Chemical Geology 373 (2014) 71–86

Contents lists available at ScienceDirect

Chemical Geology

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

Re–Os isotopic records in Pleistocene loess–paleosol sequences from the Yili Basin, northwestern China

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ARTICLE INFO

Article history:
Received 31 August 2012
Received in revised form 6 February 2014
Accepted 6 February 2014
Available online 15 February 2014

Editor: L. Reisberg

Keywords:
Loess
Paleosol
Rhenium
Osmium
Isotope

ABSTRACT

The Re–Os isotope system is a potentially powerful tool for obtaining information on source regions and transportation processes of aerosols such as mineral dust. Re–Os isotopic systematics were studied in two Pleistocene loess–paleosols exposed at Kuerdenengbulake and Zeketai in the Yili Basin, northwestern China. In the late Pleistocene Malan Loess, $^{187}Os/^{188}Os$ ratios (0.90–1.45) varied inversely with Os abundances (28–61 pg/g). In the middle Pleistocene Lishi Loess section, fluctuations in Os abundances (25–50 pg/g) were accompanied by a limited range of variation in $^{187}Os/^{188}Os$ ratios (generally 1.21–1.40). Four samples of Malan Loess from the Kuerdenengbulake section had higher Os concentrations and less radiogenic $^{187}Os/^{188}Os$, coupled with higher zoisite/tourmaline ratios but uncorrelated with abundances of other minerals, paleomagnetic parameters, grain-size characteristics, major-element composition, or Rb–Sr and Sm–Nd isotopic systematics. The correlation between Os and zoisite/tourmaline ratio suggests that the source material of the loess changed when these samples were deposited, but this change was not evident in the other data in this study. Depth profiles show how Re–Os isotopic compositions varied with age of deposition. By characterizing Os abundances and $^{187}Os/^{188}Os$ ratios of late Pleistocene loess–paleosol samples in the Yili Basin, local paleoclimatic changes occurring over intervals of several thousand years could be identified that had not been found by traditional paleoclimatic proxies.
When the $^{143}Nd/^{144}Nd$ ratio alone cannot distinguish the provenance of global eolian sediments, a combination of $^{143}Nd/^{144}Nd$ and $^{187}Os/^{188}Os$ can sometimes be effective. However, for the Yili Basin's loess–paleosol, the range of $^{187}Os/^{188}Os$ overlapped with ratios in eolian sediments from other areas, offering no improvement over $^{143}Nd/^{144}Nd$ alone in this respect.

1. Introduction

Continental loess–paleosol sequences preserve valuable information regarding past climate changes in the terrestrial environment. Over the past several decades, significant progress has been made in loess–paleosol studies of the monsoon region of China, including the Loess Plateau (Fig. 1), site of the most extensive loess deposits on Earth (e.g., Gallet et al., 1996; Fang et al., 1999; Balsam et al., 2004; Satori et al., 2005; Bloemendal et al., 2008). The Loess Plateau's loess–paleosol sequences record long-term paleoclimate variations caused by fluctuations in the intensity of Asian paleomonsoons over the past ~2.4 to ~22 Ma (e.g., Heller and Liu, 1986; Kukla et al., 1988; Guo et al., 2002). The upper part of the loess–paleosol sequence, deposited during the last glacial period, records Asian paleomonsoon signals on time scales of 1000 years or even shorter; the intensity of these signals is cyclic, with a period comparable to that of Dansgaard–Oeschger (D–O) cycles observed in Greenland ice cores and Heinrich events observed in the North Atlantic (e.g., Porter and An, 1995; Chen et al., 1997; Fang et al., 1999).

Extensive loess deposits also occur in northwestern China and central Asia, where the modern climate is controlled by a westerly wind system. Changes in paleoclimate are recorded in the loess–paleosol sequences in these areas, therefore, may reflect fluctuations in the westerly wind system (Ye, 2001). Comparisons of loess–paleosol records from monsoon-influenced regions such as the Loess Plateau and from westerly-influenced regions such as northwestern China and central Asia may provide valuable information about the mechanisms of hemispheric or global climate evolution, but few studies of loess–paleosols in northwestern China and central Asia have been published (e.g., Ding et al., 2002; Jia et al., 2012).

Proxies, including magnetic, geochemical, biological, and sedimentological features, have been used to characterize paleoclimatic changes

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http://dx.doi.org/10.1016/j.chemgeo.2014.02.007
0009-2541/

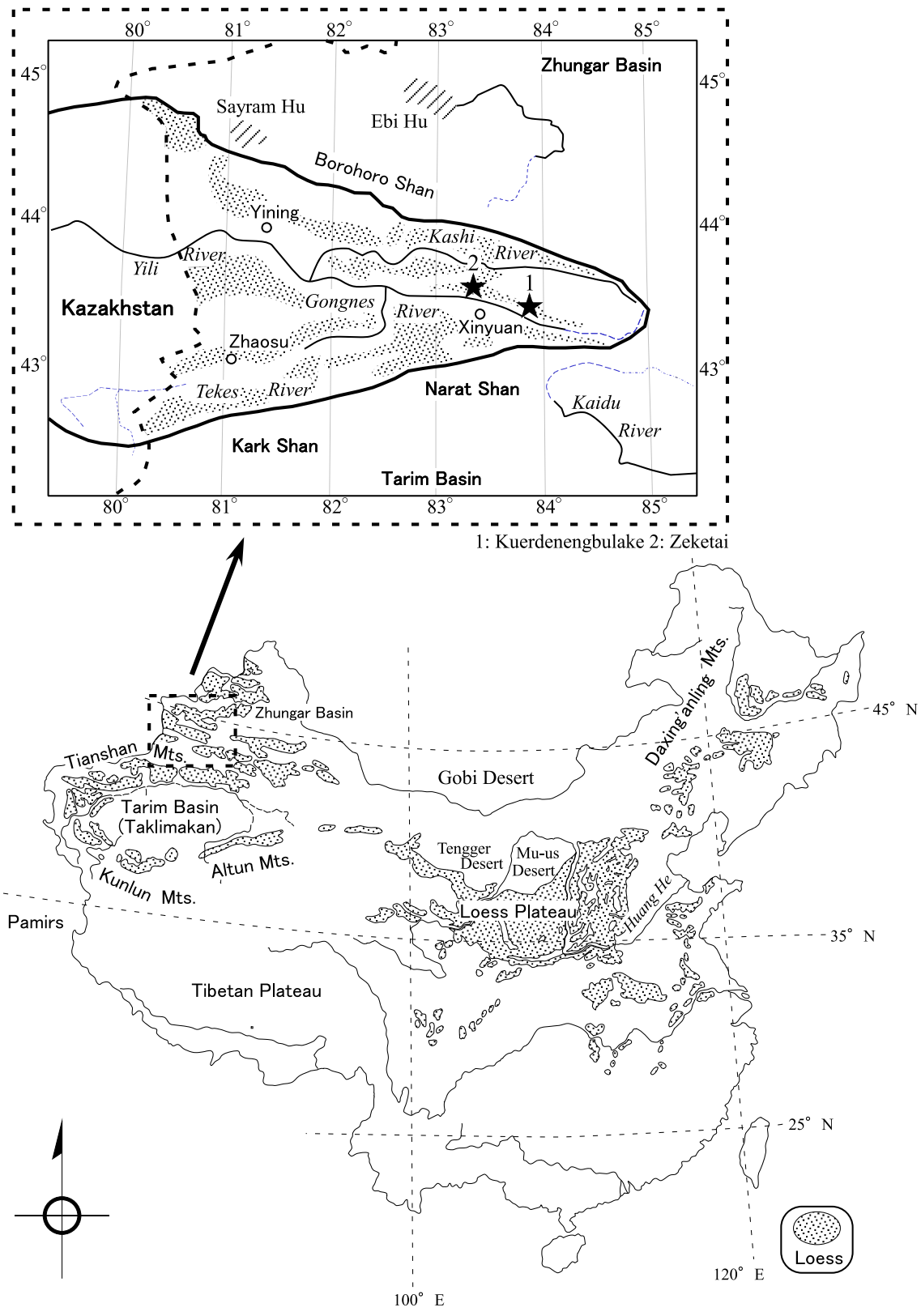

Fig. 1. Map showing sampling localities and the distribution of loess in China (Pye, 1987), after Pye (1984) and based partly on Liu et al. (1981). Bold lines in magnified map represent the Yili Basin and dashed bold lines represent the border between China and Kazakhstan.

in Chinese loess–paleosol sequences, particularly on the Loess Plateau (e.g., Heller and Liu, 1986; Gu et al., 1996; Vandenberghe et al., 1997; Guo et al., 2002). Most of these proxies are related to precipitation. Magnetic susceptibility records from the Loess Plateau's loess–paleosol sequences, in particular, have revealed both long-term and short-term fluctuations in the intensity of past Asian summer monsoons (e.g., Heller and Liu, 1986; Chen et al., 1997). On the Loess Plateau, magnetic susceptibility is invariably enhanced in layers with a paleosol as a result