Aeolian Research 13 (2014) 1–6

Contents lists available at ScienceDirect

Aeolian Research

journal homepage: www.elsevier.com/locate/aeolia

Grain-size study of aeolian sediments found east of Kumtagh Desert

Benli Liu [a,*], Jianjun Qu [a,b], Duihu Ning [c], Yanhong Gao [d], Ruiping Zu [a], Zhishan An [a]

[a] Dunhuang Gobi Desert Research Station, Cold and Arid Regions Environmental and Engineering Research Institute/Key Laboratory of Desert and Desertification, Chinese Academy of Sciences, Lanzhou 730000, China
[b] Gansu Center for Sand Hazard Reduction Engineering and Technology, Lanzhou 730000, China
[c] International Research and Training Center on Erosion and Sedimentation, Beijing 100048, China
[d] Key Laboratory for Land Surface Process and Climate Change in Cold and Arid Regions, Chinese Academy of Sciences, Lanzhou 730000, China

ARTICLE INFO

Article history:
Received 27 July 2013
Revised 16 January 2014
Accepted 16 January 2014
Available online 21 February 2014

Keywords:
Deposition environment
Dunhuang
Grain size analysis
Kumtagh Desert

ABSTRACT

A grain-size study was conducted on the surface sediments found east of Kumtagh Desert and its connected geomorphic units, such as the wadi, wetland, oasis, and alluvial fan. The frequency, cumulative curves, and scatter diagrams of four grain-size parameters, namely, the mean grain size, sorting, skewness, and kurtosis, were plotted to study the grain-size characteristics of each sediment. Multiple discriminant analyses were applied to distinguish the deposition environments. Results indicated large diversities in the sediments from different environments. The aeolian sediments from the sandy desert and the gobi land show uniform characteristics or homogeneous changes. The sand resources from the eastern part of the desert can be considered as the alluvial deposits from the southern Altyn Tagh Mountain carried by several erosion gullies. Meanwhile, the western Mingsha Megadune inherited sediments from the nearby Danghe River. The discriminant functions proposed by Sahu can distinguish the deposition process. However, these functions lose their accuracy when applied to heavily eroded aeolian and gobi sediments.

1. Introduction

The grain-size study is a basic and popular method used to determine the sedimentary environment, the dynamics, deposition mechanism, and the development of the aeolian landforms, as well as the transportation and sorting of aeolian particles (Sahu, 1964; Visher, 1969; Barnorff-Nielsen and Christiansen, 1988; Wang et al., 2003; Farrell et al., 2012; Guan et al., 2013). Over the past century, numerous measurement methods and analysis models were developed for grain-size research (Bagnold, 1937; Konert and Vandenberghe, 1997; Flemming, 2007; Vandenberghe, 2013). The grain-size study of a certain aeolian unit, usually found in the desert or loess land, has been carried out worldwide from a single dune level to a sand sea level (Wang et al., 2003).

The Kumtagh Desert, located in the northwest inland of China, is unique because of its feather-like dunes (Dong et al., 2008; Wang et al., 2009). This desert contains most of the aeolian landform types, including deposition units, such as flat sand surfaces, bush dunes, barchan dunes, grid dunes, linear dunes, star dunes, and their compositions, as well as erosion units, such as yardang, flat gobi, and gravel piles (Dong et al., 2011a). The abundance of landform units makes Kumtagh Desert an ideal place to study arid land geomorphology, and to evaluate arid environments, climate change, and the environmental response of the Qinghai–Tibetan Plateau's uplift. However, the Kumtagh Desert remains the least explored desert in China because of its harsh environment (Dong et al., 2008). Only after the first scientific investigation in 2004 (E et al., 2006) did researchers have the opportunity to collect samples and study the mineralogical, geochemical, and grain-size characteristics of desert sands and their potential sources (Wei et al., 2007; He et al., 2009; Xu et al., 2011). Despite the insufficient research history and quantity, previous research mainly focused on sand sediments within the desert, while the surrounding source areas were generally overlooked. The study of sediments beyond the desert border is necessary because the conditions of source areas serve a key function in the understanding of the formation, development, and migration of the desert.

In this study, the grain-size analysis of surface aeolian sediments was conducted on the eastern part of Kumtagh Desert and its connected geomorphic units, such as wadi, wetland, oasis, and alluvial fan. This study aims to investigate the variations of surface sediments from different landforms, as well as to evaluate their sources, migration, and circulation in a typical arid region.

* Corresponding author. Address: No. 320 Donggangxi Road, Lanzhou 730000, Gansu, China. Tel.: +86 931 4967562.
E-mail address: liubenli@lzb.ac.cn (B. Liu).

http://dx.doi.org/10.1016/j.aeolia.2014.01.001
1875-9637/

2. Material and methods

2.1. Study area

Kumtagh Desert covers an area of 2.28×10^4 km^2 and is located east of the Tarim Basin, northwest of the Lop Nur Depression, and at the north edge of the Qinghai–Tibetan Plateau. The prevailing wind direction is northeast, followed by northwest. The eastern part of the desert touches the Xihu (which is translated as "lake at the west") Wetland National Nature Reserve, which protects the Dunhuang Oasis, wherein the world-renowned Mogao Grottos and Crescent Spring are located. The Xihu Reserve is a natural desert wetland, but over the past 60 years, it has been eroded by climate change and wind-blown sand problem from 2500 km^2 to 980 km^2.

The southern arm of the Kumtagh Desert extents eastward, covering a low branch of the Altyn Tagh Mountain found at the north edge of the Qinghai–Tibetan Plateau. This mountain branch, also known as the southeast edge of the Kumtagh Desert, is cut by several seasonal streams (i.e., erosion gullies) originating from the alluvial fan of the Altyn Tagh Mountain and vanishing toward the Xihu Wetland. Barchan chains can be found over this mountain branch. Different underlying sediments can be observed, indicating that the sand materials are from outside sources. Further east, Danghe River, which is the water source of Dunhuang Oasis, separates the Kumtagh Desert region from another sand dune area, i.e., the Mingsha Megadune, the material sources of which have yet to be confirmed (Fig. 1).

2.2. Samples and analytical methods

Twenty-two sediment samples weighing 500 g each were collected from the six types of landform surfaces: A1 to A2 are points from the alluvial fan north of the Altyn Tagh Mountain, whereas A3 and A4 are the original surface sediments in the south and middle part of the mountain branch. G1 to G5 are gobi points from north of the desert to west of the Dunhuang Oasis. K1 to K5 are sandy samples from the flat dunes at the eastern edge of the Kumtagh Desert. In particular, K3 to K5 were obtained from the north, middle, and south of the Altyn Tagh Mountain branch. Sediment M was located in the flat sand on the western edge of the Mingsha Megadune. R1 was located in the upstream watershed of the Danghe River, while R2 was from the downstream flood zone of the Danghe River to the west of Sediment M. R3 was located in the wadi surface periphery of the Xihu Wetland. Finally, V1 to V4 were vegetated points from shrubland in the yardang (V1), Xihu Wetland (V2), north of the Dunhuang Oasis (V3), and east of the Dunhuang Oasis (V4) (Fig. 1).

Grain-size distribution data were determined to be between 0.02 and 2000 μm by using a Malvern Mastersizer laser grain-size analyzer, which resulted in a better than 1% accuracy and better than 1% variation in terms of reproducibility. Values were converted to the Φ (phi) unit. Before each measurement, chemical pretreatment following the procedure by Konert and Vandenberghe (1997) was performed to isolate the discrete particles and provide evenly dispersed suspension particles. Grain-size parameters were calculated based on the Folk and Ward method (Folk and Ward, 1957). The discrimination functions from Sahu (1964) were used to distinguish the sedimentary environments of these aeolian particles.

3. Results and discussions

3.1. Grain-size distribution

The classification of the different grain sizes intuitively expresses the fraction of each grain-size group. The frequency and cumulative plots of the grain-size distribution provide useful information on particle components and their sedimentary conditions. The three main sediment transport patterns, namely, suspension, saltation, and surface creep, can be observed from the curves (Visher, 1969).

The grain-size distributions of the sediments from the six environments are shown in Table 1, and their frequency and cumulative curves, based on the logarithmic particle size method proposed by Udden (1914) and Wentworth (1922), are given in Fig. 2. The previous grain-size parameters of the sand from the Eastern Kumtagh Desert (EK) (He et al., 2009) and the crescent dunes in the Taklimakan Desert (CT) (Wang et al., 2003) were compared with the results.

The grain-size distributions clearly differed among different environments. The alluvial sediments from the Altyn Tagh Mountain (A1 and A2) showed no dominant size group and similar

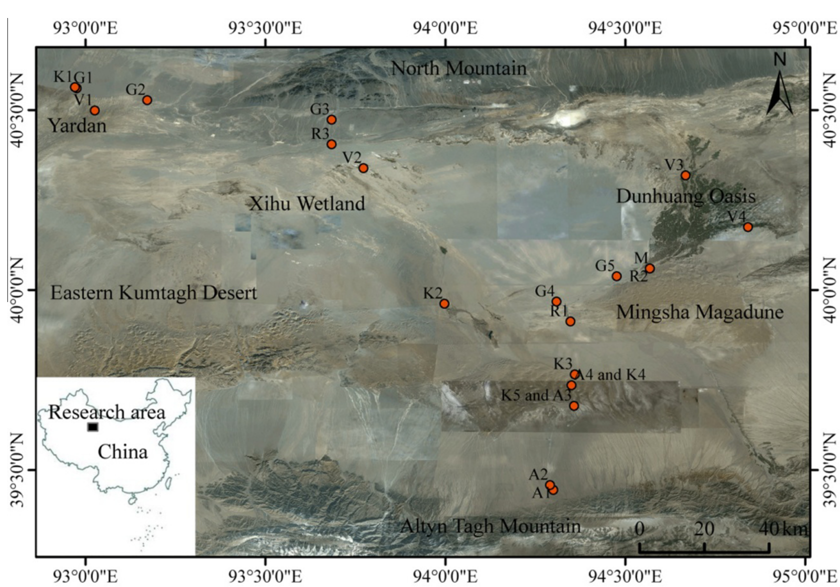

Fig. 1. Sampling sites of the study. Image data taken from Google Earth.