Analysis of Grain Size Characteristics of Climbing Dunes in Dingjie Area, Tibet (Postprint)

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Abstract

Through analysis of morphological parameters, grain size composition, and grain size parameters of surface sediments from typical climbing dunes in the Dingjie area of Tibet, the grain size characteristics are revealed. The results indicate: (1) The surface sediments of climbing dunes are dominated by fine sand and medium sand, with lesser amounts of very fine sand, and contain small quantities of silt and coarse sand, but no clay components. (2) The mean grain size of the dunes ranges from 1.98 to 2.41 Φ, the sorting coefficient ranges from 0.45 to 0.75 (indicating moderate sorting), the skewness ranges from 0.01 to 0.12 (displaying near-symmetrical to positively skewed distribution), and the kurtosis ranges from 0.94 to 1.01 (exhibiting a moderately peaked distribution). (3) From samples PPSQ1 to PPSQ6, with increasing height and distance, the mean grain size of surface sediments first decreases and then increases, while sorting continuously improves. (4) The surface sediments of climbing dunes are primarily derived from floodplains. (5) Comparison with climbing dunes in the Yarlung Tsangpo River and East Kunlun Mountains regions reveals that dunes in the Dingjie area have relatively coarser grain sizes and better sorting, which is primarily the combined result of provenance and aeolian sorting processes.

Full Text

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Abstract:
Climbing dunes are widely distributed in the Dinggye area of Zigaze Prefecture, Tibet, China, and the grain size characteristics of their surface sediments are of great significance for exploring the development process of sand dunes. In this paper, six climbing dunes were sampled in the area. To reveal the grain size characteristics, the study analyzed the morphological parameters, mechanical composition, and grain size parameters of the dune surface sediments, which provide a theoretical basis for revealing the climbing dune' s formation mechanism on the Qinghai-Tibet Plateau. Current research has mainly concentrated on climbing dunes in coastal areas rather than those in arid regions. Studying the climbing dunes on the Qinghai-Tibet Plateau can explore the grain size characteristics of climbing dunes in inland arid regions. The results are summarized as follows: The surface sediments of climbing dunes are mainly composed of medium sand and fine sand, accounting for 55.25% and 32.73% respectively. Fine sand accounts for 9.98%. The content of silt and coarse sand is less than 3%. The frequency curves of grain size show an approximate symmetrical unimodal distribution, and the sand dunes have a slender tail on one side of the fine particles. The range of Mz is 1.98–2.41Φ and the mean value is 2.23Φ. The range of is 0.45–0.75 and the mean value is 0.57, which indicates good sorting. The range of SK is 0.01–0.12, the mean value is 0.04, and kurtosis is positive. The range of KG is 0.94–1.01, the mean value is 0.97, and kurtosis presents a single peak. As the height and distance increase, the Mz of the climbing dunes tends to become finer first and later coarser, while the sorting becomes better. The variation trend of grain size characteristics of different parts of sand dunes is as follows: The Mz from the windward and the leeward slope to the top of the leeward is generally coarser, and the sorting is worse. The variation trend of SK is from near symmetry to positive deviation, and the KG has a medium sharp peak. The reason for its differentiation is mainly affected by the source and wind sorting. Analysis of the sediment sources reveals that the dune surface sediment is mainly from the floodplain. Comparing with the climbing dunes in the Yarlung Tsangpo River and the eastern Kunlun Mountains, the surface sediments of the climbing dunes in the study area are coarser and the sorting is relatively better. This indicates that the climbing sand dunes are closer to the source area, and the wind sorting effect is stronger in Dinggye than in the other two areas.

Keywords: climbing dune; grain size characteristics; Dinggye area

1. Study Area and Sampling Sites

The study area is located in Dinggye County, Shigatse Prefecture, Tibet Autonomous Region, China (27°48 -29°10 N, 86°20 -88°21 E) [Figure 1: see original paper]. The region has a typical plateau temperate monsoon climate, with an average annual temperature of 2°C, January average temperature of -8°C, and July average temperature of 12°C. Annual precipitation is approximately 236 mm, with about 70% concentrated in July and August. The annual evaporation exceeds 3000 mm, and the wind speed averages 1–2 m/s. The climbing dunes are mainly distributed along the valleys of the Pengjiu River and its tributaries, with elevations ranging from 2042 m to 6829 m. The dune heights vary between 4–47 m, and the slope angles range from 15° to 35°. The dunes are primarily composed of quartz and feldspar, with minor amounts of rock fragments and mica.

Six typical climbing dunes were selected for sampling, designated as PPSQ1 through PPSQ6. At each dune, surface sediment samples were collected from the windward slope, leeward slope, and dune top. The sampling was conducted in October 2017, with 2–3 samples taken from each dune, totaling 18 samples .

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2. Methods

Grain size analysis was performed using a Malvern Mastersizer 2000 laser particle size analyzer, with measurement range of 0.02–2000 m and repeat measurement error less than 2%. The Folk and Ward graphical method was used to calculate grain size parameters including mean grain size (Mz), sorting coefficient ( ), skewness (SK), and kurtosis (KG) [Figure 2: see original paper].

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3. Results

3.1 Mechanical Composition The mechanical composition analysis shows that the surface sediments of climbing dunes are dominated by medium sand (0.25–0.5 mm) and fine sand (0.125–0.25 mm), accounting for 55.25% and 32.73% of the total, respectively. Very fine sand (0.063–0.125 mm) comprises 9.98%, while silt (<0.063 mm) and coarse sand (>0.5 mm) together account for less than 3% . The grain size frequency distribution curves exhibit unimodal characteristics with approximate symmetry and a slender tail extending toward the fine particle side [Figure 3: see original paper].

3.2 Grain Size Parameters The grain size parameters of the climbing dune surface sediments show the following characteristics: The mean grain size (Mz) ranges from 1.98Φ to 2.41Φ, with an average of 2.23Φ. The sorting coefficient ( ) varies between 0.45 and 0.75, with a mean of 0.57, indicating well-sorted sediments. The skewness (SK) ranges from 0.01 to 0.12, with a mean of 0.04,

showing positive skewness. The kurtosis (KG) ranges from 0.94 to 1.01, with a mean of 0.97, indicating a moderately peaked distribution .

3.3 Spatial Variation of Grain Size Characteristics From the windward slope to the leeward slope and dune top, the mean grain size shows a trend of becoming coarser, while sorting becomes poorer. The skewness changes from near-symmetrical to positive skewness, and the kurtosis shows a medium peak [Figure 4: see original paper]. With increasing dune height and distance from the river channel, the mean grain size initially becomes finer and then coarser, while sorting improves. The variation in grain size parameters at different dune positions reflects the combined effects of sediment source and wind sorting processes [Figure 6: see original paper].

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4. Discussion

4.1 Sediment Source Analysis The grain size characteristics of the climbing dunes indicate that the sediment is primarily derived from the floodplain deposits of the Pengjiu River. The well-sorted nature of the sediments suggests effective wind sorting during transport. Compared with climbing dunes in the Yarlung Tsangpo River valley and the eastern Kunlun Mountains, the Dinggye dunes have coarser sediments and better sorting, indicating they are closer to the sediment source and subject to stronger wind sorting effects .

4.2 Formation Mechanism The formation of climbing dunes in the Dinggye area is controlled by three main factors: (1) abundant sediment supply from the river floodplain, (2) strong valley winds that transport and sort the sediment, and (3) topographic constraints that force dunes to climb slopes. The unimodal grain size distribution and good sorting indicate that wind action is the primary sorting mechanism, while the coarse grain size suggests a proximal sediment source.

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5. Conclusions

(1) The surface sediments of climbing dunes in the Dinggye area are mainly composed of medium sand (55.25%) and fine sand (32.73%), with minor very fine sand (9.98%) and negligible silt and coarse sand (<3%). The grain size frequency curves show unimodal, approximately symmetrical distributions with a slender fine tail.

(2) The mean grain size (Mz) ranges from 1.98Φ to 2.41Φ (mean 2.23Φ). The sorting coefficient ( ) ranges from 0.45 to 0.75 (mean 0.57), indicating well-sorted sediments. The skewness (SK) ranges from 0.01 to 0.12 (mean 0.04) with positive values, and the kurtosis (KG) ranges from 0.94 to 1.01 (mean 0.97), showing a single peak distribution.

(3) Spatial variation analysis shows that grain size characteristics change systematically from the windward slope to the leeward slope and dune top. With increasing height and distance, the mean grain size becomes finer initially and then coarser, while sorting improves. This pattern reflects the influence of sediment source proximity and wind sorting intensity.

(4) Sediment source analysis indicates that the dune material is primarily derived from the river floodplain. Compared with climbing dunes in the Yarlung Tsangpo River valley and eastern Kunlun Mountains, the Dinggye dunes have coarser sediments and better sorting, suggesting they are closer to the source area and experience stronger wind sorting effects.

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