Ice-dammed lakes in the Hindukush-Karakoram Mountains (Pakistan): Geomorphological impacts of outbursts floods in the Karambar valley

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Glacial outburst floods have played a prominent role in shaping of the Hindukush-Karakoram landscape. In the Karambar valley occurred in the last two centuries some of the most devastating glacial floods in this mountain range. The glacier dams were caused by tributary glaciers located at an height between 2800 m and 3750 m with potential lake volumes amounting up to 300–500 mill. m³. Up to date, only the Karambar glacier was considered as the origin of these flood events. However, more detailed investigations showed that seven more glaciers could have dammed the main valley in historical times (**Figure 1, Plates 1, 2, 3, 4**). At least five of them have definitely formed lakes in the 19th and 20th century. The dense concentration of eight glacier dams along a horizontal distance of only 32 km results in a complex interfingering from lake basins and flooded valley sections. In the individual flood events were involved probably almost synchronously the drainage of at least two lakes. Disastrous flood events were registered in the years 1844, 1861, 1865, 1893, 1895 and 1905. The reconstructed Karambar flood chronology, including five glacier outbursts before 1900, represents with a time period of 150 years one the longest record for this region. On the basis of the formation of glacier dams and glacial lakes conclusions can be drawn in respect to glacier oscillations and especially to the timing of the decline of the *Little Ice Age* in the Hindukush-Karakoram. In 1905, glacier lake outbursts are also reported from the Khurdopin-/Yuskhin Gardan glaciers in the Shimshal valley (Iturrizaga 1994, 1997) and from the Kilchik glacier in the Shyok valley.

The abundant occurrence of unconsolidated sediments in form of mud flow cones and slope moraines manteling the valley flanks caused a high sediment load and enhanced its erosion potential. The up to 100 m high erosion cliffs of the sediment cones, wash limits along the slopes and longitudinal bars in the gravel floors are main characteristics of the flood landscape. Lacustrine sediments are scarcely deposited due to the short sedimentation time of those temporary ice-dammed lakes or they are removed by later flood events. Secondary lake formation in consequence of blockages of the ice- and mud-loaden flood masses in the narrower valley sections occurred at Matram

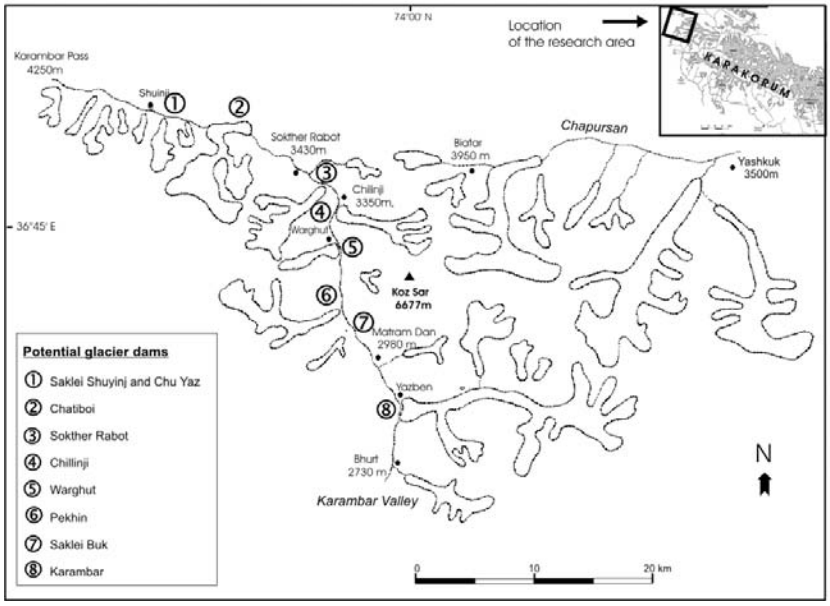


FIGURE 1. The research area: Glacier dams in the Karambar valley

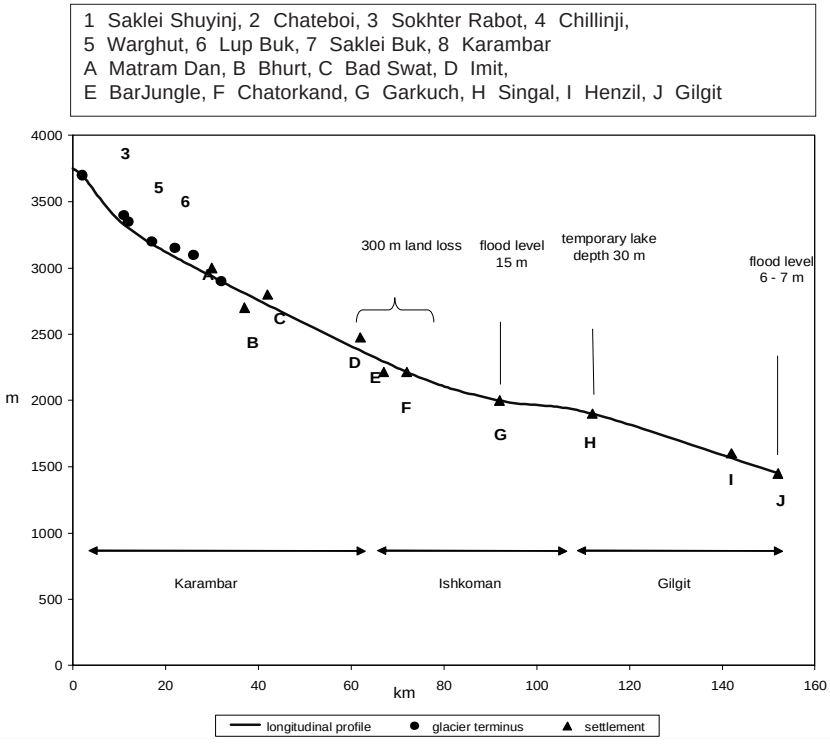
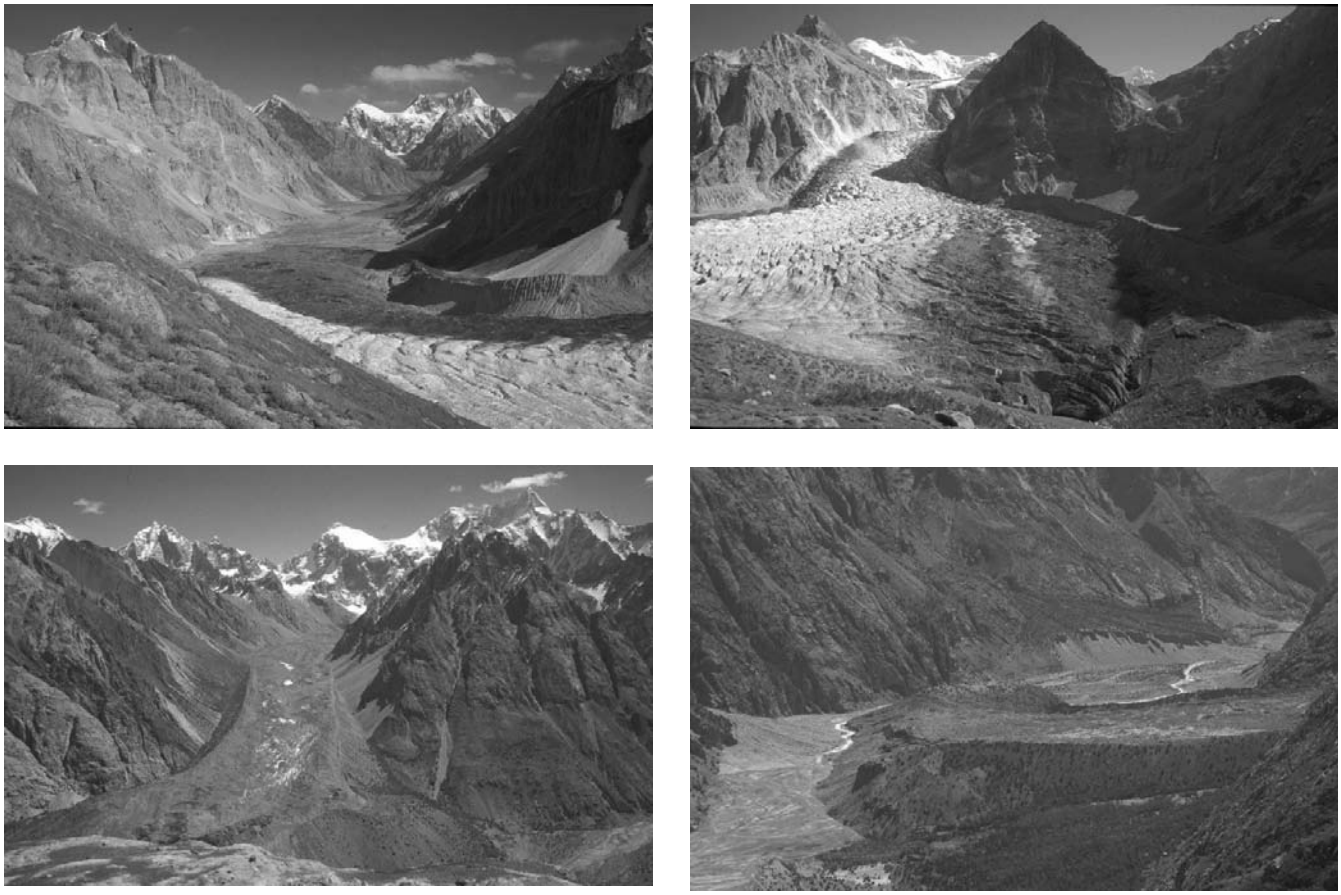


FIGURE 2. Longitudinal profile along Ishkkoman –Karambar – Gilgit valleys



PLATES 1 AND 2. Chateboi glacier dam. PLATE 3. Chillinji glacier dam. PLATE 4. Warghut glacier dam

Das, Bad Swat, Imit, Bar Jungle, Chatorkand and Singal and lasted for several days.

Downvalley from the glacier dams, the Karambar and Gilgit valleys are densely populated. On the basis of settlement losses and eye witness reports the extent, erosion rates and characteristics of the 1905 flood event can be reconstructed. The horizontal range of the flood is documented as far as Gilgit, almost 160 km far away from its origin (**Figure 2**). The flood level in Gilgit was still as high as 6 m. Up to 300 m broad sediment strips were eroded at the settlement areas. In order to warn the villagers living downstream, the Karambar people established an early fire-warning system (*Puberanch*) from Matram Das down to Gilgit until 1905, which was also sucessfully operated in the flood-affected Shimshal valley (Iturrizaga 2004).

The highest glacial dam was produced by the Saklei Shuyinj glacier, a short and inconspicious hanging glacier, which is nowadays not even visible from the main valley. In 1911, it had formed in combination with a roche moutonée a barrier (cf. Stein 1928), which lied inside the the former Chateboi lake basin. A glacier advance could have easily triggered an lake outurst. One of the latest glacier lakes occurred in 1990 at the Warghut glacier, which also blocked the valley in 1909 (**Plate 4**).

The Chateboi glacier presently blocks the Karambar valley over a distance of 2 km (**Plates 1 and 2**). The Karambar river drains subglacially and small lakes are occasionally impounded. Slight changes in the glacier interior and its subglacial environment could therefore again produce a large-sized lake. Additionally a minor decrease in snowline depression could also result in several glacier dams in the Karambar valley. A future flood event would have disastrous impacts to the human infrastructure as the settlement areas expanded to the flood plains in the last decades. Also mudflows have dammed temporarily the Karambar valley (Hewitt 1998), especially at Matram Dan (2800 m) and pose nowadays a permanent threat to the villagers. The landslide-induced deposits and terraces are closely interfingered with the glacial lake outburst sediments.

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