ornamental and recreational value, historical and cultural value, scientific value, rarity or strangeness, scale and abundance, integrity, popularity and influence, scope of use, pollution status, etc.

According to the evaluation criteria of geological tourism resources (Table 2) [15], the expert scoring method is used. It mainly includes the individual quality and structure evaluation, development conditions and comprehensive evaluation, and the final evaluation score is obtained. According to the total score, monomers are divided into five grades: grade 5 tourism resources score is more than 90; grade 4 tourism resources score is between 75 and 89; grade 3 tourism resources score is between 60 and 74; grade 2 tourism resources score is between 45 and 59, and grade 1 tourism resources score is between 30 to 44.

| Items | Criteria |
|-------|----------|
| The ornamental value, recreation value or use value provided by the monomer for tourists | All or one of them has the highest ornamental value, recreational value and use value. 30-22 |
| | All or one of them has the higher ornamental value, recreational value and use value. 21-13 |
| | All or one of them has high ornamental value, recreational value and use value. 12-6 |
| | All or one of them has general ornamental value, recreational value and use value. 5-1 |
| The historical value, or cultural value, or scientific value, or artistic value contained in the monomer | At the same time or one of them has historical value, cultural value, scientific value and artistic value of world significance 25-20 |
| | At the same time or one of them has national historical value, cultural value, scientific value and artistic value 19-13 |
| | At the same time or one of them has provincial historical value, cultural value, scientific value and artistic value 12-6 |
| | Historical value, or cultural value, or scientific value, or artistic value has regional significance 5-1 |
| Rarity and singularity | There are a large number of rare species, or the landscape is very strange, or such phenomena are rare in other areas 15-13 |
| | There are many rare species, or the landscape is strange, or such phenomena are rare in other areas 12-9 |
| | There are a few rare species, or the landscape is prominent, or such phenomena are rare in other areas 8-4 |
| | There are some rare species, or the landscape is more prominent, or such phenomena are more common in other areas 3-1 |
| Individual size, group structure and density | The scale and volume of independent monomer are huge; Tourism resources have perfect single structure and excellent density; Natural scenes and human activities occur periodically or frequently 10-8 |
| | Independent monomer has large scale and volume; The single structure of combined tourism resources is very harmonious and the density is good; Natural scenes and human activities occur periodically or frequently 7-5 |
| | Independent monomer with medium scale and volume; The individual structure of combined tourism resources is harmonious and the density is good; Natural scenes and human activities occur periodically or frequently 4-3 |
| | Independent monomer has small scale and volume; The 2-1 |
The single structure of combined tourism resources is harmonious and the density is general; natural scenes and human activities occur periodically or less frequently. Is it disturbed and damaged by nature or man-made, or is the preservation completed?

| Level | Description                                                                 | Score |
|-------|-----------------------------------------------------------------------------|-------|
| 5-4   | Keep the original shape and structure                                       |       |
| 3     | The morphology and structure changed a little, but not obvious              |       |
| 2     | There are obvious changes in morphology and structure                        |       |
| 1     | Significant changes in morphology and structure                              |       |
|       | Well-known in the world or constitutes a famous brand recognized by the world| 10-8  |
|       | Well-known nationwide or constitutes a national famous brand                | 7-5   |

Popularity

| Level | Description                                                                 | Score |
|-------|-----------------------------------------------------------------------------|-------|
| 4-3   | Well-known in the province or constitutes a famous brand in the province    |       |
| 2-1   | Well-known in the region or constitutes a famous brand in the region        |       |
| 5-4   | Suitable sightseeing days exceed 300 days a year, or suitable for all tourists to use and participate |       |
| 3     | Suitable sightseeing days are more than 250 days a year, or it is suitable for about 80% of tourists to use and participate |       |
| 2     | Suitable for sightseeing days are more than 150 days a year, or it is suitable for about 60% of tourists to use and participate |       |

Travel time

| Level | Description                                                                 | Score |
|-------|-----------------------------------------------------------------------------|-------|
| 1     | Suitable for sightseeing days are more than 100 days a year, or it is suitable for about 40% of tourists to use and participate |       |
| -5    | It has been seriously polluted or has serious potential safety hazards      |       |
| -4    | It has been moderately polluted or has obvious potential safety hazards     |       |
| -3    | It has been slightly polluted or has certain potential safety hazards       |       |
| 3     | Engineering protection measures have been taken to ensure environmental safety.                |       |

4. Results

According to the method, 146 geological tourism monomers in Hainan Island were firstly evaluated combining with the evaluation results of Hainan Geological Survey Institute [1]. In which, 5 field investigations in November 2016, July 2017, March 2018, July 2018 and November 2018 were carried out.

The results showed that Hainan Island was rich in geological tourism resources. There were 85 excellent geological tourism monomers, including 13 basic geological tourism resources: islands, rocks, beaches, hills, volcano and lavas, rock caves, hot springs, valleys, waterfalls, lakes, seismic relics, ore accumulations and meteorite craters. Among these types, beaches accounted for 32.9%, followed by hills and islands, with a proportion of 15.3% respectively; Next was the volcano and lavas, with a proportion of 10.6%.

From Figure 2, we can see that the coastal areas are mainly islands and beaches, the northern volcanic eruption hilly areas are mainly volcanic lava, the low mountain areas in the Eastern are mainly waterfalls and hot springs, the high mountain areas in the middle are mainly valleys and
waterfalls, and the low sedimentary mountain areas in the Western and Southern are mainly rocks, caves and waters.

Figure 2. Classification map of geological tourism resources in Hainan

Figure 3. Proportion chart of different geological tourism resources in Hainan

5. Conclusions
In this paper, 146 geological tourism monomers in Hainan Island were firstly evaluated. Main conclusions can be drawn as follows.

(1) Hainan Island is rich in geological tourism resources
Most geological tourism monomers in Hainan Island are excellent geological tourism monomers, which include islands, rocks, beaches, hills, volcano and lavas, caves, hot springs, valleys, waterfalls, lakes, earthquake heritages, ore accumulations and meteorite craters.

(2) Hainan Island geological tourism resources have the characteristics of wide suitable population and long tourism time.

The geological tourism resources in Hainan Island can be available for a long time. In winter, Sanya in the southern is an ideal place for overwintering; When the temperature is high in summer, the central mountains are summer resorts; In spring and autumn, most of the scenic spots in Hainan Island are suitable for whole family to travel mountains, rivers and leisure sightseeings.

(3) A Hainan Island geological tourism resources evaluation method was established.

Combing remote sensing, geology, geomorphology and field investigations, a Hainan geological tourism resources evaluation method was established, which provided a reference for geological tourism resources evaluation in similar scenic spots.

Most scenic spots in Hainan Island are relatively mature, but the traffic conditions of some scenic spots, especially the geological tourism spots that have not been commercialized, are needed to be further improved in geological tourism infrastructures and popularities.

In future, it is necessary to strengthen on the transformation of geological tourism infrastructures, evaluation on geological environment stability, detailed investigations on geological tourism resources etc in Hainan Island.

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