Quaternary Research 83 (2015) 137–149

Contents lists available at ScienceDirect

Quaternary Research

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

Late Glacial lake-level changes in the Lake Karakul basin (a closed glacierized-basin), eastern Pamirs, Tajikistan

Tetsuya Komatsu [a,*], Sumiko Tsukamoto [b]

[a] Faculty of Environmental Earth Science, Hokkaido University, W-5, N-10, Sapporo 060-0810, Japan
[b] Leibniz Institute for Applied Geophysics, Stilleweg 2, Hannover 30655, Germany

ARTICLE INFO

Article history:
Received 10 November 2013
Available online 29 November 2014

Keywords:
Lake Karakul
Pamirs
Paleolake
Glaciation
Paleoshoreline
Luminescence dating

ABSTRACT

The lake-level variations during the Late Glacial in the Lake Karakul basin (a closed glacierized-basin), in the northernmost part of the eastern Pamirs, were reconstructed using geomorphological and sedimentological evidence, with a chronology developed using luminescence ages from sand-sized quartz and K-feldspar in the lake sediments. Lake transgression started before ~19 ka, with the peak water level of ~35 m above the present elevation occurring at ~15 ka. This was synchronous with a significant advance of the glacier in the catchment. Stepwise lake regression, including a rapid lowering of the lake level (~13 m at ~12 ka), persisted until at least ~10 ka. Lake transgression and localized glacier expansion from ~19 to ~15 ka likely correlate with the more regional Late Glacial glacier advances across the semi-arid western Himalayan–Tibetan orogen and the eastern Pamirs. The longer-term trend of this lake transgression was probably caused by colder and/or wetter climatic conditions, forcing a notable glacier advance.

Introduction

The Pamirs are a high mountainous region of the westernmost part of the Himalayan–Tibetan orogen. Lake Karakul is a closed-basin lake surrounded by glaciers (a closed glacierized-basin lake) within the northeastern part of the Pamirs (Fig. 1A–C). A series of well-preserved paleoshoreline landforms and multiple terminal moraines are present around the lake (Komatsu, 2009). From the mapping and classification of these landforms, Komatsu et al. (2010) identified four paleoshorelines. The timing of each likely coincided with glacier advances in the catchment during the late Quaternary. However, apart from several radiocarbon ages obtained from lacustrine sediments (e.g. Mischke et al., 2010; Taft et al., 2014; Velichiko and Lebedeva, 1973), the chronologies of the lake-level highstands and the glacier advances have not been adequately constrained. Due to the lack of numerical ages, lake and glacier changes have not been correlated with other paleoclimatic records. Numerous glacial chronostratigraphies have already been established in the central and southern parts of the eastern Pamirs using cosmogenic radionuclide dating methods (Abramowski et al., 2006; Owen et al., 2012; Röhringer et al., 2012; Seong et al., 2009; Zech et al., 2005a, 2005b). Paleoenviromental changes across northern and southern parts of the eastern Pamirs could therefore be examined if the timing of lake and glacier changes in the Lake Karakul basin (located in the northeast) could be defined. Furthermore, correlation of the paleolake chronology with other paleoclimatic records would help identify the underlying cause of lake-level variations.

This study aims to determine a chronology of the lake-level and glacier fluctuations that occurred during the second-last paleolake highstands named "L Shoreline lake cycle" as defined by Komatsu et al. (2010). Focusing on these time frames is justified because the lacustrine and glacial landforms/deposits assigned to this paleolake highstand are particularly well developed around the shore area of the lake (Komatsu et al., 2010). We first document the geomorphology, sedimentology, and stratigraphy of terrestrial records associated with the lake-level and glacier variations, and then describe optically stimulated luminescence (OSL) and infrared stimulated luminescence (IRSL) dating of lacustrine sediments to develop the chronology. Based on the age-constrained paleolake and glacial history in the Lake Karakul basin, we then discuss two topics: (1) regional features of the glaciation in the eastern Pamirs during the highest stand of the L Shoreline lake cycle, and (2) causes of the lake-level variations.

Setting and previous research

Lake Karakul basin

Lake Karakul (Fig. 1) is internally drained with the present lake level at ~3915 m asl and an area of 388 km^2 (calculated on the basis of a digital elevation models developed by the Shuttle Rader Topographic Mission-3 (SRTM) in 2000). Bathymetry studies (Nöth, 1932) show an asymmetric lake basin, with the western part of the lake bottom (>230 m) much deeper than the eastern part (<30 m). The watershed

* Corresponding author.
E-mail address: tkomatsu@wwwgeo.ees.hokudai.ac.jp (T. Komatsu).

http://dx.doi.org/10.1016/j.yqres.2014.09.001
0033-5894/

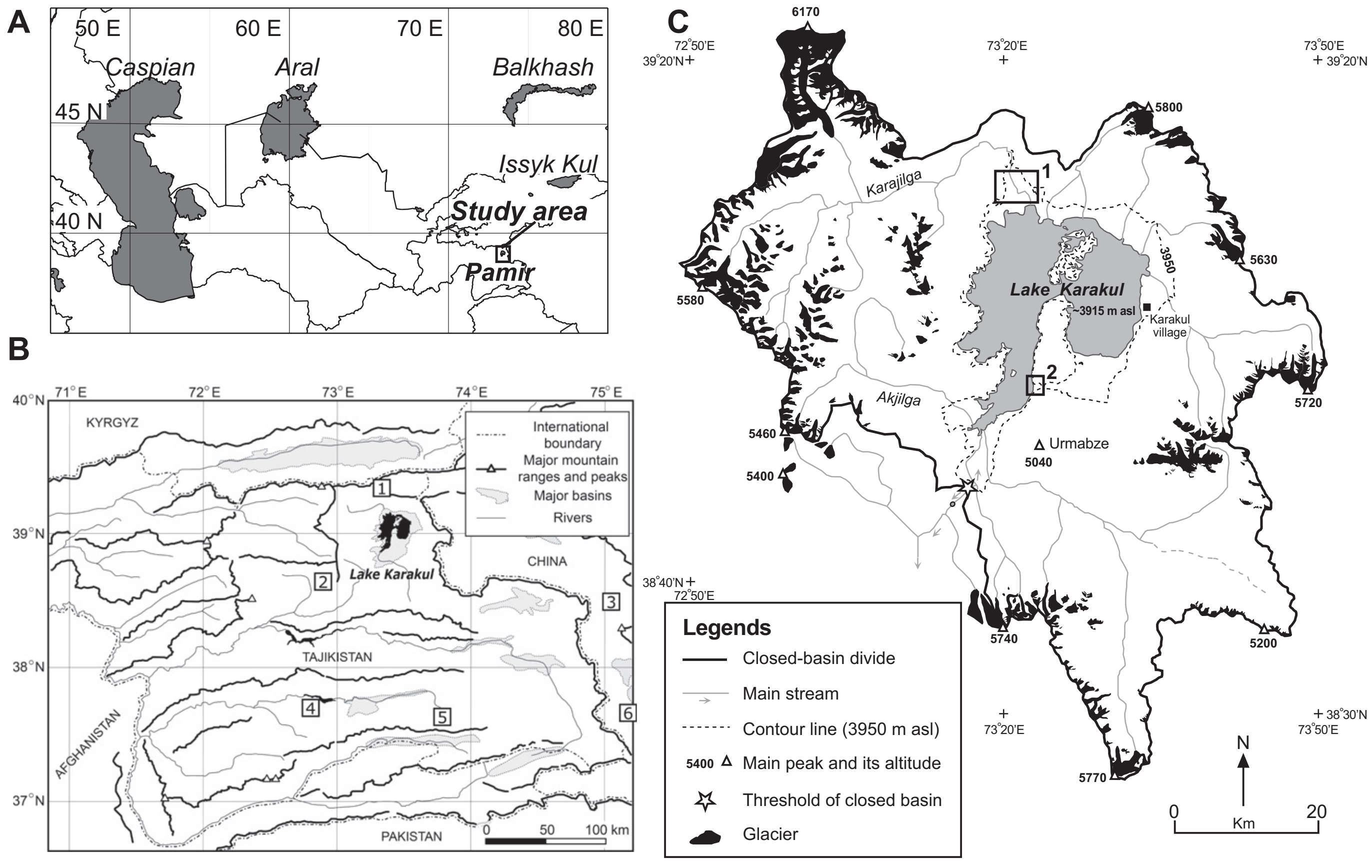

Figure 1. (A) Location of study area in the western Central Asia. The shaded area shows major closed basin lake (or seas). (B) Overview map of the Pamirs.Numbers 1–6 in boxes show the location of glacial chronology studies discussed in the text. 1: Markansu Valley (Velichiko and Lebedeva, 1973), 2: Tanymas Valley (Abramowski et al., 2006), 3: Muztag Ata and Kongur Shan (Seong et al., 2009), 4: Bogchigir Range (Zech et al., 2005a, 2005b; Röhringer et al., 2012), 5: Southern Alichur Range (Abramowski et al., 2006) 6: Tashkurgan Valley (Owen et al., 2012). (C) Map of Lake Karakul basin. Boxes show location of detailed study area. 1: Lowermost reaches of the Karajilga basin (see Fig. 2), 2: Northern Urmabze embayment (see Figs. 3 and 4).

of the closed basin (Fig. 1C) is mountainous, rising to 5000–6000 m asl with the highest peak at 6780 m asl. The lowest drainage divide (threshold) is situated in the southern margin of the basin and is only 35 m above the present lake level (at 3950 m asl).

The mean annual temperature is −3.6°C, and mean annual precipitation is 80.6 mm at the basin floor (at 39.01°N 75.36°E, 3930 m asl; Williams and Konovalov, 2008). This aridity is attributed to the presence of the mountain ranges to the west of the basin, which block the moisture advection by the mid-latitude westeries. The present equilibrium-line altitudes (ELA) of mountain glaciers range from 4600 to 5200 m asl (Bazhev et al., 1975).

Previous Quaternary studies

A framework for late Quaternary landscape evolution over the Lake Karakul catchment area, with a particular focus on the relationship between the lake-level fluctuation and the glacier variation, was presented by Komatsu et al. (2010), on the basis of the identification and classification of lacustrine, fluvial, and glacial landforms and sediments. Paleoshorelines were grouped in descending order into four: H Shoreline (4000–4120 m asl); M Shoreline (3950–4000 m asl); L Shoreline (3925–3950 m asl); and LL Shoreline (3915–3925 m asl). The four high lake-level cycles were assumed to have been separated by lowstands comparable to or lower than present day lake level, because three outwash fans, (each carved by the M, L and LL Shorelines) are present between the piedmont and the lake (Komatsu et al., 2010).

Komatsu et al. (2010) argued that the glaciers in the catchments attained their maximum size when the paleolake was close to its highest level. This was mainly inferred from evidence that the lacustrine terraces are connected with the outermost terminal moraines at two different levels (3950 m and 4120 m asl); these correspond to the highest levels of the L and H Shorelines in the lower Akjilga basin (Fig. 1C).

A relative chronology of lake-level fluctuations has been proposed, based on a combination of the following criteria: features of the geomorphic development and glaciation; relative dating of the moraines; and reference to established glacial history in and around the Pamirs (Komatsu et al., 2010). Based on this view, the periods of H, M, L, and LL Shoreline lake cycles were correlated with the antepenultimate glacial period (Marine Oxygen Isotope Stage (MIS) 8), the penultimate glacial period (MIS 6), the early Last Glacial Period (MIS 4), and the late Last Glacial Period (MIS 2), respectively. Several studies have provided radiocarbon ages that relate to the paleoenvironmental changes in the Lake Karakul basin. Velichiko and Lebedeva (1973) reported an age of 27,700 ± 700 ^{14}C yr BP (29.8 ± 0.7 cal ka BP based on the CALIB 7.0 calibration program; Reimer et al., 2013) for gyttja from a lake terrace of unknown altitude. Bulk organic matter from a lake sediment core yielded ages covering the last 4.2 ka cal BP (Mischke et al., 2010). It is not clear how these ages relate to the lacustrine and glacial landforms classified by Komatsu et al. (2010). Therefore, up to this time no adequate age control has been developed for the proposed relative chronology of the lake-level fluctuations.

Field work and site descriptions

To reconstruct the style and timing of L Shoreline lake cycles and the corresponding glacier advances in the Lake Karakul basin, field work was undertaken in August 2011 in two areas: 1) the lowermost reaches of the Karajilga basin and; 2) the Northern Urmabze embayment (Fig. 1C). In the former area, the morphostratigraphical relationship