Danger of glacial and dammed lakes outburst in the mountain areas of Kazakhstan

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INTRODUCTION

Outbursts of glacial and dammed lakes in the mountains lead to disaster mudflows with material damage and human casualties. Catastrophic outburst mudflows in Kazakhstan occurred more often in the Ile Alatau and the Zhetysu Alatau ranges (Fig. 1). They were observed in 1963, 1970, 1973, 1977, 1978, 1979, 1980, 1982, 1983, 1984, 1993, 2014, and 2015. Formation of glacial lakes connects with intensive deglaciation in the second half of the 20th century. The area of glaciers reduced from 198 to 117 sq. km (41 %) on the northern slope of the Ile Alatau range and from 316 to 217 sq. km (31%) in the Zhetysu Alatau range in the last 50 years. The dammed lake is formed when large landslides or rockfalls block the valley. It usually happens during strong earthquakes with M more than 8. Outbursts of dammed lakes occur much rarer than outbursts of glacial lakes. They occurred in 1887 in the Aksay river valley and in 1963 in the Yesik river valley in the Ile Alatau range. A dammed lake outburst can be caused by heavy rains, intensive melting of glaciers, or descent of a mudflow or a landslide into a lake.

METHODS

Catalogues of glacial lakes were composed for the Ile Alatau and the Zhetysu Alatau ranges in order to assess the danger of glacial lake outbursts. The catalogues display the data including geographical coordinates of the lakes, their altitudes, areas, and volumes. We used Landsat satellite images. Identification of glacial lakes was made manually. The results were checked during aerial visual researches from a helicopter. Morphometric characteristics of the lakes were determined using satellite images and topographical maps by ArcGis 9.3.1 program. The water volumes of 35 key lakes were measured by a bathymetric survey using sonar. The volume of water in other lakes was estimated by empirical dependence of the volume on the area of a lake, obtained in the result of bathymetric surveys. Danger of GLOF was estimated according to the lake size, the dam stability, steepness of the valley below the lake, and existence of social and economic objects in the mudflow prone zone. Maximum outburst danger is observed when 1) the lake volume exceeds 100 000 cu. m, 2) the lake is proglacial, 3) the dam is a young moraine with an ice core, 4) steepness of the valley is more than 15 degrees, and 5) there are important non-protected objects affected by the mudflow.

RESULTS

There are 186 glacial lakes in the Ile Alatau range and 577 lakes in the Zhetysu Alatau range. Distribution of the lakes according to water volume is shown in the table.

The Kalesnik Lake in the Leviy Talgar river valley is the biggest glacial lake in the Ile Alatau range. Its volume is 400 000 cu. m. The Kapkan Lake with the volume of 3 700 000 cu. m in the Korgas river valley is the biggest glacial lake in the Zhetysu Alatau range (Fig. 2).

We determined 14 most dangerous glacial lakes: 6 lakes are in the Ile Alatau and 8 lakes are in the Zhetysu Alatau. They are located in the Kaskelen, Bolshaya Almaty, Malaya Almaty, Talgar, and Yesik river valleys in the Ile Alatau range, and in the Korgas, Osek, Aksu, and Sarkan river valleys in the Zhetysu Alatau range.

There are 15 big dammed lakes in the Ile Alatau and in the Zhetysu Alatau ranges. Volume of dammed lakes usually exceeds a million cu. m. The biggest dammed lakes in the Zhetysu Alatau range are the Upper Zhasylkol Lake and the Lower Zhasylkol Lake in the Aganakty river valley. Their volumes are 44 and 35 million cu. m.

The biggest dammed lake in the Ile Alatau range is the Bolshoye Almaty Lake with the volume of

14 million cu. m in the Bolshaya Almaty river valley.
The Kazankol Lake is the most dangerous dammed lake in the Korgas river valley in the Zhetysu Alatau range. The Bolshoye Almaty Lake is the most dangerous dammed lake in the Ile Alatau range.
Control of dangerous glacial lakes is made by the Kazakhstan Mudflow Protection Service. Fourteen protective dams were built in the mountain river valleys. Aerial and ground monitoring is carried out on glacial lakes. An early warning system is operated. The lakes are emptied through open channels and siphons to reduce outburst risk. Natural dams are strengthened to prevent outbursts of dammed lakes.

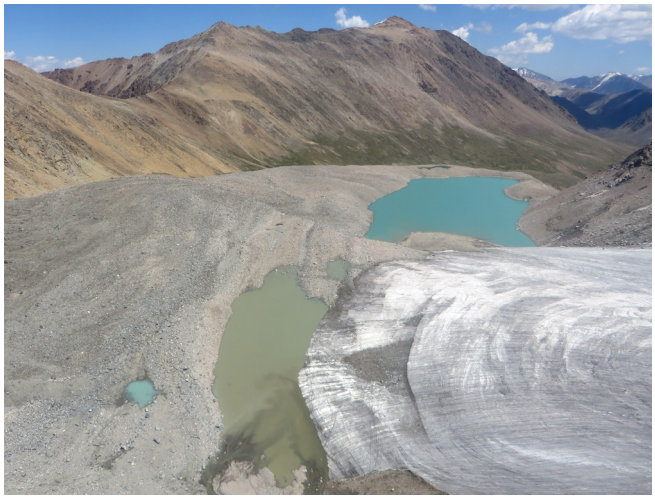

Figure 1. The Kapkan Lake with the volume of 3.7 million cu. m is the biggest glacial lake in the Zhetysu Alatau range

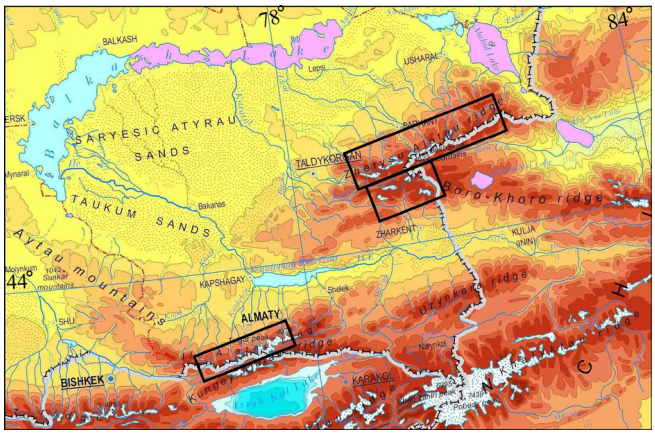

Figure 2. Location of the study area

Table 1. Distribution of the lakes according to water volume

Mountain range	Index	Lake's volume, thousand cu. m						
		< 1	1-5	5-10	10-50	50-100	100-200	> 200
Ile Alatau	Number	27	51	15	43	18	17	15
	Percentage, %	14.8	27.9	8.2	23.5	8.2	9.3	8.2
Zhetysu Alatau	Number	44	116	65	198	53	39	62
	Percentage, %	7.6	20.1	11.3	34.3	9.2	6.8	10.7

KEYWORDS
glacial lakes; dammed lakes; outburst danger.

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