

# Petrov lake: dynamics of glacier and lake development, hazards and measures



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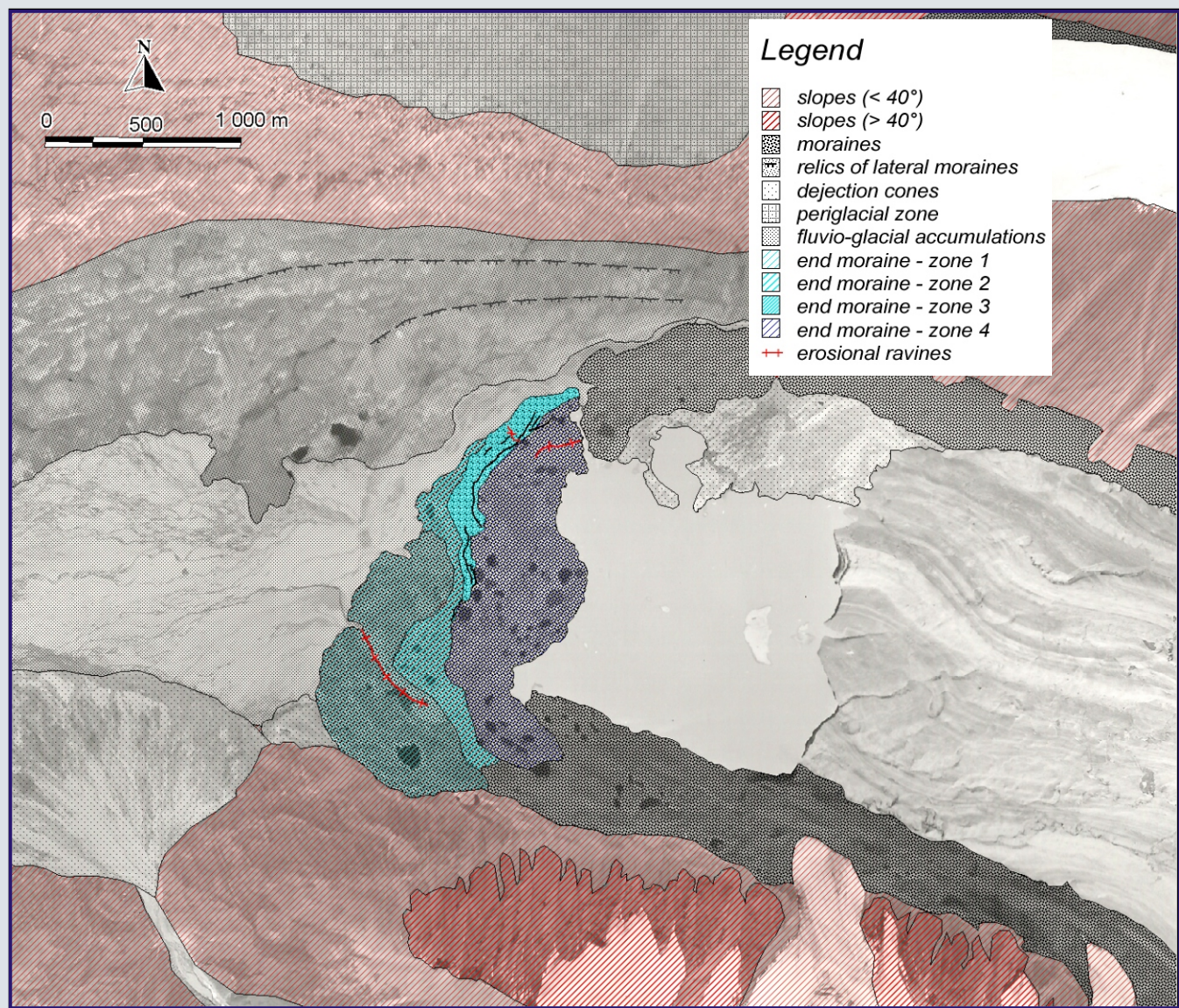
**Petrov lake** - located in the foreground of the same-called glacier on the north-western slope of Ak-Shiyrak massive in south-central Tien-Shan.

**Moraine-glacial lake** - developed in the basin of intramoraine depression after retreat of Petrov glacier

**Petrov glacier** - area 69,8 km<sup>2</sup>, length 23 km



Global climate warming causes an intensive melting and retreat of glaciers in the majority of high mountains all over the world. This process is evident also in mountain regions of central Tien-Shan. Melting of glacial water influences changes in hydrological regime of water streams and causes overfilling of high mountain lake basins. Dams of many lakes are very unstable and outburst occasionally. To determine the risk degree, it is necessary to analyse the genesis of lakes, to characterize the morphology of lake basins and to know the peculiarities of their hydrological regime. Petrov Lake is located in the foreground of the Petrov Glacier which is situated on the north-western slope of Ak-Shiyrak massive in southern Tien-Shan. In front of the retreating glacier the process of lake broadening is taking place. The lake takes concurrently share on the speeding up the process of the glacier thaw. In the last 30 years Petrov Lake has enlarged in area by 1.5 times while in recent years its area has been increasing by more than 6 ha per year! Enlarging of the lake size and volume together with weakening of moraine stability causes an extremely dangerous situation.

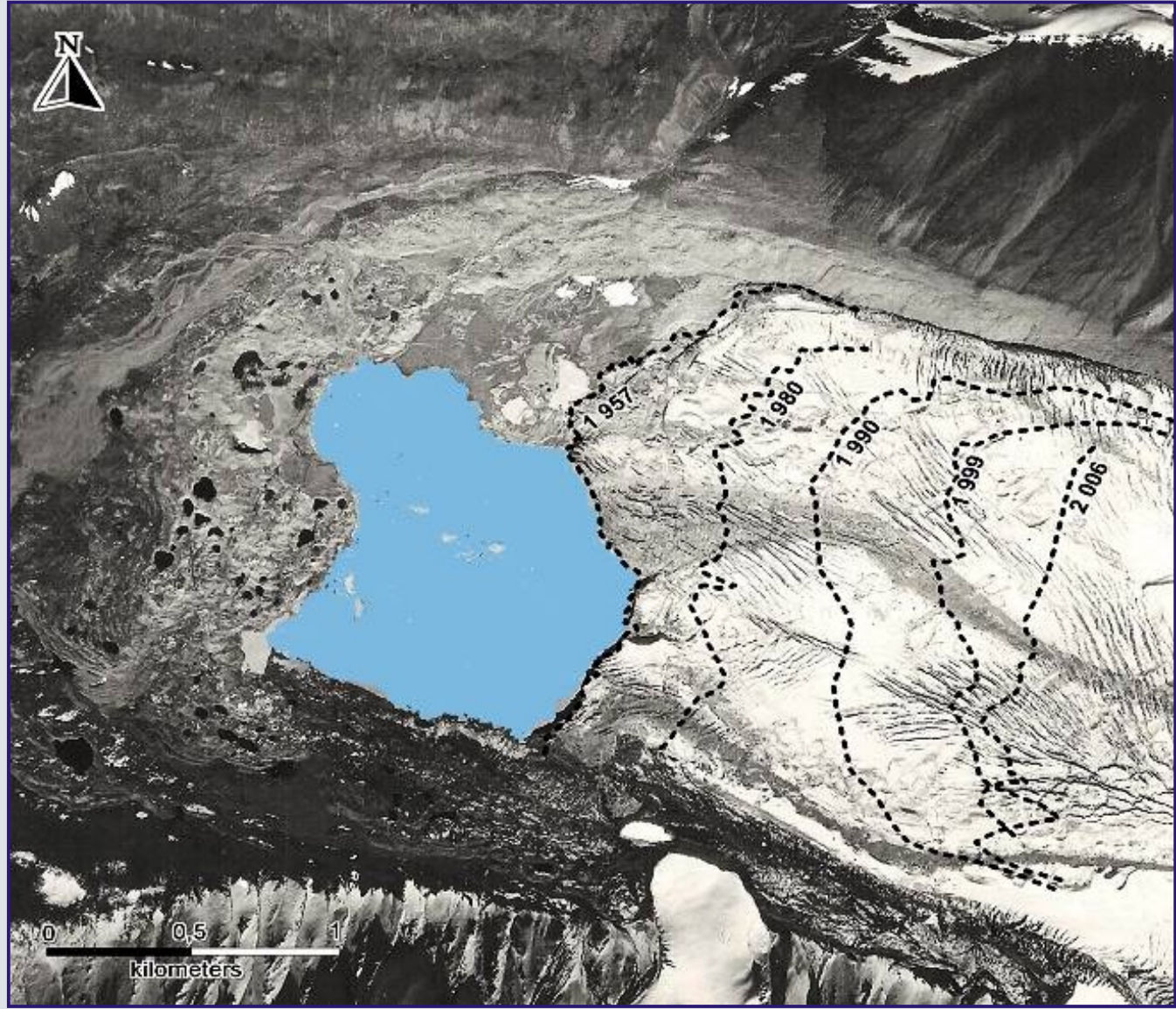
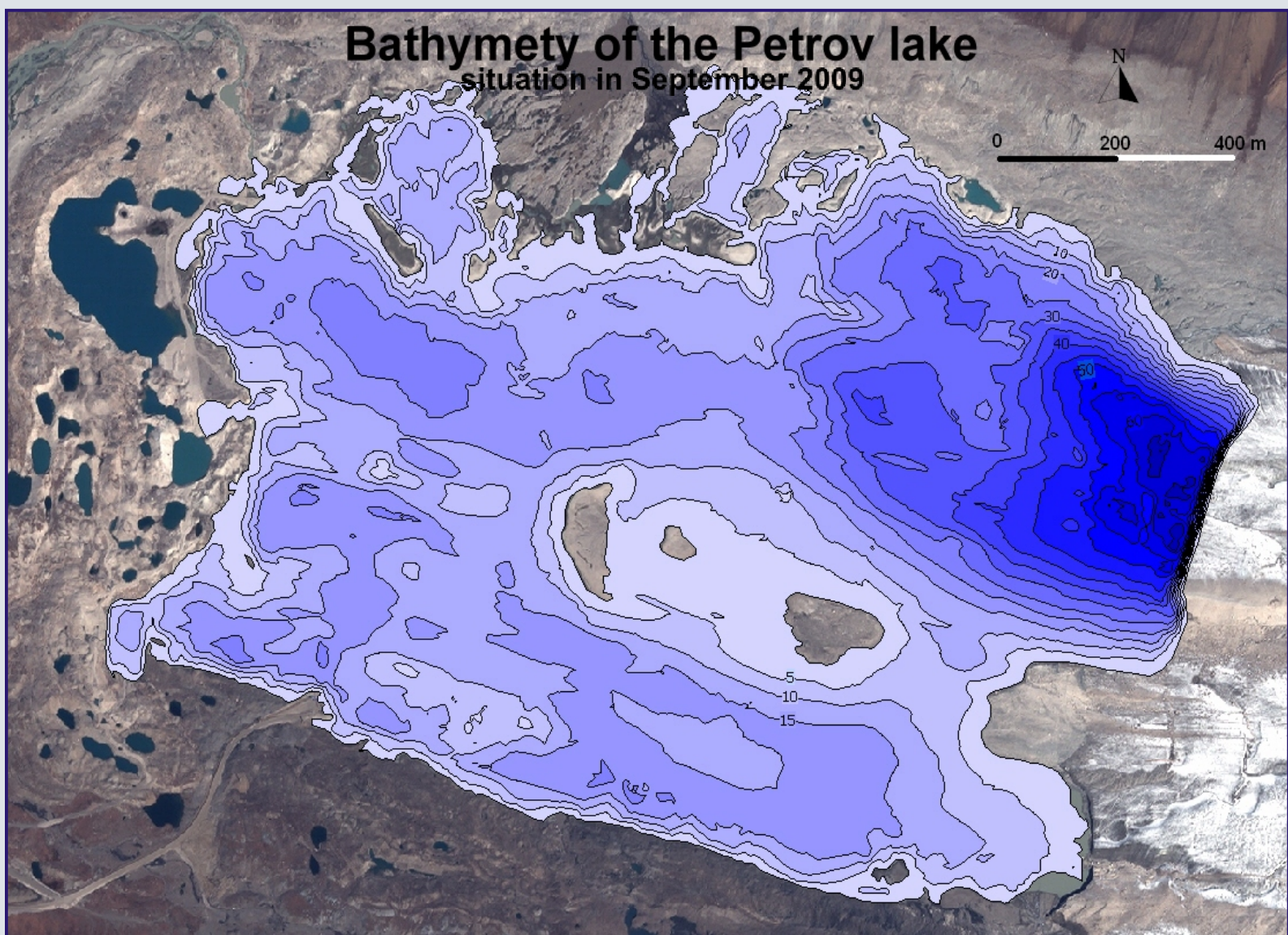


**Geomorphological map of Petrov lake basin and its surroundings**

The Petrov lake is enclosed by terminal moraine and lateral moraines at the foot of the valley slopes. Moraine dam is composed by four generations of moraine sediments. While the lateral moraines are of no serious danger to the lake, the eastern and western shores are under continual development. The glacier dam on the western side of the lake is affected by the most destructive processes. It is exposed to lake level oscillations and to degradation processes in the moraine area.

The lake basin is splitted in two depressions separated by central ridge appearing above the water level in form of shallow islands. The southern depression is shallower while the depth of northern one falls steeply to the broad hole. The maximum depth found during 2006 bathymetrical research was 69,3 m.

Morphometric characteristics of Petrov Lake (results of fieldwork in 2006)	
Area (km <sup>2</sup> )	4.033
Perimeter (km)	17.95
Maximum length (km)	2.885
Maximum width (km)	1.88
Maximum depth (m)	69,3
Medium depth (m)	15.86
Volume (mil. m <sup>3</sup> )	64.0

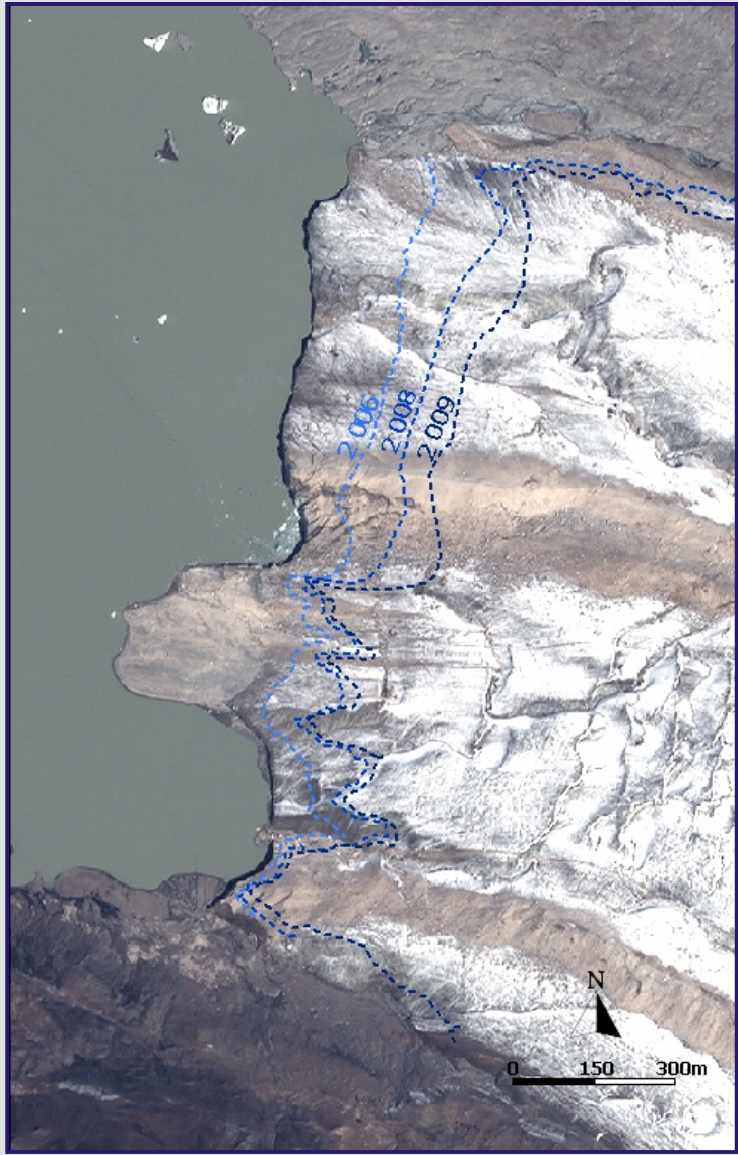


**Terminus fluctuation of Petrov Glacier**

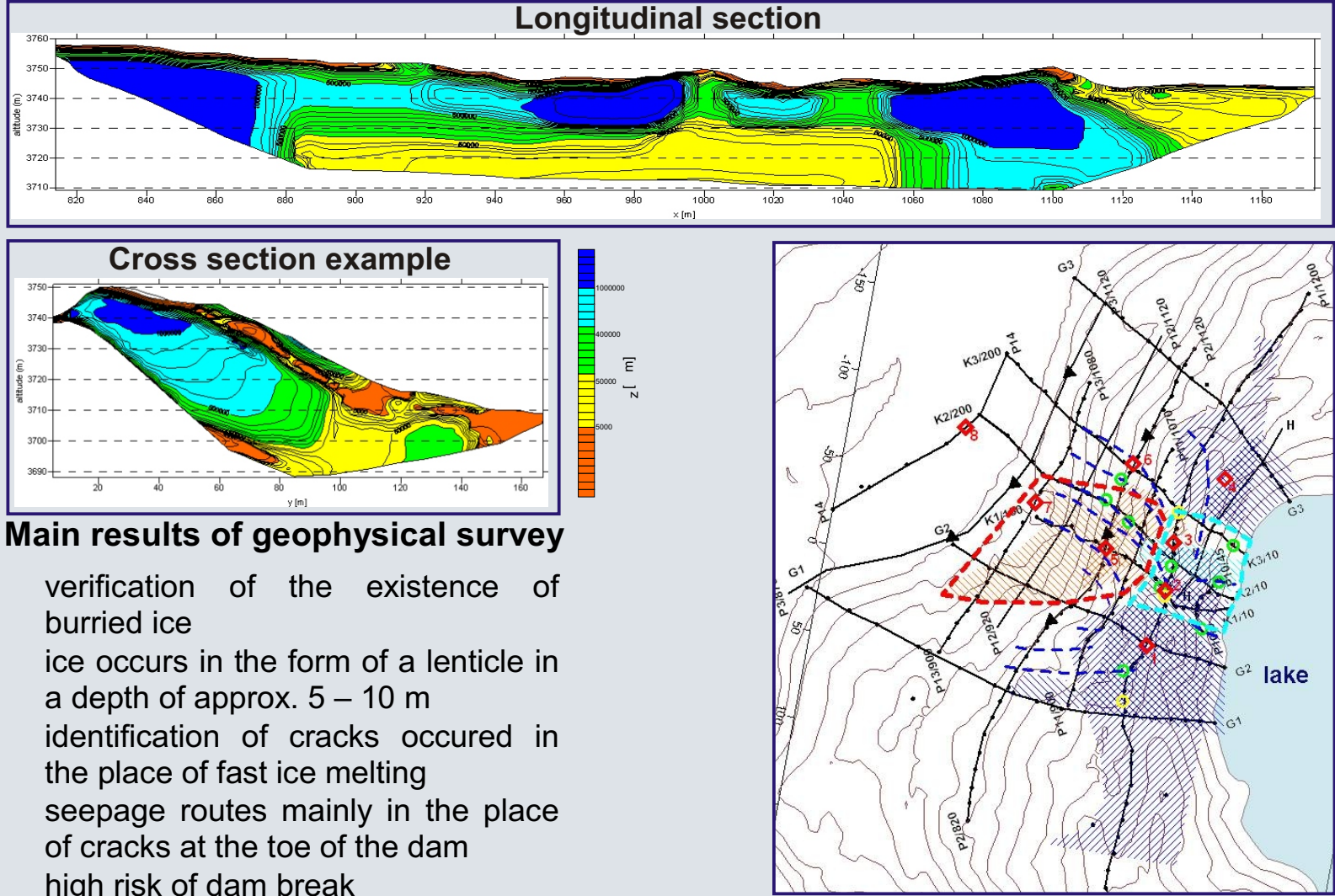
	Total retreat (m)	Annual retreat (m/y)
1869-1957	1330	15.1
1957-1980	570	24.8
1980-1990	380	38.0
1990-1999	390	43.3
1999-2006	430	61.4
2006-2008	88	44.0
2008-2009	10 - 50	10 - 50

**Increase of lake area**

year	lake area [km <sup>2</sup> ]	annual growth [m <sup>2</sup> ]
1911	0.20 - 0.30	
1947	0.80	15 000 - 18 000
1957	0.96	11 000
1980	1.83	37 600
1995	2.78	63 000
2006	3.80	92 700



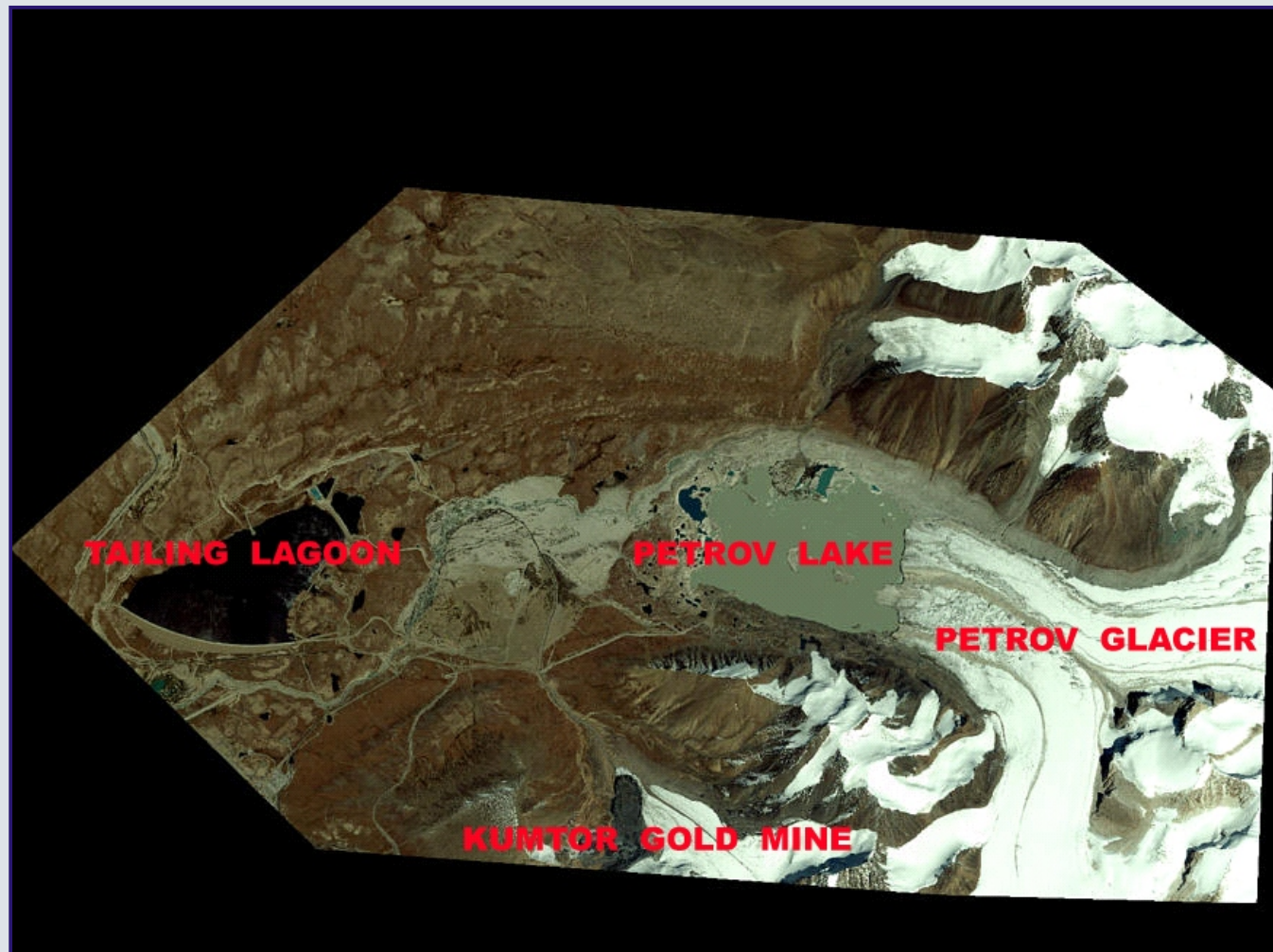
**Geophysical survey on the moraine dam resistivity tomography**



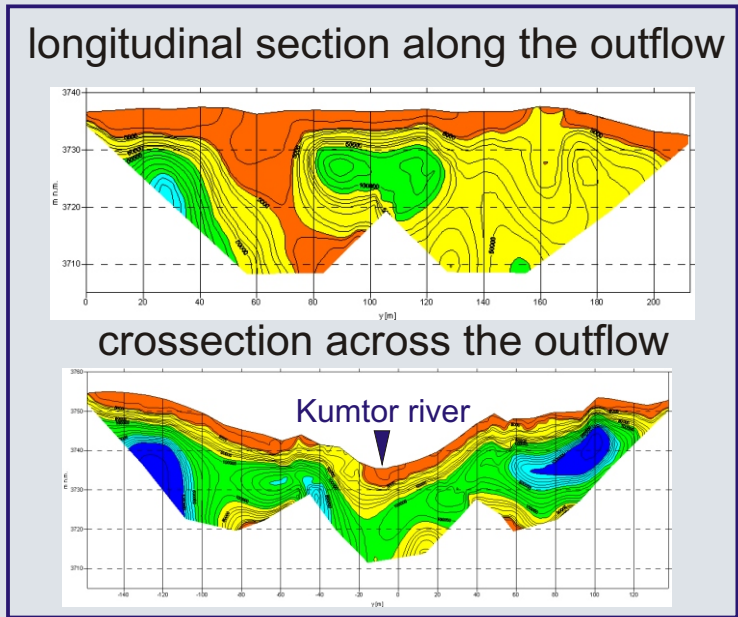
**Main results of geophysical survey**

verification of the existence of buried ice  
ice occurs in the form of a lenticle in a depth of approx. 5 – 10 m  
identification of cracks occurred in the place of fast ice melting  
seepage routes mainly in the place of cracks at the toe of the dam  
high risk of dam break

**Situation of Petrov lake and Kumtor mine area**



**Resistivity tomography of outflow**



**Main results of research and monitoring**

The lake increases its area and volume annually  
The annual retreat of Petrov glacier is between 40 – 60 mts in northern part and 10 – 20 mts in southern part of glacier snout  
The thermocast processes in the dam are very active  
Thermocast lakes in inner part of moraine extend their area and depth, new channels appear, the lakes connect one another  
Inside the moraine dam are the bodies of ice forming the „chain“ of segments separated by attenuate parts with higher content of clastic material and seepage paths  
The volume of buried ice diminishes  
The danger of outburst is not actual but probable in future

KUMTOR operating company has financed new research work this year.  
The purpose of work was to prepare the data for project aimed at deepening the surface runoff and decrease of lake water level.

Lowering	Resulting volume m <sup>3</sup>	Difference of volume m <sup>3</sup>	Difference of volume %
0 m	64000688		
1 m	60066957	3933731	6.5
3 m	52670445	11330243	17.7
5 m	45725561	18275127	28.6

