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Research Paper

OSL dating of sediments from the Gobi Desert, Southern Mongolia

D. Hülle [a,*], A. Hilgers [a], U. Radtke [b], C. Stolz [c], N. Hempelmann [c], J. Grunert [c], T. Felauer [d], F. Lehmkuhl [d]

[a] Department of Geography, University of Cologne, Germany
[b] Rectorate, University Duisburg-Essen, Germany
[c] Department of Geography, Johannes Gutenberg-University of Mainz, Germany
[d] Physical Geography and Geoecology, Department of Geography, RWTH Aachen University, Germany

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ABSTRACT

The present study focuses on the chronological relationship between alternating dune sand and silty water-lain sediments in the central part of the Khongoryn Els dune field in the Gobi Desert, Southern Mongolia. The 23 m high section evolved from the construction of a natural dam by west–east moving sand dunes and fluvial inundation by a river system from the mountain ranges in the south. To resolve the chronology of events, optically stimulated luminescence (OSL) dating was applied and from sedimentological and geochemical analysis the depositional processes could be characterised. Quartz OSL dating of these sediments is hindered by feldspar contamination. Thus, dating of coarse-grain K-feldspars is applied to provide a more reliable chronostratigraphy. As this fraction might be influenced by signal loss over geological time scales, the extent of fading is measured and corrected for. The resulting ages fit well in a supraregional reconstruction of Central Asian palaeoclimate. The data imply that the basal aeolian sediments were deposited 27 ka ago, while the major part of the profile was accumulated in a rather short period of time around ~15 ka. The temporal differentiation implies that the stratification of aeolian and fluvial sediments is not caused by long term climatic variations. It rather represents arid conditions with episodical fluvial activity. Samples between 20 and 15 m depth could not be taken, but it is assumed that this part of the section represents an extremely arid time period with an intensive remobilisation of sand around LGM. A dune overlying the section was deposited during the Late Holocene and represents the ongoing aridity in this region.

1. Introduction

Few results have been published in the western literature about Pleistocene, Late Glacial and Holocene climatic fluctuations in Mongolia. Studies have focused mainly on lake level changes (e.g. Walther, 1999; Walther et al., 2003; Lehmkuhl and Lang, 2001; Naumann, 1999) and pollen data (e.g. Schlütz, 2000; Tarasov et al., 2000), the latter primarily for the Holocene. Furthermore, the knowledge about palaeoclimate is considerable for the northwestern part of Mongolia (Uvs Nuur basin) (e.g. Grunert et al., 2000; Klein, 2001), but rather scarce for the desert region in the south.

In the Khongoryn Els dune field in the Gobi Desert, the incision of an episodic river in its natural dam formed by a dune belt exposed a 23 m sediment sequence of alternating sandy dune and silty fluvio-lacustrine sediments. In this landscape, episodic flooding and fluvial transport ensures sorting of the sediment which is finally supplied to aeolian systems either as dust for long distance transport or as sand for dune construction. On the other hand, the fluvial processes are also involved in eroding aeolian landforms (Bullard and McTainsh, 2003).

So far, nothing is known about the depositional age of these sediments and the temporal resolution of the interaction between aeolian and fluvial processes. This study aims to resolve the chronology of this sediment archive by optically stimulated luminescence dating. Once established, this ought to allow a link of the fluvio-aeolian interaction either to past changes from wetter to drier climatic conditions or merely to an alternating dominance of different geomorphodynamical processes driven by factors other than major climatic conditions.

2. Study area

The study area is situated in a basin (1000–1500 m a.s.l.) in the Gurvan Sayhan region in the Gobi Desert (Southern Mongolia), between 44 and 43° N and 102 and 104° E (Fig. 1). The basin is

* Corresponding author. Tel.: +49 221 4704851; fax: +49 221 4705124.
E-mail address: huelled@uni-koeln.de (D. Hülle).

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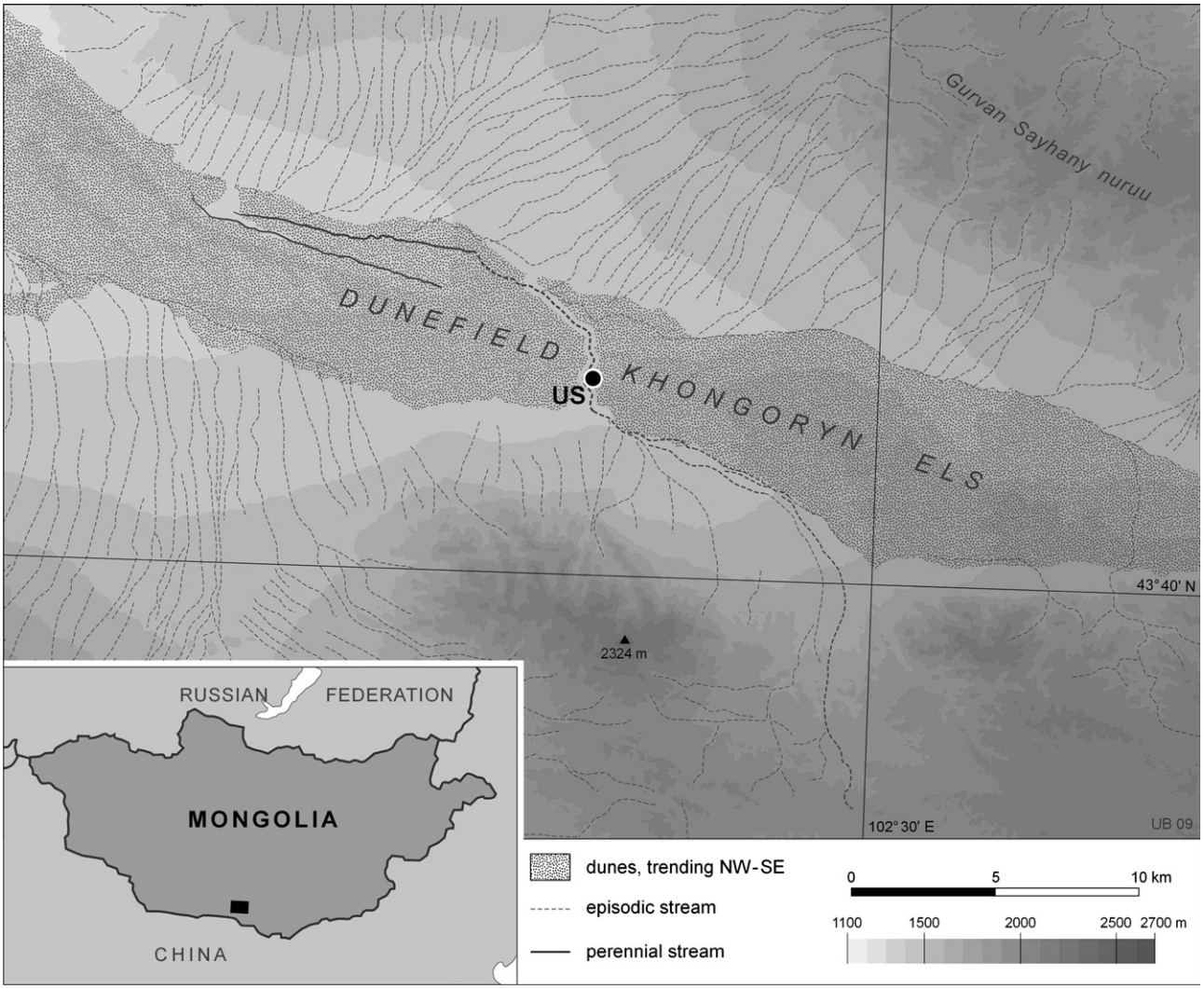

Fig. 1. Map showing the study area in Southern Mongolia and location of the sampling site US (102.37° E, 43.72° N) in the dunefield Khongoryn Els.

surrounded in the north and south by isolated Gobi Altai mountain ranges of less than 2700 m a.s.l.. The study site is located in the central part of the Khongoryn Els dune field, which is a narrow NW–SE trending belt of dunes 80 km in length and 3–5 km wide (Murzaev, 1954). It is characterised by >100 m high complex dunes. The dune sediments are mainly generated through weathering and erosion processes of the vast endorheic basin north-west of the dune field (Baasan, 2004).

The basin surface is composed of alluvial fans developing in the surrounding mountain ranges and transporting material including highly erodible Cretaceous and Palaeogene sandstone and basalt (Mineral Resources Authority of Mongolia, 1998). Due to the variability of parent material the heavy mineral spectrum is diverse.

At the study site "Ujim Sair" (US), episodic discharge from the mountain range in the south concentrates in a broad channel cutting through the dune belt before flowing in a north-west direction parallel to the dune field. The 23 m high section consists of stacked aeolian and lacustrine sediments (Fig. S1), thus representing an alternating natural dam construction by west–east moving sand dunes and frequent fluvial inundation by the episodic river system "Khongoryn Gol" from the mountain range in the south. The sequence of processes is reflected in the grain-size analysis results (classical sieve–pipette technique, i.e. sieving of the sand fractions and pipette extraction of the mud fractions using settling tubes): silt (Ø 90% clay and silt content) and sand layers (<10–15% clay and silt content) alternate. Additionally, salinity measurements revealed a tenfold heightened salt content in the silt layers when compared to the sand layers, hence indicating evaporation from ponded water.

The recent continental climatic conditions are characterised by a wide annual range of temperatures between −15 °C mean temperature in January and 20 °C mean temperature in July (Administration of Land Affairs, Geodesy and Cartography, 2004), as well as aridity and a highly variable annual precipitation of 130 mm in the lower parts (data provided by the Mongolian Ministry of Hydrology and Meteorology, 2008) and >400 mm in the mountain regions (Lehmkuhl and Lang, 2001). Strong winds >15 m/s prevail during 30–40 days per year and often are combined with dust storms (Natsagdorj et al., 2003), early spring is the main wind season (Administration of Land Affairs, Geodesy and Cartography, 2004; Han et al., 2008).

3. Equivalent dose estimation

3.1. Experimental details

Twelve OSL samples were taken from the profile at US to gain a detailed insight into the chronostratigraphy. Additionally, three