Science Highlights: China

Grain-size Record of Stepwise Expansion of the Mu Us Desert for the Past 3.5 Ma

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The Mu Us Desert lies immediately north of the Loess Plateau in northern China (Fig. 1). A reconstruction of the desert environment has demonstrated that the southern margin of the desert migrated several hundred km north of its Last Glacial Maximum (LGM, ~20 ka BP) limit in response to increased monsoon rainfall during the Holocene Optimum (~8-4 ka BP) (Sun et al., 1998). However, little is known about the long-term evolution of this monsoon-sensitive environment because of the sparseness of directly extractable geological evidence of suitable type and quality to be found within it. In this report, we’ll first show, on the basis of the spatial grain-size changes of three north-south loess transects across the Chinese Loess Plateau, that sand-sized particle content within loess can be used to assess the shift of the southern desert margin. We then present a grain-size record of loess-red clay deposits from the desert-loess transitional zone to provide insight into the evolitional history of the Mu Us Desert during the Plio-Pleistocene period. The three loess transects are

Fig. 1: The sampling localities and annual precipitation isopleths (mm) in the Loess Plateau.

REFERENCES

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from Hongde (HD) to Yangling (YAL), Zichang (ZC) to Lantian (LAT), and Yulin (YL) to Weinan (WN) (Fig. 1), and respectively consist of 12, 8, and 7 sections covering the last glacial cycle. Closely-spaced samples were taken and analyzed for all the sections, and the grain-size curves are well-correlated among the sections (not shown). Theoretical and experimental studies by Pye (1987) and Tsoar and Pye (1987) concluded that during low-level atmospheric dust storms, sand-sized particles are usually transported by saltation or modified saltation near desert surfaces, and that any sand particles transported in suspension quickly settle back onto the ground surface. We thus plotted changes in sand-sized particle content within loess with increasing distance southward of the present southern desert margin for four representative stratigraphic units: L1-1, L1-4, L1-5 and S1 (Fig. 2). Loess units L1-1, L1-4, L1-5 and S1 accumulated respectively in marine isotope stages 2, 3, 4 and 5. As shown in Fig. 2, all horizons exhibit a consistent southward decrease in the sand particle content, the rate of decrease for L1-1 and L1-5 being more rapid than that for L1-4 and S1. Both the L1-1 and L1-5 records show an abrupt decrease near the desert margin and a gradual decrease beyond. According to the reconstruction of Sun et al. (1998), the southern border of the Mu Us Desert during the cold-dry LGM (L1-1) was broadly similar to that of today, whereas it retreated several hundred km to the north during the warm-humid Holocene optimum. This implies that this desert margin experienced wide-ranging advance-retreat cycles in response to climatic oscillations at orbital time-scales. It is clear that significant increase in sand percentages in L1-1 and L1-5 relative to S1 and L1-4 were controlled at the first order by the desert advance during their accumulation. Using the sand content-distance relation of L1-1 (Fig. 2), it is therefore inferred that sand particle contents of ~30% and ~15% within the loess indicate a distance from the desert margin of ~100 km and ~200 km, respectively. The Jingbian section (37°40'54"N, 108°31'15"E), at 1,370 m a.s.l., is located only ~12 km south of the present margin of the Mu Us Desert. The section is composed of a ~252-m-thick Pleistocene loess-soil sequence resting on a ~30 m Pliocene red clay deposit. A previous magnetic polarity study showed that this sequence has a basal age of 3.5 Ma (Ding et al., 1999). Field observations have demonstrated that the Pleistocene loess-soil stratigraphy correlates well with the classic loess sections. To the best of our knowledge, the Jingbian section is the only desert margin eolian sequence known to cover the whole Pleistocene and the late Pliocene. Its proximity to the dust source region makes it ideal for the study of long-term desert changes.

The Jingbian magnetic susceptibility and grain-size records, plotted on the Chiloparts timescale (Ding et al., 2002), are shown in Fig. 2, together with a composite marine oxygen isotope record (Shackleton and Piasias, 1985; Shackleton et al., 1990, 1995).
Human-induced Changes of Organic Carbon Storage in Soils of China

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In the last two centuries, land use has been a significant source of atmospheric CO2 through conversion of natural vegetation to farming land (Houghton, 1999; Lal, 2004). It has been estimated to be about half of the CO2 emission from the combustion of fossil fuels over the period from 1850 to 1990 (Houghton, 1999). In terrestrial ecosystems, soil organic carbon (SOC) is the largest terrestrial carbon pool. Because SOC generally has a slower turnover rate, it may be preserved for a longer time (IGBP Terrestrial Carbon Working Group, 1998). The huge carbon pool of soils and the significant changes of SOC related to land use by human activity suggest a considerable potential to enhance the rate of carbon sequestration in soils through suitable management, and thereby to decrease the atmospheric CO2 level.

A number of efforts have been carried out to determine the changes of SOC storage induced by land use at regional and global scales. However, because of the high inherent natural variability in the world’s soils and variable dynamics of carbon loss under different land uses, accurate estimates of the historic loss are usually hampered by the lack of the required baseline data on soils. More exact estimates on the size of the human-induced changes of SOC storage from natural to current conditions at regional scale are very much needed, especially based on greater data density with direct field measurements. This would provide a basis for a better understanding of the future SOC sequestration from the atmosphere, as well as its role in carbon cycles.

Currently, China has ~1375 million ha of cropland (NSSO, 1998), and the long history of agricultural exploitation and the changes of land use suggest that the terrestrial ecosystem of China would have played an important role in the global carbon cycle. In this study, the spatial patterns of soil organic carbon density and storage under natural conditions and those under present-day conditions are investigated comparatively, based on the 34,411 soil profiles analyzed from China’s second national soil survey (NSSO, 1998). Among these, 2,553 profiles were considered the most representative based on their geomorphological units, hydrothermal conditions, morphological peculiarities, physicochemical characters, and land-use conditions. According to the land-use conditions, they were then divided into two basic groups. 923 profiles are regarded in this study as natural profiles as they were not cultivated in the land-use history and the profiles had not experienced disturbance by human activity. Their current vegetation are ecologically consistent with the climatic conditions. The other 1,630 profiles were all considered cultivated profiles, including the present-day cultivated soils and those cultivated in the

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