Aeolian Research 34 (2018) 18–26

Contents lists available at ScienceDirect

Aeolian Research

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

Geochemical characteristics of the fine-grained component of surficial deposits from dust source areas in northwestern China

Xunming Wang[a,b,*], Ting Hua[c], Bingqi Zhu[a], Lili Lang[a], Caixia Zhang[c]

[a] Key Laboratory of Water Cycle and Related Land Surface Processes, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China

[b] University of Chinese Academy of Sciences, Beijing 100049, China

[c] Key Laboratory of Desert and Desertification, Cold & Arid Regions Environmental & Engineering Research Institute, Chinese Academy of Sciences, Lanzhou 730000, China

ARTICLE INFO

Keywords:
Dust aerosol source area
Surface fine-grained deposits
Geochemistry
Northwestern China

ABSTRACT

Identifying the geochemical characteristics of the surface fine-grained sediments in the mid-latitude deserts of Asia is essential for interpreting and tracing the aeolian sediments deposited in the far-away regions. The geochemical characteristics of ground surface fine-grained deposits (fractions < 63 μm in diameter) at five potential dust source areas (gobi deserts) of northwestern China, including the northern Qinghai-Tibet Plateau, the Tarim Basin, the Turpan-Hami Basin, the Hexi Corridor, and the Ala Shan Plateau, were investigated. The analytical results show that there are significant spatial differences in the geochemical characteristics among these regions. Geographically, the high contents of P, Ti, La, Ce, and Nd in the Tarim Basin, Mn, Co, Cu, Zn, Ga, Sr, Pb, and CaO in the Turpan-Hami Basin, Rb, Ba, Al_2O_3, Na_2O, and K_2O in the Hexi Corridor, and V, Cr, Ni, As, Y, Zr, Nb, SiO_2, Fe_2O_3, and MgO in the Ala Shan Plateau, are identified. The spatial differences in the geochemical characteristics may be integrated signatures resulted from the differences in the fine-grained sediments' formation, provenance, transportation, and deposition dynamics related to the local geologic and climatic settings. These mixed signatures in compositions may result in deviations in interpreting aeolian deposits far from the source regions, and consequently, affect their environmental implications as the proxies used in the past climate reconstructions.

1. Introduction

Aeolian deposits, especially in arid and semiarid desert regions, are significant components of the earth surface system (Hesse, 1994; Yung et al., 1996; Goudie and Middleton, 2001; Kurtz et al., 2001; Porter, 2001; Thomas and Wiggs, 2008; Winckler et al., 2008; Sugden et al., 2009; Dansie et al., 2018). Arid and semiarid desert region provides a large proportion of global dust production, which has a significant impact on the Earth system such as radiative balance, hydrological and biogeochemical cycles, and climate states (Arimoto, 2001; Hara et al., 2006; Maher et al., 2010). About 40% of global dust aerosols originates from surface fine-grained deposits in Central Asia (Zhang et al., 1999, 2003; Gong et al., 2003; Zender et al., 2003; Liu et al., 2016) with the regions mainly including the northern Qinghai-Tibet Plateau (Pullen et al., 2011), the Tarim Basin (Zhang et al., 1997, 2008; Bory et al., 2002; Xuan and Sokolik, 2002; Xuan et al., 2004), the Hexi Corridor (Derbyshire et al., 1998; Wang et al., 2005), and the Ala Shan Plateau (Wang et al., 2006, 2008, 2017b). After being transported from those source regions, these fractions of material may result in huge accumulations in the Chinese Loess Plateau (Liu, 1985), which will provide source of aeolian materials that regulate phytoplankton growth in North Pacific (e.g., Bishop et al., 2002; Tsuda et al., 2003) and particles in ice cores (e.g., Bory et al., 2003). After being subjected to post-depositional weathering, the aeolian deposits originating from these regions were also employed as proxies of monsoons intensity (Chen et al., 2007), precipitation, wind regime, and chemical weathering changes (Maher and Thompson, 1991; Weiss et al., 2002; Jeong et al., 2008; Hao et al., 2010; Sun and Zhu, 2010; Huang et al., 2013).

In addition, by comparative analysis methods, the geochemical characteristics of the surface sediments collected in these regions were also employed to determine the potential dust source areas in different parts of Central Asia, or to infer the provenance of the loess (e.g., Chen et al., 1999, 2005, 2006, 2007; Sun, 2005; Chavagnac et al., 2008; Rao et al., 2009; Sun and Zhu, 2010; Wang et al., 2017b). However, the

* Corresponding author at: Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, 11A Datun Road, Beijing 100101, China.

E-mail address: xunming@igsnrr.ac.cn (X. Wang).

https://doi.org/10.1016/j.aeolia.2018.07.004
Received 1 June 2018; Received in revised form 27 July 2018; Accepted 27 July 2018
1875-9637/

heterogeneity in geochemical characteristic of the surface sediments may result in difficulties for sourcing these sediments deposited in areas far away from the source regions, and consequently, may lead to discrepancies in interpretating the significance of these aeolian sediments as proxies of past climate and environmental changes.

Poor understanding of the surface sediments in potential source areas of northwestern China hinders our ability to identify the dust aerosols transported from different source areas, and decreases our confidence in using these sediments as proxies of past climate changes and as the tracers of the dust aerosol sources. Therefore, by field surveys and geochemical characteristic analysis on the surface samples collected in these regions, we discuss the spatial differences in the chemical characteristics of surface fine-grained deposits of the northwestern China. The objective of this study is to provide supports for assessing the heterogeneity on the geochemical characteristics of these sediments, thereby improving our understanding of its significance on past climate change reconstructions based on sediments that have been affected by Central Asian dust aerosols.

2. Sampling and analytical methods

The study areas (36°N to 44°N, 82°E to 104°E) mainly include the northern Qinghai-Tibet Plateau, Tarim Basin, Turpan-Hami Basin, Hexi Corridor, and the Ala Shan Plateau (Fig. 1), which are the potential dust aerosol source areas and the important sediment sinks of Chinese Quaternary deposits in Central Asia (Wang et al., 2008). In the study areas, the annual precipitation varies between 50 and 200 mm with potential evaporation exceeding 2000–3500 mm, and the average wind velocity ranges from 2.0 to 4.0 m/s. More details of the regional environment settings have been described in Wang et al. (2005, 2006, 2010). In these regions, the gobi deserts, defined as “wide, shallow basins of which the smooth rocky bottom is filled with sand, silt or clay, pebbles or, more often, with gravel” (Cable and French, 1943; Cooke, 1970), are developed extensively. On gobi desert surfaces, the processes that create fine materials include physical weathering (McFadden et al., 2005), salt weathering (Goudie, 1986, 1999), frost weathering, fluvial comminution, glacial grinding (Wright et al., 1998), and aeolian processes (Bullard et al., 2004). The abundance of these fines makes the gobi deserts highly vulnerable to dust generation. Considering the gobi deserts are the dominant dust emission landscapes in the region (e.g., Derbyshire et al., 1998; Wang et al., 2008), we only sampled from gobi deserts for further analysis in order to facilitate comparisons within the same landscape (Fig. 2). Each sample was obtained to a depth of 1 cm in a 20 × 20 cm area, and the principal sampling criteria included the presence of a smooth and intact (sealed) surface, a range of gravel cover values among the samples, no vegetation cover, the absence of biological or physical crusts, and no sign of anthropogenic impacts (Wang et al., 2012). Because the elemental composition and mineralogy characteristics of the surface samples may vary at each site, we collected ~10 samples (within 200 m from the central sampling point) at each site. After the field works, in total 629 gobi surface samples at 66 sites were employed for further analysis (Fig. 1).

All samples were air-dried and the surface fine-grained deposits (fractions < 63 μm) were extracted by sieving. These fractions were selected because they are the dominant dust aerosol fractions transported by near-surface winds (Pye and Tsoar, 1990), which account for most of the fractions of sediments deposited in Chinese Loess Plateau and of the fractions collected in ice cores and lake sediments (Liu, 1985). A fully automated sequential wavelength-dispersive X-ray fluorescence (XRF) spectrometer (AXIOS, PANalytical B.V., Almelo, The Netherlands) was employed for element analyses. Concentrations of 28 elements and oxides were determined at the Key Laboratory of Desert and Desertification, Chinese Academy of Sciences: P, Ti, V, Cr, Mn, Co, Ni, Cu, Zn, Ga, As, Rb, Sr, Y, Zr, Nb, Ba, La, Ce, Nd, Pb, SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O, and K_2O. More details of measurement processes and methods have been described in Wang et al. (2012). In addition, in order to reveal spatial trends in the geochemical characteristics in the study area, we used the ordinary Kriging method (Lloyd and Atkinson, 2001) to interpolate between the mean values of each parameter at the 66 sampling sites.

3. Results

Summary of the element/oxide contents of the surface fine-grained deposits in the 66 sites is shown in Table 1. The results show that there are spatial differences in the geochemical characteristics of the surface fine-grained sediments in different regions. Among the 5 regions we investigated, the Tarim Basin has high contents of P, Ti, La, Ce, and Nd, the Tupan-Hami Basin has high contents of Mn, Co, Cu, Zn, Ga, Sr, Pb, and CaO, the Hexi Corridor has high contents of Rb, Ba, Al_2O_3, Na_2O and K_2O, and the Ala Shan Plateau has high contents of V, Cr, Ni, As, Y, Zr, Nb, SiO_2, Fe_2O_3, and MgO (Fig. 3). It also shows that there are relative high contents of Ti, La, and Nd in the Tarim Basin and the Ala Shan Plateau, while there are low contents of Fe in the northern

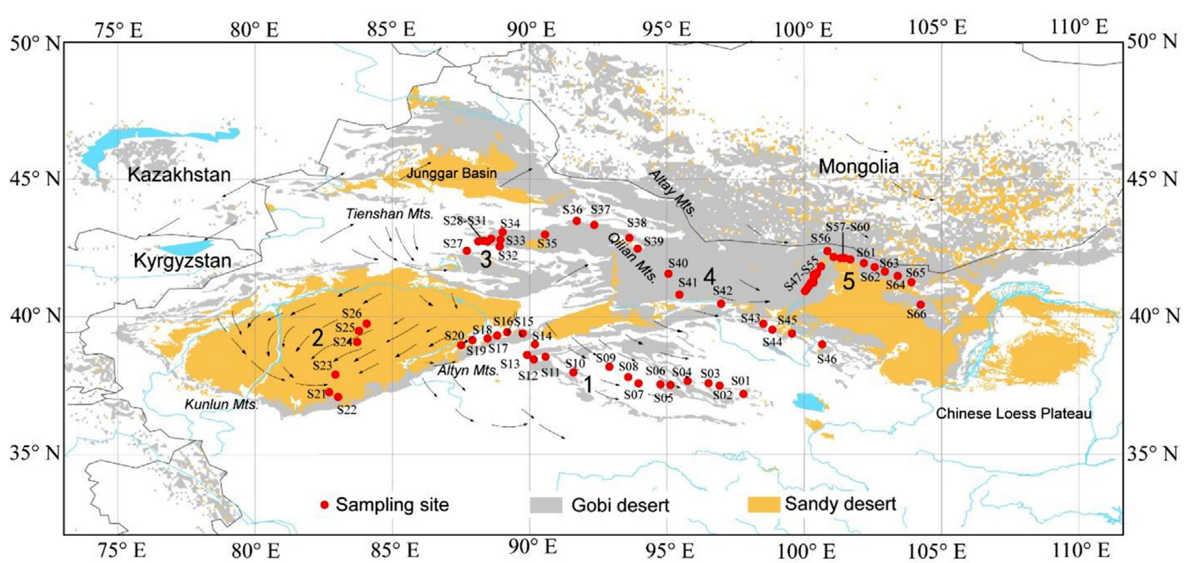

Fig. 1. Location map of the sampling areas. The arrows refer to the dominant wind direction. 1: Northern Qinghai-Tibet Plateau, 2: Tarim Basin, 3: Turpan-Hami Basin, 4: Hexi Corridor, and 5: Ala Shan Plateau.