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Grain size characteristics in the Hexi Corridor Desert

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ABSTRACT

This study investigates grain-size characteristics on the dune surfaces in the Hexi Corridor Desert, a little-researched area of northwestern China. Grain-size parameters (mean, standard deviation, skew, and kurtosis) were determined on dune surfaces at the windward toe, stoss, crest, and leeward toe. Multiple discriminant analyses were applied to distinguish deposition environments. Results indicated that the aeolian sediment in the Hexi Corridor Desert is mainly composed of very fine and fine sand (0.07 mm ± 0.01 to 0.24 mm ± 0.06). Sorting improves as grain size becomes finer. However, mean grain size increased with skew, but decreased with kurtosis. There is a good negative correlation between skew and sorting. However, there is no correlations between sorting and skew, and skew and kurtosis. The sediment deposition environment includes aeolian, lacustrine and alluvial sediments. The lacustrine sediment provides the source material for the formation and development of dune windward toes and stoss, but the aeolian sediment provides the source material for the formation and development of dune crest and leeward toes. Based on log-probability of grain size distributions, aeolian sediments in dune networks are composed of two distinct saltation populations. Sand sources affect the mean grain size changed from upwind to downwind, medium sand decreases and fine sand, very fine sand, and silt and clay increase, sand sediment become finer from upwind to downwind. There are three types of mean sand grain sizes over dune surface: coarser crest (69%), finer crest (24%), or no difference (7%) with windward slope and leeward slope.

1. Introduction

Sediment grain size distribution is important in aeolian research, as grain size controls creep, reptation, saltation, and suspension in dune formation and development. At present, three models are used to describe mean grain-size patterns for desert sand dune sediments: finer crest, coarser crest, and no difference (Lancaster, 1986; Livingstone and Warren, 1996). Studies on sediment grain size and distribution on dune surfaces have included reversing dunes (Lancaster et al., 2002), crescent dunes (Ahlbrandt, 1979; Qian et al., 2011), transverse dunes (Ha and Wang, 1996; Qian et al., 2011), dune networks (Ha, 1998; Ha et al., 1999), echo dunes (Qian et al., 2012), and linear dunes (Lancaster, 1986; Wang et al., 2003). Many studies have focused on grain size and distribution in sand seas such as China's Taklimakan Sand Sea (Wang et al., 2003), Tengger Desert (Ha and Wang, 1996), Kumutagh Desert (Dong et al., 2011), Badain Jaran (Qian et al., 2011), and Ejina desert basin (Zhu et al., 2014), and in southern Africa's Namib Desert (Lancaster, 1995) and Kalahari Desert (Thomas, 1988). Good examples of transportation grain size distribution studies include Williams' (1964) wind tunnels studies and field studies by Chen and Fryrear (1996), Arens et al. (2002), Farrell et al. (2012), and Zhang and Dong (2014).

Over a large sand sea, grain size distribution is largely controlled by wind velocity, dune patterns, and dune formation source material characteristics. However, over an individual dune surface sand grain size is largely controlled by the range of saltation grain size, the falling or sliding effect of the leeside slope, the air flow over the dune surface, and the grain-size distribution of the source sediment and associated geological processes (Livingstone et al., 1999). Sediment grain size characteristics are not only a reflection of the effects of wind on source material transportation and sorting, but also a reflection of how land surface characteristics (such as geomorphology or vegetation) affect aeolian transport. During sand sea formation and development, sediment material can be transported downwind by wind. Coarser, heavier sediments remain in place, but finer sediments can be transported over long distances. Many studies show that as transport distances increase, the mean grain size becomes finer and sorting becomes easier

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(Lancaster, 1986; Mischke, 2005; Dong et al., 2011; Qian et al., 2011); however, this finding is not universal. For instance, Chen (1993) and Zhu et al. (2014) found no relationship between grain size and transport distance, and Qian et al. (2011) found that the mean grain size becomes finer or does not change with distance in the Badain Jaran Desert.

This study focuses on the Hexi Corridor Desert which is located in the middle and western parts of Gansu Province (Fig. 1). The Hexi Corridor is small compared with other Chinese deserts (about 1100 km^2), and accordingly, little research has been done on this desert. However, the Hexi Corridor Desert is important in Chinese desertification research. First, this desert area lies in the middle of the Heihe River Basin, where a combination of natural factors (climate change) and human activities have degraded the regional ecosystem; as a result the Hexi Corridor has attracted considerable attention from the Chinese government. Second, the distinctive characteristics of the Hexi Corridor's aeolian geomorphology have developed as a result of regional wind regimes, sediment supply, geometry of the sediment source and deposition areas, and topography; the relative impact of each of these factors on dune formation and development differs among regions. This study can provide key information on the characteristics of regional aeolian geomorphology and also support efforts to prevent further desertification and help control sandstorms.

The aims of the study are to determine the sediment grain size distribution in the Hexi Corridor Desert, to discuss the spatial differences in grain size distributions, and to discuss the grain size distribution with transport distance. This will provide useful reference data on the formation of dune networks.

2. Study region and methods

2.1. Study region

The desert areas of the Hexi Corridor, which formed at least 0.85 Ma (Guan et al., 2011), and sparsely distributed in an area between two large continental rivers, the Baida and the Heihe, and in the lower reaches of three smaller continental rivers, the Bailang, Maying, and Fengle. The lower reaches of these rivers contain large deposits of alluvial sediments, the source material for downwind dune formation and development (Fig. 1). Research by Zhang et al. (2002) and Wang et al. (2011) on the Tengger Desert (adjacent to the study region) indicated that, because of climate change, the water levels in the palaeolake present in the area

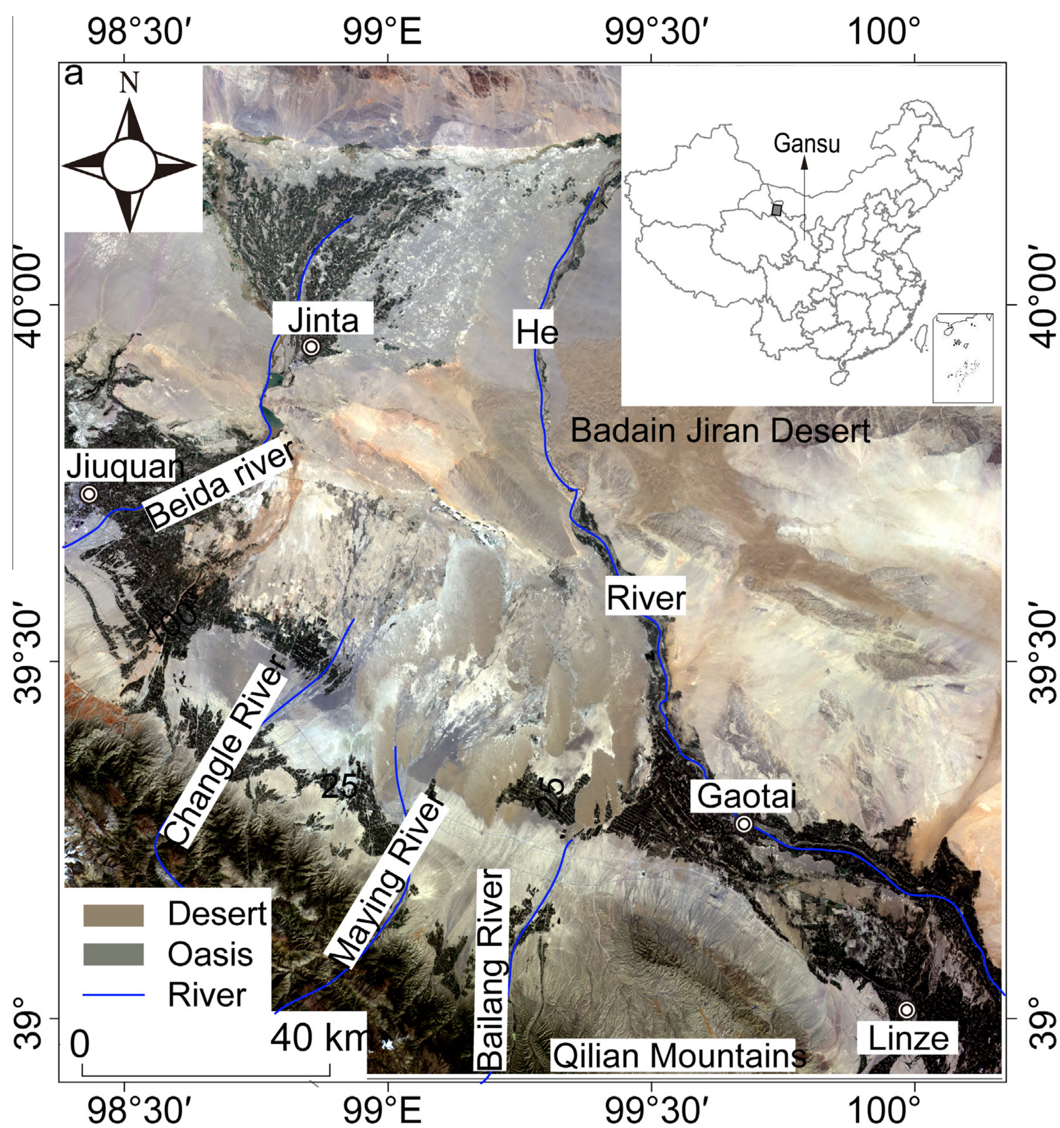

Fig. 1. (a) Study region location (b) potential sand transport, and sand transport direction in the study region.