Spatial information management platform for Dunhuang Global Geopark

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Abstract. As a member of UNESCO Global Geoparks, Dunhuang Global Geopark has developed a great quantity of landforms formed under special geological background and extremely droughty climate, which integrate together with specific geographic location and cultural relics on the “Silk Road Economic Belt”. The main geoheritage in Dunhuang Global Geopark is Yardang landform, which is formed by loose Quaternary sediments. According to different shapes, the Yardang landform were divided into five types, namely, ridge-shaped Yardang, wall-shaped Yardang, tower-shaped Yardang, column Yardang and Yardang monadnock. In order to monitor and protect the unique morphological features of Yardang landforms, a spatial information management platform is established, using SPOT 6 remote sensing image, with object oriented approach and manual interactive interpretation. Study shows that the maximum area, perimeter, length and width of Yardang were 324843.1 m², 3447.52 m, 1508.41m, and 285.81 m, respectively. Additionally, the aspect ratio of Yardang has a certain positive correlation, with the coefficient of correlation being 0.675. Furthermore, the relationship between length and width of Yardang is calculated using formula \( Y = 2.546X \), where \( Y = \text{length} \), \( X = \text{width} \).

1. Introduction

Located in the western of Gansu Province, as a key position of the ancient Silk Road, Dunhuang City will play an irreplaceable role in constructing the Silk Road Economic Belt, realizing the communication of policies, transportation, trades and currency among countries along the ancient Silk Road. Situated in the extremely arid climatic region, there has developed very typical geoheritage in Dunhuang Geopark. Being a member of GGN will not only open up a new way for ecological civilization construction, ecotourism development and geoheritage protection simultaneously, but also bring Dunhuang City a great opportunity to develop worldwide. Geoparks play significant role in
promoting geoconservation and realizing sustainable development of geoheritage (Gizzi & Lazzari, 2012; Dowling & Newsome, 2006).

The Yardang landform are widely distributed in Dunhuang Geopark, including different development stages. They are more densely distributed than their counterparts anywhere else in the world. Therefore, the Geopark showcases the most typical Yardang landforms in China and even in the world. Their formation was a result of the combined action of tectonic uplift, wind, running water and gravity on incompletely consolidated Quaternary fluvial and lacustrine sediments (Cooke et al. 1993; Lin et al. 2012; Ren et al. 2011; Dong, 2013). The Dunhuang Yardang landform has high aesthetic value and also serves as the best place to study their formation, development and evolution.

2. Materials and method

2.1 Yardangs
“Yardangs” were used by the Swedish explorer Sven Hedin (1903) meaning “steep bank”. They are streamlined forms up to 150 km long and 75 m in height resulting from a number of formative processes, including wind abrasion, deflation, fluvial incision, desiccation cracks, slumping, weathering and mass movement (Goudie, 2007; McCauley et al., 1977b; Ward & Greeley, 1984). The Dunhuang Yardang landforms are typical wind-erosion landforms.

2.2 Study area
Yardang area is located in the western part of Dunhuang Global Geopark, 160 kilometers away from Dunhuang city, covering an area of 346.35 square kilometers. Yardang Landform is the typical landform under the extremely arid climate, mainly formed by the wind and water erosion on the Quaternary sediments during the past 100,000 years. The major landscapes of this geo-area include mound-shaped, wall-shaped, tower-shaped and columnar Yardang landforms, which are very lifelike and has become the real ghost city in western China, and associated with the vast Gobi and desert.

Fig. 1 Transportation Sketch Map of Dunhuang Geopark of China

2.3 Materials and method

SPOT 6 satellite, launched on September 9, 2012, is the first satellite of SPOT 6 and SPOT 7 constellation that will assure continuity of 1.5 m high spatial resolution, 60x60 km wide-area image data through to 2024. It provides 6m multispectral image with blue, green, red and NIR bands in addition to 1.5m panchromatic image (Alganci, et al. 2013). The image covering the study area was acquired on
February 18, 2014.

With the development of remote sensing technology, remote sensing image has a higher spatial resolution and makes us obtain very abundant information of nature. In addition to the spectral information outside of itself, it also contains a large number of shapes and texture information. The traditional image classification method based on spectral of pixels, can work well for the image that have middle or low resolution. But this method cannot be fully utilized other information such as texture, not well adapt to the development of today’s remote sensing data and classification accuracy. In this context, the classification of object-oriented methods have emerged. In object-oriented classification, different features have different best scale for image segmentation. Using visual methods to determine best segmentation scale and rules for extracting as below.

Refine: 9053.30 to 13784.0

Attributes Computed:
- Spatial
- Spectral
- Texture

Classification: Rule-Based

Rule Set:

#1 (1.000): If area [867.4445, 17887.1465] AND length < 1500.0000 AND numholes < 0.0000 AND holesolrat > 1.0000 AND maindir > 60.0000, then object belongs to "Feature_1".

Export Options:
- Vector Output Directory: C:\Users\Administrator.PC-2012124JOLJ\AppData\Local\Temp\Output Class Image: G:\yadan20140116\FX\class result
- Output Rule Image: G:\yadan20140116\FX\rule result

Feature Info:
- Feature_1 Type: Polygon
- Smoothing: Threshold of 1

| Feature Name | Feature Count | Total Area | Mean Area | Min Area | Max Area |
|--------------|---------------|------------|-----------|----------|----------|
| Feature_1    | 958           | 5580675.00 | 5825.34   | 450.00   | 60187.50 |

Through this we got Yardangs classification and established a Spatial information management platform in Arcgis software to calculatedata of all the Yardang bodies of area, perimeter, length and width.
3. Conclusion and discussion

3.1 Morphological features of Yardang landforms
By calculation and statistical analysis of all the Yardang bodies such as area, perimeter, length and width, with the maximum area, perimeter, length and width were 324843.1 m$^2$, 3447.52 m, 1508.41 m, and 285.81 m, respectively. Additionally, the aspect ratio of Yardang has a certain positive correlation, with the coefficient of correlation being 0.675. Furthermore, the relationship between length and width of Yardang is calculated using formula $Y=2.546X$, where $Y =$ length, $X =$ width.
3.2 Yardang types based on morphological features
According to the research data and field observations, combined with Yardang body growth process: incubation period, childhood, youth, maturity, old age and death period, Yardangs were divided into five types: ridge-shaped Yardang, wall-shaped Yardang, tower-shaped Yardang, column Yardang and Yardang Monadnock.

| No. | Type | Description | Evolution stage |
|-----|------|-------------|-----------------|
| 1   | Mound-shaped Yardangs, wall-shaped Yardangs (Fleet out to Sea) | The mound-shaped Yardangs run from south to north, with a distribution range of about 5 km². They cover an area of 50-200 m long and 5-30 m wide, and rise 15-25 m high, with an interval of 20-80 m between adjacent mounds. The stratum is basically level, with vertical joints. There are water erosion gullies along the joints. Some of them have collapsed. | This area has hundreds of south-to-north, great importance for mound-shaped Yardangs and wall-shaped studying the development of Yardang landforms. They are of home to a wide range of... |
| 2   | Mound-shaped Yardangs (Western Sea Fleet) | This area has hundreds of south-to-north, great importance for mound-shaped Yardangs and wall-shaped studying the development of Yardang landforms. It is like a neatly arranged fleet sailing grandly on the sea. The joints which developed in the Yardangs run at 185°-194°. Wall-shaped Yardangs about 10 m high and 100 m long are distributed in a nearly south-north represent mature Yardang direction. Differential weathering formed a landforms, which have... | |
| 3   | Wall-shaped Yardang (Grotto) | This area has hundreds of south-to-north, great importance for mound-shaped Yardangs and wall-shaped studying the development of Yardang landforms. It is like a neatly arranged fleet sailing grandly on the sea. The joints which developed in the Yardangs run at 185°-194°. Wall-shaped Yardangs about 10 m high and 100 m long are distributed in a nearly south-north represent mature Yardang direction. Differential weathering formed a landforms, which have concave-convex Yardang surface, which looks diversified shapes and a like a cliff cave, giving you a solemn and serene complete range of types feeling. | |
Surface erosion changed the tall wall-shaped mature Yardang mature Yardangs into magnificent, towering castles landforms, the Geopark measuring 170 m in length and 40 m in height. has become the optimal The castle shape comes from the development of vertical joints and gullies on the surface. Yardang landforms and for This is a kind of mature Yardang landform geotourism for both between wall-shaped Yardangs and tower-shaped Yardangs, measuring 50-100 m in length, 20 m in height, on average, and 10 -15 m in width. international and domestic visitors because of its great height.

Co-existing with the Yardangs are desert wetlands, fixed dunes, etc. Due to erosion along vertical joints, formerly wall-shaped Yardangs were split into columnar Yardangs. Various forces caused the Yardangs to collapse and lean towards each other. This kind of tower-shaped Yardang looks like a lotus throne and measures 15 m in height and 60 m in diameter. It consists of alternating layers of sand and clay. This is a tower-shaped Yardang, about 20 m high. Its base is about 50 m long and 30 m wide. It looks like a golden lion lying with its face toward the east. This is the only oval Yardang in the vast black gobi, measuring about 30 m in diameter and 10 m in height, and looking like a lonesome boat on the black sea. Two parallel tower-shaped Yardangs, each of studying Yardang in height and 15 m in diameter, forming a natural gate.

Located in the west of the Yardang Geo-area, these Yardangs, measuring 15 m in height and 40 m in diameter, form a natural gate to the Yardang Geo-area. This kind of Yardang looks like a graceful As a kind of old-age peacock standing about 10 m high. The clay layer Yardang landform, it has stronger resistance to wind erosion than the arenaceous layer. It is this differential weathering Yardang landform that helped shape the lifelike peacock standing development and has gracefully.

As a kind of old-age Yardang landform, it marks an important step in evolution of studying Yardang landform. It has important significance for evolution of studying Yardang landform.
This was formed in the late period of Yardang landform development. Gravity and other forces caused avalanches along the vertical joints and resulting in Yardang fractures, resulting in the collapse of the Yardang monadnocks piling up in a disorderly fashion.

### 3.3 International significance of Yardangs in study area

Mostly developed in arid regions, the Yardang landforms are distributed in deserts on every continent except Australia. In China, they are distributed mainly in the Qaidam Basin in Qinghai, in the middle and lower reaches of the Shule River, and around Lop Nur in Xinjiang. Compared with other typical Yardang landforms in the Iranian Lut Desert, Kuwait, the Chad Basin in Africa, and the Mojave Desert in California, and other major Yardang landforms in China, the Dunhuang Yardang landforms feature complete and typical variety and have high scientific value (McCabe, et al. 1977a; Parsons & Abrahams, 2009; Desir, et al. 2002).

Great diversity, dense distribution, graceful shapes, large quantities and obvious changes in trend make the Dunhuang Yardangs unique in the world. The north part of the Yardang Geo-area features nearly SN-trending Yardangs, while the south is characterized by nearly EW-trending Yardangs, which shows that the major agents creating Yardang landforms vary significantly. This is important for the study of the formation of Yardang landforms and for comparative studies of the regional environment. The great variety of Yardang landforms reveals multiple evolution stages in their formation, which is of great significance in the study of the evolution of landforms, the paleo-geography and paleo-climate in arid regions, and distinct wind erosion (Dong, 2013; Cao & Yang, 2009; Huang, et al. 2006).

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