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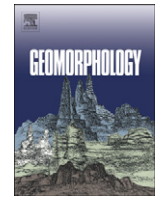

OSL dating of glacier extent during the Last Glacial and the Kanas Lake basin formation in Kanas River valley, Altai Mountains, China

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ABSTRACT

The Kanas River originates on the southern slope of Youyi Peak, the largest center of modern glaciers in Altai Mountains, China. Three sets of moraines and associated glacial sediments are well preserved near the Kanas Lake outlet, recording a complex history and landscape evolution during the Last Glacial. Dating the moraines allows the temporal and spatial glacier shift and climate during the Last Glacial to be determined, and then constrains when and how the Kanas Lake basin was formed. Dating of the glacial tills was undertaken by utilizing the optically stimulated luminescence (OSL) method. Results date four samples from the three sets of moraines to 28.0, 34.4, 38.1, and 49.9 ka and one sample from outwash sediment to 6.8 ka. The Kanas Lake basin is a downfaulted basin and was eroded by glacier before 28.0 ka, and the glacial moraines blocked the glacier-melt water after the glacier retreat, which made the present-day Kanas Lake eventually form at least before 6.8 ka BP. In Altai Mountains, the glacier advance was more extensive in Marine Isotope Stage (MIS) 3 than MIS 2, probably because the mid-latitude westerlies shifted northward and/or intensified during the MIS 3, resulting in a more positive glacier mass balance. Nevertheless, the Siberian High dominated the Altai Mountains in MIS 2, resulting in a relative decrease in precipitation.

1. Introduction

Alpine glaciers are a sensitive indicator of regional climate change and a significant geomorphic feature that shape the landscapes of high altitude mountains. Therefore records of past glacial advances preserved in moraines, glacial extent, and other geomorphic features give valuable clues of past climatic change (Thackray et al., 2008). On the other hand, alpine glaciers have been broadly considered as having sustained erosion rates of 0.1–100 mm a^{-1}, and it is generally assumed that large glaciers can erode more rapidly than smaller glaciers, especially in an ablation zone (e.g., Hallet et al., 1996; Alley et al., 2003; Brocklehurst and Whipple, 2006; Zhao et al., 2008).

In order to reconstruct climate change from alpine glacier deposits and understand the evolution of glaciated landscapes, researchers are eager to obtain the absolute ages of glacier advances and retreats. Dating techniques provide absolute chronologies and allow researchers to (i) model regional climate at a particular moment in time; (ii) compare regional and global glacier extents (Yi et al., 2005); and (iii) understand the duration of certain landscape formations from a geomorphological perspective. From the late twentieth century, new dating methods such as optically stimulated luminescence (OSL; e.g., Owen et al., 2002a; Spencer and Owen, 2004), cosmogenic radionuclide exposure (CRN; e.g., Owen et al., 2002b; Finkel et al., 2003; Owen et al., 2006), electron spin resonance (ESR; e.g., Yi et al., 2002; Zhou et al., 2002; Zhao et al., 2006), and accelerating mass spectrometry (AMS; e.g., Yi et al., 2004), have been refined and applied widely to dating glacial sediment.

In recent years, increasing evidence has confirmed Gillespie and Molnar's (1995) view that the maximum advances of glaciers were not globally synchronous. Owen et al. (2002c) found that the largest glacial extent in southern Tibet during the Last Glacial stage occurred in MIS 3 and did not coincide with the global Last Glacial Maximum (LGM_G: 18–25 ka BP). Also, Shi et al. (2000) investigated 23 glaciated sites that are distributed in 12 areas in Asia, Europe, America, and Australia and concluded that glacial advances in those regions happened in MIS 3 or earlier when the glacier extents exceeded the MIS 2 scales. Shi and Yao (2002) inferred, based on the isotopic record preserved in the Guliya ice core, that the MIS 3 had three substages (a, b and c) and that the MIS 3b (44–54 ka) was cold and wet. Other investigations (e.g., Cui and Zhang, 2003; Owen et al., 2003; Zech et al., 2003; Kamp et al., 2004; Owen et al., 2006; Yang et al., 2006, 2007) have also provided evidences for this view.

Our study focuses on the southern slope of the Altai Mountains, which lie in the north of the Xinjiang Uigur autonomous region, China, and geographically belong to the Arctic Ocean system (Fig. 1A). These mountains stretch for ~500 km from west to east in China and consist

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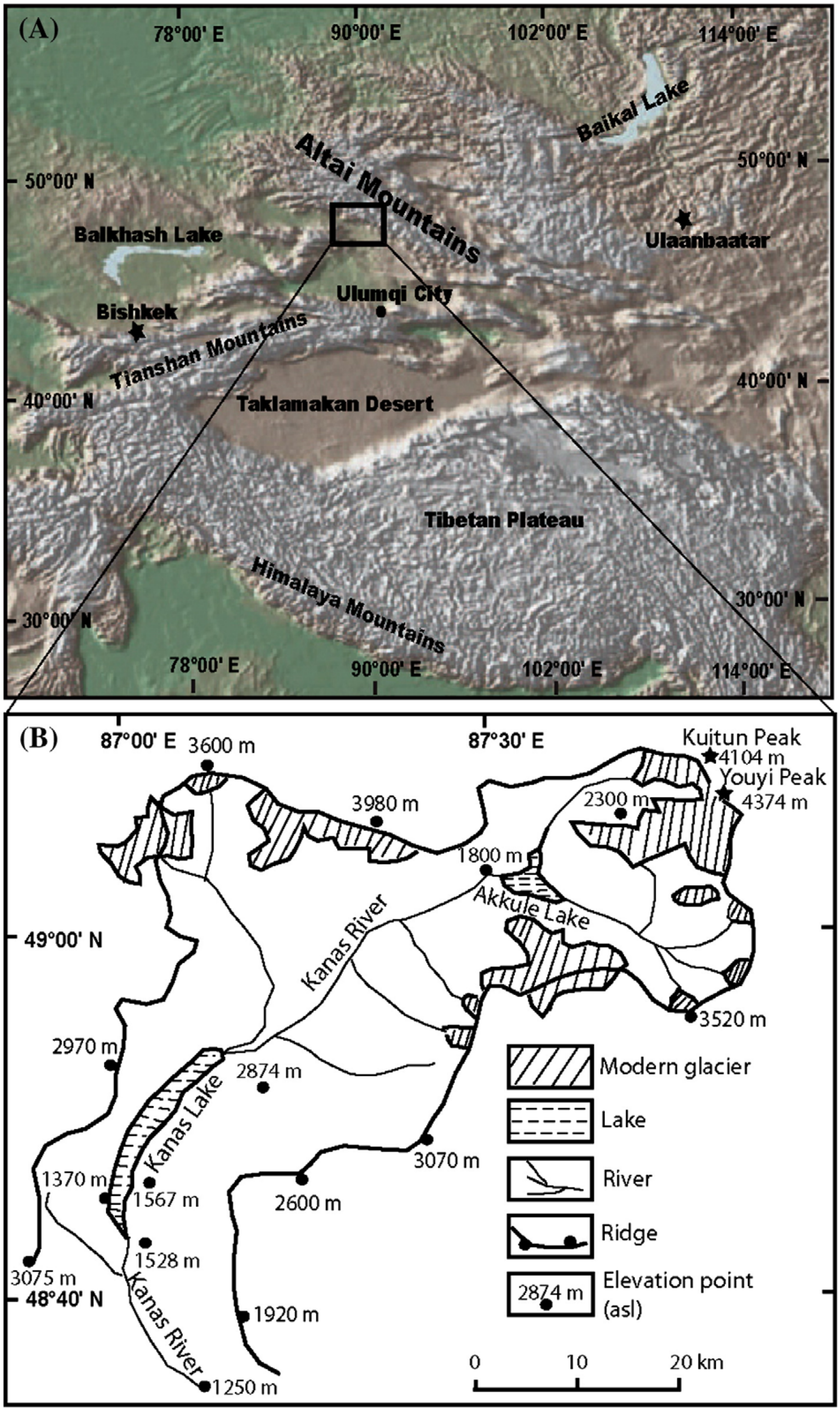

Fig. 1. Map of study area. (A) Location of the Altai Mountains, China; (B) map of Kanas River valley showing the modern glaciers and Kanas Lake.

of a series of NW–SE trending mountain ranges with the highest peak being Youyi Peak (4374 m asl). The highest peak, together with Kuitun Peak (4104 m asl), is the center of modern glaciers in the Kanas River valley. Quaternary glaciations of the river valley have been studied since the 1970s based on morphologic field investigation (e.g., Liu and Wang, 1983; Cui et al., 1992). However, even now it is still a place without an absolute chronology, which hampers the accurate study of the paleoclimate and the landscape evolution during the Last Glacial and therefore prohibits its comparison with other mountain regions. This paper will describe glacial deposits and landscapes formed during the Last Glacial and provide some new OSL dating results.

An interesting debate, also associated with the glaciations, is the formation mechanism of the Kanas Lake in the Kanas River valley. One opinion is glacial origin, that is, the Kanas Lake basin was formed by