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Holocene geomorphological processes and soil development as indicator for environmental change around Karakorum, Upper Orkhon Valley (Central Mongolia)

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ABSTRACT

Mantles of silt- and sand-size particles, paleosols and fluvial deposits preserve valuable information on Holocene environmental change. These archives were used to reconstruct the landscape history in the upper Orkhon Valley close to the former capitals of the Uighurs (Kharbalgasin Tuur) and the Mongolian Empire (Karakorum) near the recent town of Kharkhorin, Central Mongolia. A holistic approach involving the use of high spatial resolution geomorphological mapping, sedimentological and geochemical analysis, palynology, and geochronology shows several phases of landscape activity and stability in the region. This includes phases of fluvial erosion, aeolian sedimentation, and soil formation. By using luminescence and radiocarbon dating, phases of landscape change, indicated by soil formation, occurred mainly at around 6.5–6 ka. Pollen data and a weakly humic horizon at around 1.0 ka probably indicate enhanced moisture supply in the region and a reduction of human activity between the time of the reigns of the Uighurs (8th–9th century AD) and the Mongols (1220–1388 AD). Since 3 ka, especially within the last two millennia of Historical Time (300 B.C.–present), a more intensified human occupation in the Upper Orkhon Valley occurred in this region. This included a more densely grazing of cattle to supply the growing population demands of the Uighurs and Mongols. This overgrazing caused an increase in erosion and the formation and deepening of fluvial gullies, together with soil deflation and subsequent deposition of aeolian sediments. Human activity, in addition to climate, has been dominant in driving landscape evolution of this region since the late Holocene.

1. Introduction

The slopes of the upper Orkhon Valley, Central Mongolia, 3 to 4 km south of Kharkhorin (Figs. 1 and 2) are trenched by deep gullies exposing successions of sand and silt deposits of up to several meters thick (see Fig. 3A and B). These sediments, deposited by aeolian or slope wash processes, contain paleosol horizons and ash layers, thus providing evidence for alternating periods of landscape stability and geomorphic activity in the past. To unravel the causes, character and history of these environmental changes, detailed field studies supported by various analytical approaches have been carried out including palynology, radiocarbon and luminescence dating as well as sedimentological and geochemical analysis.

The study area is located in the upper Orkhon Valley and is particularly interesting, because there is little known about the Late Quaternary environmental history of Central Mongolia. Only a few studies have been published in the western literature about Pleistocene and Holocene climatic fluctuations in Mongolia. The Holocene climatic evolution of Central Asia is based mainly on lacustrine records with studies focussing on lake level changes (e.g. Herzschuh, 2006; Lehmkuhl and Haselein, 2000; Lehmkuhl and Lang, 2001; Naumann and Walther, 2000; Tarasov and Harrison, 1998; Tarasov et al., 1996; Walther, 1999) and pollen data (e.g. Trasasov et al., 2000; Wang et al., 2009). Summaries of lake level variations in Mongolia are provided by Walther et al. (2003), Yang et al. (2004) and An et al. (2008).

In addition, the study area is well-suited to investigate the human–environment interaction during the Late Holocene, because the upper Orkhon Valley is known to have been one of the best grazing grounds in Mongolia since prehistoric times. On the northeastern foothills of the Khangay Mountains, several capitals of ancient cultures were established, specifically the Kharbalgasin Tuur of the Uighur kingdom (8th to 9th century) or Karakorum, near the present day Kharkhorin, whose capital was established by Chinggis Khan (1220 AD; destroyed 1388 AD). Our paper provides one of the first pollen studies to examine the nature of vegetation change driven by human occupation for this region.

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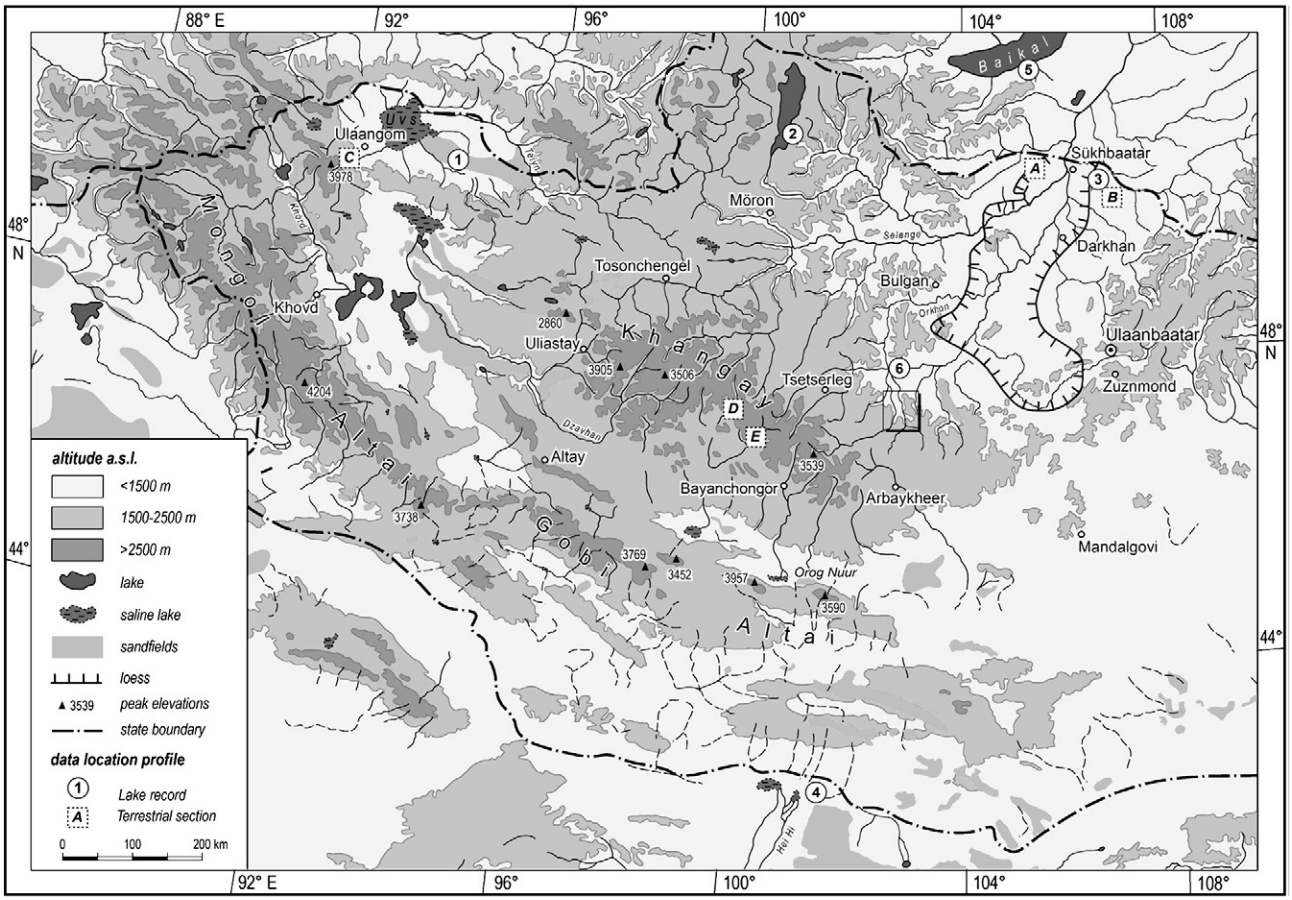

Fig. 1. Map of Western Mongolia. The box shows the location of the study area at the eastern foothills of the Khangay. The numbers indicate lacustrine records, the letters terrestrial sections discussed in the text.

To allow us to differentiate between climatic and human impact on the landscape, it is important to know the climatic conditions and their changes in the study area. Lake records are particularly significant in this context. Contrary to the overall pattern of lake level trends, some lakes exhibit a different or even opposite behavior in the lake status, which is dependent on local factors controlling the hydrological regime. Karabanov et al. (2000) published a high resolution Holocene record from Lake Baikal, about 500 km north of the study area. They suggest that the sedimentary signal from Lake Baikal reflects the climate conditions of arid and semi-arid areas of

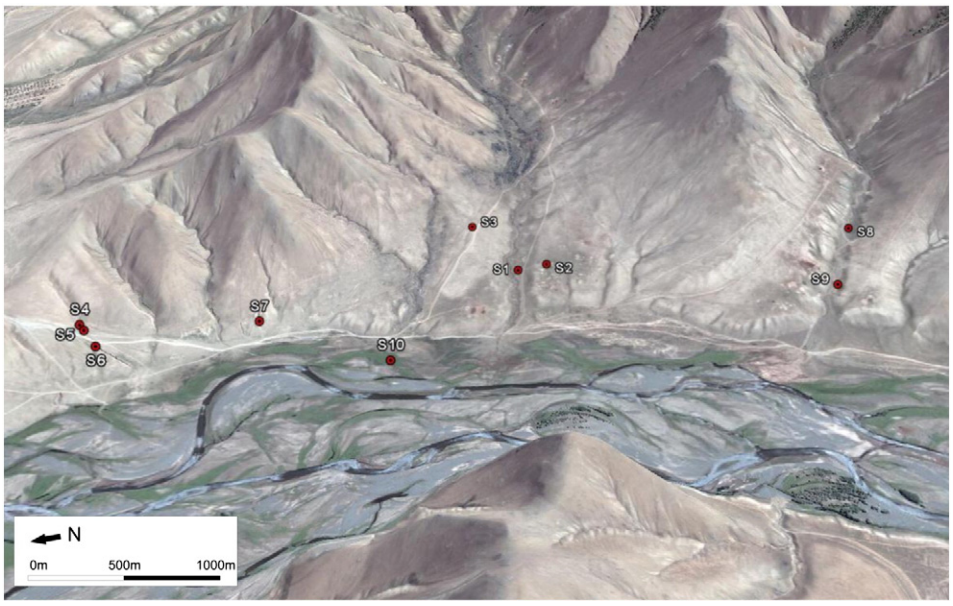

Fig. 2. GOOGLE-satellite image of the study area showing the sections.