# Historical (<2000 B.P.) and Recent Glacier Fluctuations in the Inner Himalaya (North of the Annapurna and Dhaulagiri Himalaya)

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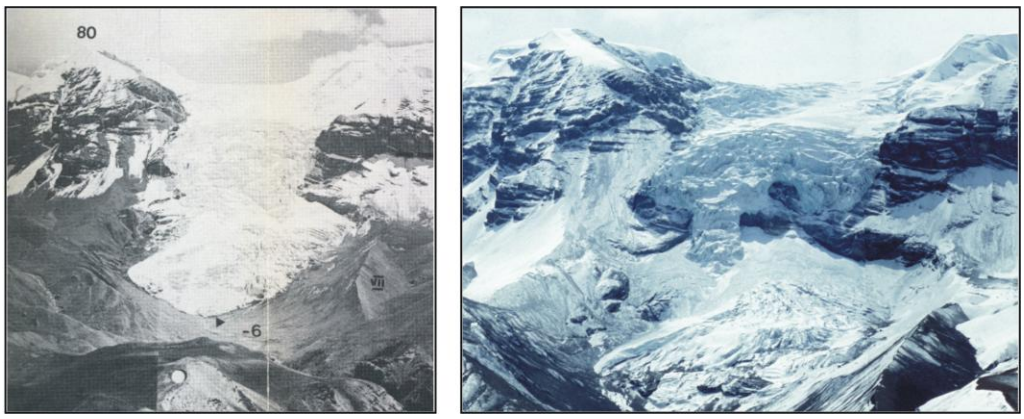
In 2007 and 2008 glacial geomorphological researches were carried out north of the Annapurna and Dhaulagiri Himalaya (28°48'N/83°31'E). Due to climate and relief, the glaciers here are comparatively suitable for setting up a relative glacier chronology. As a consequence of the subtropical location and the rain shadow of the Higher Himalaya, the equilibrium line altitude (ELA) in the study area lies at approximately 5700 m asl. The glaciers under investigation are of subcontinental type. Typically, their ablation zones terminate between 5200 to 5500 m asl and are free of debris or covered with just a thin layer of supraglacial till. The lengths of the glaciers vary from 1 to 8 km. Compared with many huge glaciers in the Higher Himalaya, the ice streams in the Inner Himalaya (north of the Annapurna and Dhaulagiri Himalaya) were less fed by avalanches and their equilibrium lines do not run in high and steep walls surrounding the glaciers. For these reasons it is expected that the snouts of the investigated ice streams north of the Annapurna and Dhaulagiri massifs react more directly to climate signals than huge debris covered glaciers in the Higher Himalaya (e.g. Khumbu Himalaya).

On two expeditions the glacial geomorphological settings of more than 20 glacier forefields were mapped (Figures 1 and 2). In the vicinity of almost all current glacier snouts fresh lateral moraines indicate a youngest glacier stage (stage 4) (mean ELA-depression = 10 m). As can be seen on photos taken by different scientists and mountaineers from 1960 to 1980 these moraine walls and ledges were deposited by the ice margins around the 1970s. Climate measurements as well as proxy data evidence a drop in temperature starting around 1950 A.D. and reaching minimum values around 1970 A.D. (Shrestha and others, 1999, Thompson and others, 2000). After this cooling period the temperatures rose continuously and up to the present the glacier snouts have retreated some decameters to a few hundred meters (Figure 1). The synchronous reactions of the glaciers to these temperature changes prove their sensitivity to such climate signals.




a) 1977 (Kuhle, 1982) b) 2008

**Figure 1:** Photo a), taken by Kuhle shows the ice front of the Chulu W-Glacier in 1977. Photo b), taken by the author in 2008, shows the interim decrease in volume and the length reduction of the glacier tongue.

For every glacier the maximum historical extension (stage 1) is evidenced by great lateral moraines, which were deposited during several glacier-advances/-stagnations in historical times. These moraine walls border each glacier forefield (Figure 2) and were highly likely built up finally during the "Little Ice Age" (1400 - 1900 A.D.) (mean ELA-depression = 80 m). According to Kuhle (1982) and confirmed by a radiocarbon date, smaller moraine walls downwards the glacier forefields were accumulated before 2000 B.P. Consistently two more glacier stages (stage 2 and 3) could be reconstructed between the moraines of stage 1 (historical maximum) and the lateral moraines deposited around the 1970s (stage 4) (Figure 2).

The lateral moraines of stage 2 (mean ELA-depression = 70 m) indicate a former glacier front just a few decameters inwards of stage 1. The moraines of stage 3 (mean ELA-depression = 40 m) are situated in the middle of the glacier forefields.

The analogue geomorphological settings of the investigated glacier forefields as well as the synchronous glacier stage around the 1970s verify the hypothesis that, in contrast to many glaciers in the Higher Himalaya, the snouts of the glaciers in the Inner Himalaya react relatively directly to climate signals.

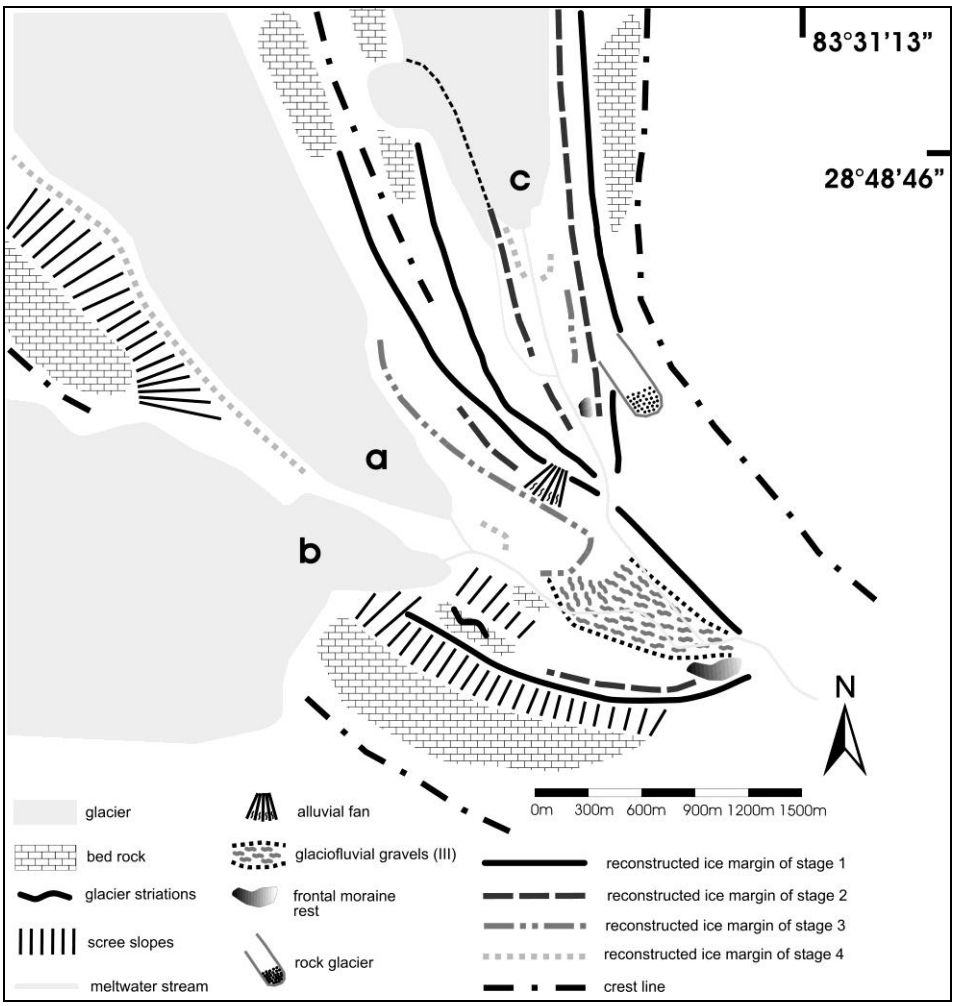



**Figure 2:** Glacial geomorphological map of the Mukut Glacier (a), the adjacent glacier (b), and the Hongde Himal I-Glacier (c), which are located in the Upper Hidden Valley. The current glacier termini lie in forefields surrounded by great lateral moraines (stage 1) indicating the maximum historical glacier extensions (highly likely LIA-maximum). Between these moraine walls (up to 80 m high) and the glacier snouts, three more stagnations/advances (stage 2; 3; 4) can be reconstructed. The lateral moraines of the youngest stage (stage 4) show the glacier retreat since the 1970s.

**References**

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