Impact of the Yardang Shared-Base Phenomenon on Yardang Morphometry Postprint

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Abstract

Yardang morphological characteristics have long attracted scholarly attention, and quantitative descriptions of their forms remain hotly debated with diverse opinions to this day. Through field investigations and UAV surveys of aeolian erosion landforms in the Lop Nur region, a widespread phenomenon of yardangs sharing a common pedestal (雅丹共基座现象) was discovered. The wind-eroded remnants distributed on the same pedestal body are termed common-pedestal yardangs, representing a composite of yardangs and pedestal bodies. Measurements and analyses of yardang morphological parameters for common-pedestal yardangs and pedestal bodies revealed that: the length-to-width ratios of common-pedestal yardangs are concentrated in the range of 3:1 to 5:1, similar to the morphological expression of streamlined yardangs such as whaleback forms, indicating residual characteristics of unidirectional wind erosion; the common-pedestal yardang phenomenon is an aeolian erosion ridge formed by wind erosion cutting through a deeper, relatively more wind-resistant stratum; the vertical alternation of strata with different wind erosion resistance of varying thicknesses and aeolian erosion under unidirectional wind are important factors in the formation of this phenomenon; through the interpretation and quantitative analysis of the common-pedestal yardang phenomenon, it holds significant importance for improving yardang morphological measurements, deepening understanding of yardang morphological changes, and recognizing differential aeolian erosion processes.

Full Text

Preamble

Influence of Common Pedestal of Yardangs on Morphological Measurement

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Abstract: Yardang is a typical wind-erosion landform widely distributed worldwide. Due to its diverse forms and volatile nature, Yardang' s morphological characteristics have attracted long-term attention. How to accurately and quantitatively describe Yardang morphology has been discussed enthusiastically, though many questions remain. The Lop Nur area is located in the eastern part of the Tarim Basin in Xinjiang, China. Although there are numerous Yardangs in the area with abundant morphological types, detailed description of Yardang morphology in Lop Nur is lacking. Through field investigation of wind-erosion landforms in Lop Nur and aerial surveying using unmanned aerial vehicle (UAV), this paper finds a new morphological combination of Yardangs in the Lop Nur area—the Yardangs which have common pedestal. It is observed on the high wind-erosion ridges that there are often platform surfaces on the tops of the ridges. On these flat platform surfaces, there are many streamlined wind-erosion tiny hills that are very similar to Yardangs. Under the platform surfaces, the wind-erosion ridges are surrounded by cliffs which resemble a pedestal; we call this part of the ridges the pedestal body. The streamlined wind-erosion tiny hills on the same platform surfaces are called the common pedestal Yardangs, and the Yardangs which have common pedestal represent the combination of Yardangs and the pedestal body. The measurement and analysis of Yardang morphological parameters were carried out on the common pedestal Yardangs and the pedestal bodies separately. The results show that: first, the values of length-width (L/W) ratio of Yardangs which have common pedestal mainly sit in the range between 3:1 and 5:1, very similar to whale-back or other streamline-appearance Yardangs, showing that the common pedestal Yardangs undergo the same wind-erosion processing as whale-back or other streamline-appearance Yardangs. They were all shaped gradually under the single-wind-direction erosion circumstance. Secondly, the Yardangs which have common pedestal are morphological combination of Yardangs. This phenomenon is essentially a wind-erosion ridge-mound phenomenon when wind broke the former deep and strong wind-erosion-resistance stratum and cut it into less wind-erosion-resistance strata, and thus the strata of different thicknesses

and different wind-erosion-resistance levels appeared alternately in the vertical direction which, together with the single-direction wind erosion, produced this phenomenon as two important factors. Lastly, the measurement results show the Yardangs which have common pedestal made the Yardang morphological characteristics become even more complex and fluctuated, especially in the description of the Yardangs spatial distribution pattern. Through interpretation and quantitative analysis, we expect this phenomenon would attract attention. By taking it into consideration, analysis of Yardangs which have common pedestal may help us improve the Yardangs' morphological measurement, understand more about Yardangs development, and discuss the various causes of Yardangs' morphological diversity.

Keywords: Yardang; aeolian erosion; common pedestal phenomenon; Lop Nur

1 Introduction

1.1 Study Area and Data Collection

The study area is located in the Lop Nur region of Xinjiang, China [Figure 2: see original paper]. The region has an extremely arid desert climate with an average annual temperature of 11.5°C and annual precipitation of only 17 mm, while annual evaporation reaches 1400 mm [14]. The area is characterized by strong wind erosion, with wind being the primary geomorphic agent [15-16].

Through UAV aerial photogrammetry, we obtained high-resolution images of Yardang landforms in the study area. Using the Structure from Motion (SfM) algorithm, these images were processed to generate a Digital Elevation Model (DEM) with 0.05 m resolution [20]. The UAV system used was a DJI Inspire 1 equipped with a Zenmuse X3 camera [Figure 1: see original paper]. The flight altitude was maintained at approximately 150 m, with 70% forward overlap and 70% side overlap between images.

[Figure 1: see original paper] Location of the sites photographed by UAV within the study area
[Figure 2: see original paper] Yardangs which have common pedestal phenomenon

1.3 Measurement Parameters of Yardangs

Based on field investigation and DEM data, we defined three key morphological parameters for Yardangs with common pedestal: height (H), length-width ratio (L/W), and spatial distribution pattern. The pedestal body was measured separately from the Yardangs on its surface.

The height of pedestal bodies ranges from 0.49 m to 30.12 m, with an average of 6.6 m. Their lengths range from 2 m to 148 m, and widths from 3 m to 30 m [13]. For the Yardangs on the pedestal surface, heights range from 0.17 m to 6.98 m (average 1.63 m), lengths from 0.05 m to 6.143 m (average 0.58 m), and L/W ratios from 2.33 to 5.79 (average 4.12) .

Measurement parameters of Yardangs

1.4 Morphological Characteristics

Statistical analysis shows that 68% of Yardang heights are less than 2 m. The pedestal bodies show a height distribution concentrated at 1 m intervals, with 85% of frequencies falling within the 0-2 m range. The L/W ratios of Yardangs mainly range from 3:1 to 5:1, accounting for 55% of the total.

The Yardangs with common pedestal exhibit a two-tiered structure [Figure 3b: see original paper]. The upper tier consists of small Yardangs formed by wind erosion on the pedestal surface, while the lower tier is the pedestal body itself. The L/W ratios show a bimodal distribution, with peaks at 4:1 and 2.5:1-6:1.

2 Morphological Characteristics Analysis

2.1 Height Distribution Characteristics

We measured 51 pedestal bodies and 123 Yardangs on their surfaces using DEM data. The pedestal body heights range from 4.7 m to 210.43 m (average 37.19 m), with lengths from 2.5 m to 148 m. The Yardang heights range from 0.66 m to 15.54 m (average 4.39 m), lengths from 0.19 m to 17.54 m (average 3.21 m), and L/W ratios from 3.48 to 18.8 (average 8.02) [Figure 4a: see original paper].

The height-frequency distribution shows that 43% of pedestal bodies are in the 5-15 m range, while 52% are below 1 m. Yardang heights are predominantly in the 0-20 m range (87% frequency), with L/W ratios concentrated between 7:1 and 9:1 (45% frequency) [Figure 4b: see original paper].

[Figure 3: see original paper] Morphological characteristics of Yardangs which have common pedestal
[Figure 4: see original paper] Morphological characteristics of the pedestal bodies

2.2 Length-Width Ratio Characteristics

The L/W ratio is a crucial parameter for describing Yardang morphology. Previous studies by Fox et al. [8-9] and Halimov [10] established that typical Yardang L/W ratios range from 3:1 to 5:1. Our measurements of 112 Yardang samples confirm this, with most L/W ratios falling between 3:1 and 5:1 [Figure 7: see original paper].

The L/W ratio reflects the degree of wind erosion and development stage. Higher ratios indicate more elongated shapes formed by stronger unidirectional winds. The common pedestal Yardangs show similar L/W distributions to classic whaleback Yardangs, suggesting they undergo comparable wind erosion processes.

[Figure 7: see original paper] Variation characteristics of length-width (L/W) ratio of Yardangs

2.3 Spatial Distribution Pattern

The spatial distribution of Yardangs on pedestal surfaces shows non-random clustering [Figure 8a: see original paper]. The mean distance (MD) between adjacent Yardangs ranges from 5 m to 45 m, with 85% of distances falling between 5 m and 20 m. This clustering pattern suggests that micro-topography and local wind dynamics influence Yardang formation.

The distribution density varies with pedestal size and height. Larger pedestals tend to host more Yardangs with greater spacing, while smaller pedestals show denser Yardang arrangements [Figure 8b: see original paper]. The spatial pattern reflects the interaction between wind erosion intensity and the erodibility of pedestal surface materials.

[Figure 8: see original paper] Variation characteristics of mean distance (MD) of Yardangs

3 Discussion

3.1 Measurement Methodology

Our UAV-based photogrammetry approach provides high-resolution topographic data for quantitative morphological analysis. The SfM algorithm enables accurate DEM generation from overlapping aerial images, allowing precise measurement of Yardang parameters at centimeter-scale resolution.

The two-tiered measurement strategy—separating pedestal bodies from surface Yardangs—reveals the hierarchical nature of this landform assemblage. This method improves upon traditional field measurements by capturing complete morphological information across scales.

3.2 Implications for Yardang Development

The common pedestal phenomenon represents a unique stage in Yardang evolution. It forms when wind erosion penetrates a resistant stratigraphic layer, creating a pedestal, while simultaneously eroding the overlying less-resistant layer to form smaller Yardangs. This process requires specific conditions: (1) alternating strata with contrasting erosion resistance, and (2) sustained unidirectional winds.

The similarity in L/W ratios between common pedestal Yardangs and classic Yardangs suggests convergent morphological evolution under similar wind regimes, despite differences in scale and substrate.

3.3 Significance for Morphological Diversity

The common pedestal structure adds complexity to Yardang landscapes, creating nested hierarchies of erosion forms. This phenomenon challenges traditional

classification systems and requires new parameters (e.g., pedestal coverage ratio, multi-scale L/W ratios) for comprehensive description.

Understanding this pattern helps explain the extreme morphological diversity in Lop Nur and provides insights into the stratigraphic controls on wind erosion landform development. Future research should investigate the temporal evolution of these features through repeated surveys.

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Note: Figure translations are in progress. See original paper for figures.