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Paleolakes in the Gobi region of southern Mongolia

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ABSTRACT

Numerous lakes and remnants of paleolakes exist in western and southern Mongolia. For six basins in the area, detailed geomorphological maps were compiled, based on extensive field studies and remote sensing datasets. Several phases of high and low lake levels were reconstructed and dated by radiocarbon and optically stimulated luminescence. During the marine isotope stage (MIS) 6 lakes in southern and western Mongolia mostly disappeared. In contrast, large paleolakes existed during the last interglacial (MIS 5e) and lasted probably until the beginning of the last glacial. These huge lakes were caused by a strong East Asian summer monsoon, which reached southern and even western Mongolia. During the MIS 3 the monsoon was considerably weaker and most of the lakes were relatively small or even disappeared. Higher lake levels of this period were only recorded at the Orog Nuur. However, at this time the lake was fed by glacial melt water from the Khangai Mountains. The MIS 2 was again a very dry period. The previously supposed phase of synchronous high lake levels and glaciations in southern and western Mongolia is not supported by the data presented here. During the Holocene, lakes in the western and southern part of the study area evolved differently. Early Holocene high lake levels were reconstructed for the western lakes, while most of the southern lakes had highest lake levels in the mid-Holocene. These differences can be attributed to different moisture bearing atmospheric systems. In the late Holocene lake levels were generally low and in the last 50 years most lakes completely disappeared due to a strong human usage of the water resources.

1. Introduction

In semiarid western and southern Mongolia numerous lakes fill the large endorheic basins (Fig. 1). The area is known as “Valley of the Lakes”, which can be divided into the “Basin of the Great Lakes” in northwestern Mongolia, and to the south between Khangai and Gobi Altai, the so-called “Valley of the Gobi Lakes”. Pleistocene lake levels and shorelines of varying altitude can be observed in almost every lake basin. The earliest observations on high lake levels in the deserts of Mongolia were reported in the early and mid-20th century (e.g. Berkey and Morris, 1927; Murzaev, 1954; Devjatkin, 1981). A geomorphological map of Mongolia at the scale 1: 1.5 Mio. was published by Deviatkin et al. (1987) and showed the shorelines of large paleolakes in western and southern Mongolia of Pleistocene and Holocene age. At Uvs Nuur and Khyargas Nuur (Nuur = lake) three shorelines at different elevations above the modern lake levels were distinguished: The lowermost at 10–30 m above the present lake level indicates paleolakes of moderate expansion, the second one at around 130 m indicates large paleolakes and the uppermost more than 300 m is indicative of giant paleolakes. For the Valley of the Gobi Lakes a similar lake extent has been reconstructed by Komatsu et al. (2001) using remote sensing data. However, in both studies information on the exact timing was not obtained. At the Uvs Nuur a 10 m-high cliff line has a Holocene age, and a cliff at the eastern border of the lake 20 m high was radiocarbon dated to 43,598 ± 654 cal. BP (Grunert et al., 2000). No indications for a cliff line at around 130 m were found, but lacustrine sediments 250 m above the modern lake level were found east of the Uvs Nuur, near the small interdune lake Bayan Nuur, pointing to a giant mid-Pleistocene paleolake (Walther, 1999; Naumann and Walther, 2000). The authors describe typical lacustrine sediments as follows: Light-grey, horizontally bedded silts with a carbonate content up to 30% covered by hard crusts at the bare surface. Numerous fragments of *Phragmites* are embedded, and dispersed

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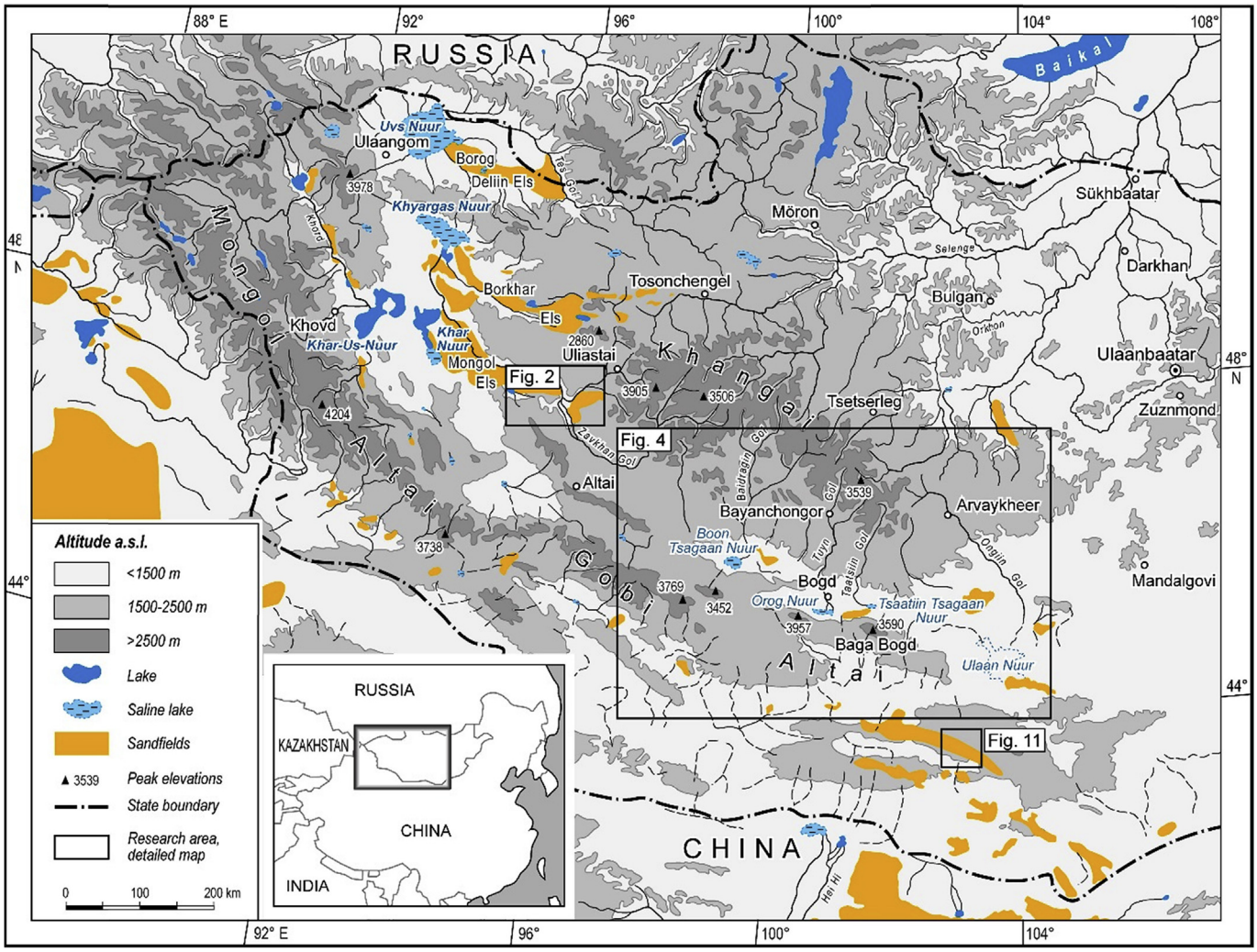

Fig. 1. Study area in Western and Central Mongolia including lakes and sandfields.

but locally concentrated, small mollusc (snail) shells indicating a former swamp vegetation which corresponded with a paleolake-level at a defined altitude a.s.l.

First detailed studies on lake level variations in southern Mongolia were obtained in the depression of the Bayan Tohomin Nuur (Fig. 1). Grunert et al. (2009) and Felauer et al. (2012) provided evidence for higher than present lake levels in the early Holocene. According to Dorofeyuk (2008) early Holocene high lake levels in Mongolia occurred at 9500 BP, and the lakes started to increase 8000 BP reaching their maximum lake levels in 7500 to 7000 BP. From 7000 BP regression started resulting in similar lake levels as the present ones and lowest lake level occured in 3000 to 4000 BP. According to Khosbayar (2005), the last warm period in Mongolia lasted from 6500 to 3250 BP and from 3000 to 2000 BP there was an increase of lake levels. Since 2000 BP lakes receded continuously (Dorofeyuk, 2008). An early Holocene humid period was also deduced from results obtained from Ulaan Nuur (Lee et al., 2011, 2013). While only few results for Holocene lake levels were reported for the Valley of the Gobi Lakes in southern Mongolia, numerous studies are available for northern Mongolia. An array of references including Tarasov and Harrison (1998), Walther (1999), Tarasov et al. (1999, 2000), Lehmkuhl and Haselein (2000), Yang et al. (2004), Herzschuh (2006), and An et al. (2008) have presented an overview concerning the Holocene lacustrine and/or vegetation history showing especially early and mid-Holocene humidity. Watanabe et al. (2009) summarized results from sediment cores of Lake Baikal and Lake Hovsgol and calculated linear sedimentation rates. In the cores the TOC concentration rapidly increased at the end of the last glacial with laminated layer deposited during Bølling/Allerød interval. A summary of moisture changes from lakes in mid-latitude arid Central Asia was provided by Chen et al. (2008) indicating major moisture phases in the mid-Holocene. From buried soil ^{14}C dating results it is possible to distinguish several Holocene wet and dry periods in Mongolian Altai region; dry periods from 2150 to 1700, 1300 to 1050, 680 to 250 BP and wet periods 1700 to 1300, 1005 to 680 BP and the last 2–3 centuries (Dinesman et al., 1989).

The former extension of glaciations were supposed to be synchronous with lake level rise (Deviatkin et al., 1987) and were recently investigated on the western flank of the Otgon Tenger mountains in the western Khangai (Rother et al., 2014; Lehmkuhl et al., 2016). Terminal moraines of MIS 2 were reported at 1900 m a.s.l., and at about 1800 m a.s.l., moraines of MIS 3 were found. They likely indicate more humidity (snowfall) in the Khangai at that time. In the Altai, the maximum extent of glaciers was reached during the MIS 2 (Lehmkuhl et al., 2011, 2016).

Lehmkuhl et al. (2011, 2012) focused on Late Pleistocene and Holocene environmental change in central and northern Mongolia