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Geomorphological and depositional features around Thulagi Glacial Lake in Manaslu Himal, central Nepal

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ABSTRACT

Several glaciers in the Higher Himalaya of Nepal show a high rate of ablation resulting in their recession and thereby giving rise to large glacial lakes on the site of former glacier tongues. The Thulagi Glacier at the southwestern foot of the Manaslu Peak (8156 m) represents one of those quickly shrinking valley glaciers whose ice tongue has been converted into a large lake of 2 km length at an elevation of 3960 m.

No till fabric occurs in the inner moraine ridges that surround and dam the lake. As these moraine deposits lack fine constituents as silt and clay, exhibit stratification as well as tilted layers, and are composed of subrounded pebbles, it is concluded that these moraine ridges represent push moraines having originated from kame terraces. A low hummocky terrain inside the high terminal push moraine at the downstream end of the lake is interpreted as a younger ice-cored push moraine still being in a collapsing state.

The Thulagi Glacier appears to have oscillated in length and volume several times in the late Pleistocene and Holocene earth history.

INTRODUCTION

Several glaciers in Nepal Himalaya show a high rate of ablation and recession resulting in the formation of large glacial lakes during the last decade. This development has been and is still menacing to induce disasters in certain downstream courses because of the danger of glacial lake outburst floods (GLOFs). A few GLOFs have already occurred in recent years, one of them in the Khumbu region in 1985 (Ives, 1986). Eventually the GLOFs rapidly move down as debris flows and possess highly destructive power. It is therefore of great public interest for Nepal to evaluate the risk of GLOFs. However, this paper is not meant to discuss the possibility of a GLOF in any detail, but rather to give a short description of the moraine situation around the Thulagi Glacier Lake in the Manaslu Himal (Fig. 1). During the late Quaternary, probably not earlier than Holocene, the Thulagi Glacier has developed several smaller glacier oscillations.

The Thulagi Glacier situated at the SW foot of Manaslu (8156 m) represents one of those quickly dwindling valley glaciers whose ice tongue has been converted into an impressive lake at 3960 m (Fig. 2, 3 and 4). The lake is roughly 2 km long, 400-600 m wide and up to 80 m deep (personal communication), which allow to estimate the volume of lake to be about 32 million cubic metre (2000 m x 400 m x 40 m). The 11-km long Dana Khola drains the lake. The stream joins the upper Marsyangdi River at Dharapani, where it debouches in cascades out of a deep gorge.

Geologically, the Manaslu Himal area belongs to the Higher Himalayan Crystalline zone. The area is underlain by high grade metamorphic rocks such as gneisses. The rocks are well-exposed around the Thulagi Lake. Granites are exposed in and around the Manaslu Peak. The glacial drift around the Thulagi Lake therefore contains both of these rock fragments.

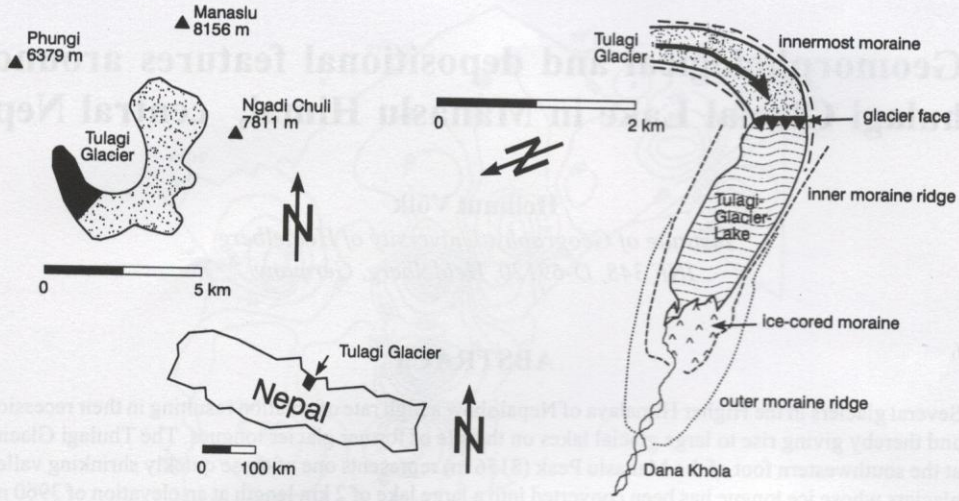

Fig. 1: Sketch maps of Thulagi Glacier Lake and moraine ridges.

GEOMORPHOLOGY

The upper end of the Thulagi Glacial Lake is formed by the tongue of the Thulagi glacier itself, which ends with a precipitous ice wall of approximately 30 m height, showing from time to time slabs of calving ice plunging into the lake. Embedded into a deep U-shaped valley exhibiting steep 1000-1500 m high rock flanks, the lake nowhere touches the rock walls, but is surrounded by moraines and debris cones on two sides, which are about 100 m wide and upto 80 m high. Next to these high standing moraines and cones the lake is bordered by several small remnants of lower moraines having only 30-35 m of elevation (Fig. 1and 2).

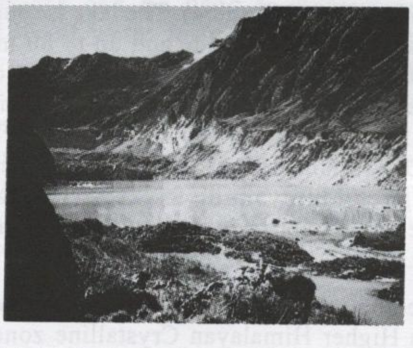

Fig. 2: Thulagi Glacier Lake (1994) looking up valley to the precipitous calving face of the glacier. The ice tongue is small in comparision to the lateral moraines. Firstly, the innermost low push moraine (dark part of side side slope), and then the hidden push moraine sediments higher up in the slide mass of loose material are covered by debris cone deposits.

Fig. 3: Close-up of marginal deposits along Thulagi Glacier Lake (1994) demonstrating outward inclined layers of ice contact drift (push moraine) at steep exposure. These sediments are covered by debris cone deposits in the upper most part of the outcrop.

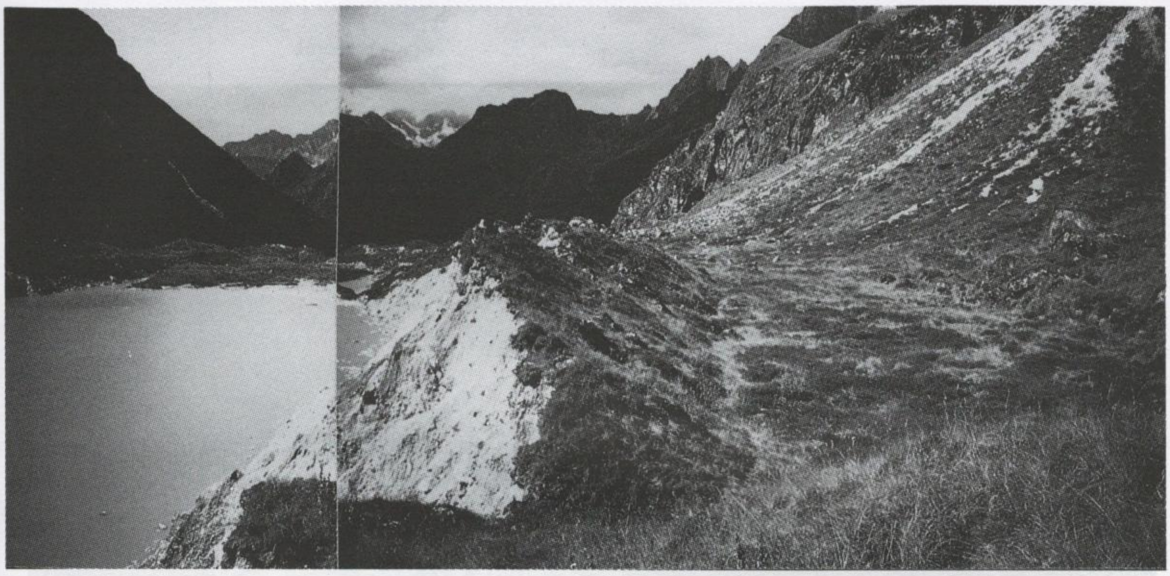

Fig. 4: Downvalley view of Thulagi Glacier Lake (1994) which is dammed by several terminal moraine-ridges (left part). The lower ones are ice-cored discontinuous younger push moraines, surrounded on the outside by a higher push moraine with a gap of the actual spill-way (cp. Fig. 5). Middle part of the picture views along crest of older push moraine whose outer slope limits the undeformed part of the kame terrace to the right.

This fringe of sedimentary material is very well exposed on its inner lateral flanks, where one can observe bare fresh looking steep slopes bordering the lakeside which are kept in their steep position by frequent sliding and slumping (Fig. 2, 3 and 4). Apart from these inner slopes at the lakeside, all the other slopes of the valley-fill are covered by dense alpine grass vegetation in accordance with the bioclimatic zone of that region. Therefore, these forms must be regarded as relics.

On those parts of the morainic valley fill along the lake side where no debris cones have developed one can distinguish two to three parallel ridges separated from each other by plane surfaces. The outermost ridge of the moraine bordering the valley flank appears to be less regular, contains more blocks on the crest and also stands somewhat higher. Moreover, viewed in a longitudinal profile this outer ridge also differs from the inner ridges by clearly showing downvalley gradient, whereas the inner crests remain more or less in horizontal positions. From these observations two different modes of origin might be suggested for these marginal moraine ridges.

The terminal moraines damming the Thulagi Lake at the downstream end reveals a greater variety of forms than at the lateral sides (Fig. 4). The outer terminal ridge stands out high above the inner lower hummocky terrain. It is here that the actual spillway is forced to cut through in a winding course, across the hummocky area before it leaves the high terminal ridge through a rather large gap (Fig. 5). The vegetational cover seems to protect all the moraines even on the lakeside, but at a close view numerous shallow initial slides are visible at the inner side of the high terminal ridge where loose stony material is exposed.

DEPOSITIONAL FEATURES

All the sedimentary materials from the moraines surrounding the glacial lake except those of the outermost ridge contain blocks, subrounded pebbles and much sand, but it is deficient of fine constituents such as silt and clay. This condition lends the exposures of these deposits a strikingly loose appearance. No till fabric can be detected in the deposits.

Another important sedimentary feature of the inner moraines is weakly developed but consistent stratification. At places, where debris cones are

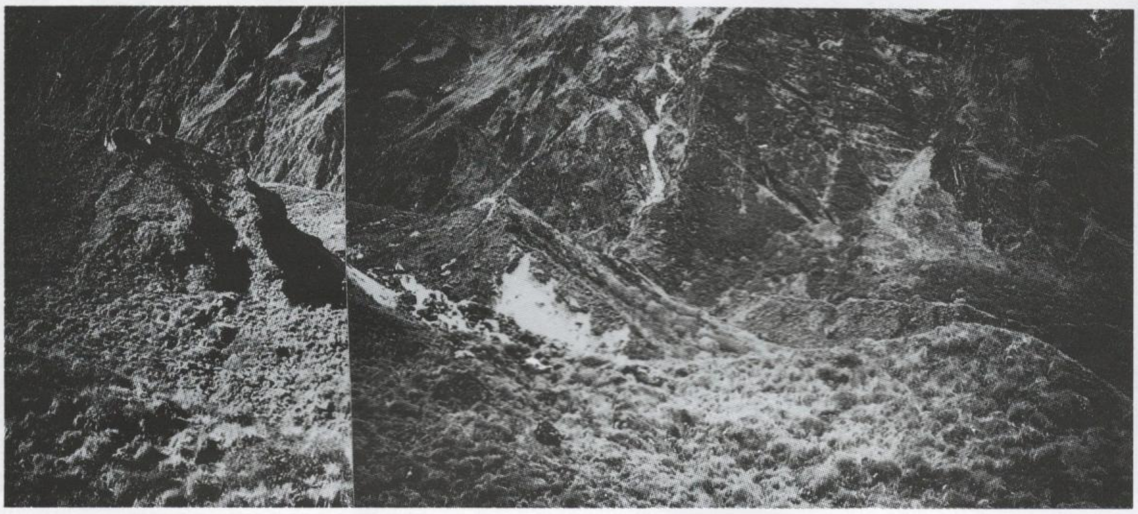

Fig. 5: Spillway of Thulagi Glacier Lake inside a large gap of the high terminal push moraine (left part), probably created by GLOF (oblique view from downvalley). Outermost and oldest moraine ridge (ablation type?) surrounds the push moraine in a low position from left to right.

covering moraines, one clearly observe a sedimentary disconformity between these two depositional units, whereby the stratification of the underlying moraine deposit is more distinct (Fig. 3). Further examination supports the first visible impression, that the bulk of these deposits are not tills but water laid deposits (Fig. 6) in which can be distinguished two different groups by additional sedimentary features:

- the underlying moraine material shows a high amount of subrounded pebbles, whereas the debris cone material above is angular to rarely rounded
- moraine material contains both gneiss and granite components but debris cone material is built up only of local gneiss components, and
- moraine deposits show its platy components as being inclined outwards together with the layering, while the debris cone deposits are layered slightly oblique towards the lakeside (Fig. 3).

Exposures of the low hummocky area encircling and limiting the downstream end of the glacial lake deliver a different kind of sediment deformation than the pushed meltwater deposits along the lake margin (Fig. 7). The meltwater deposits of the innermost

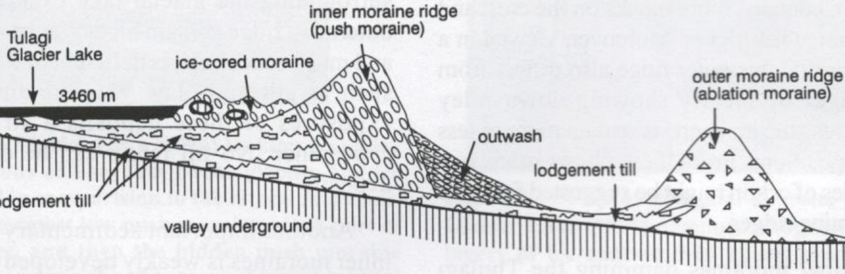

Fig. 6: Sketch profile of Thulagi Glacier Lake and its moraine ridges.

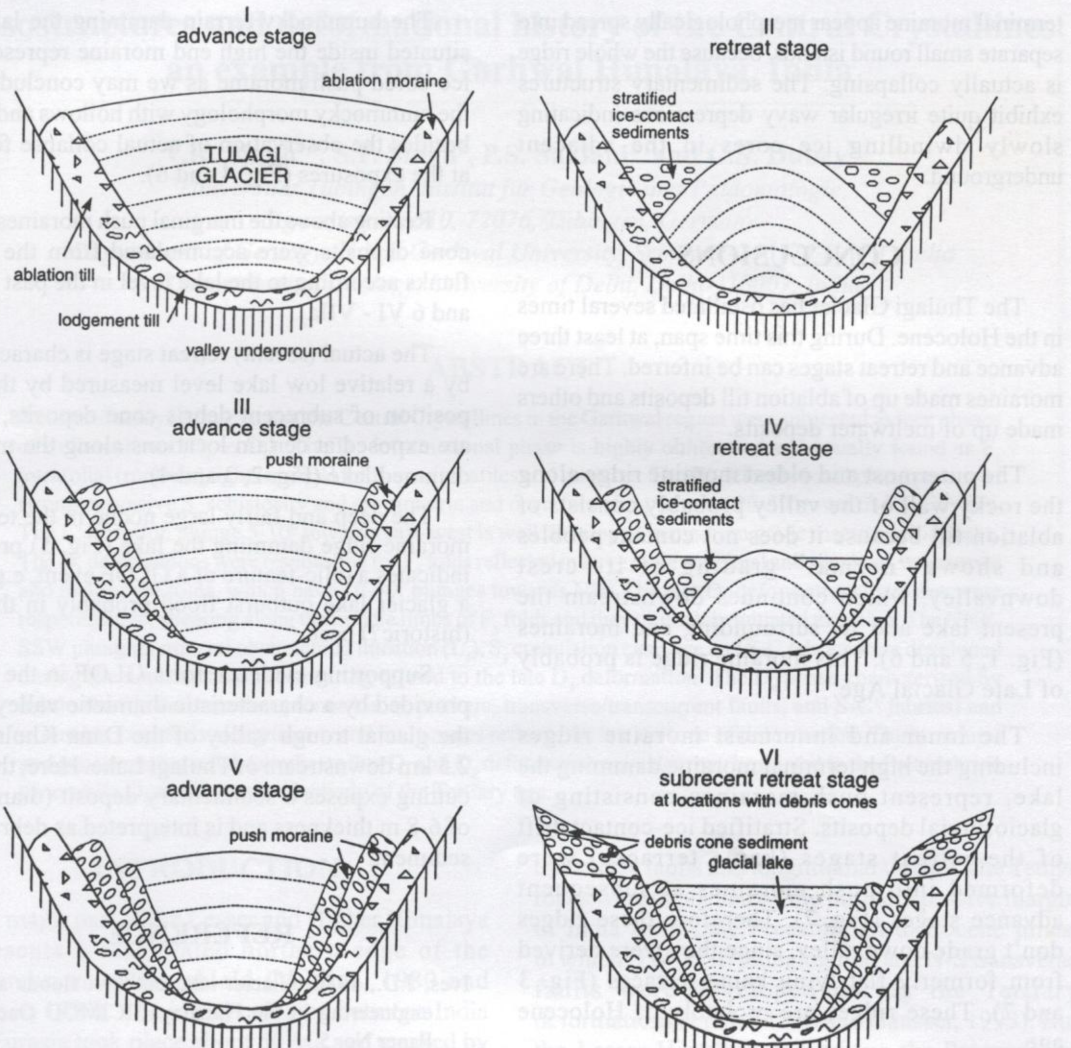

Fig.7: Inferred series of oscillations of the Thulagi Glacier (cross profiles). Retreat stages produce ice-contact stratified drift subsequently pushed aside by readvancement of glacier ice to from push moraines.

terminal moraine appear morphologically spread into separate small round islands, because the whole ridge is actually collapsing. The sedimentary structures exhibit quite irregular wavy depressions indicating slowly dwindling ice cores in the adjacent underground.

CONCLUSIONS

The Thulagi Glacier has oscillated several times in the Holocene. During this time span, at least three advance and retreat stages can be inferred. There are moraines made up of ablation till deposits and others made up of meltwater deposits.

The outermost and oldest moraine ridge along the rocky wall of the valley probably consists of ablation till because it does not contain pebbles and shows "normal" grading of its crest downvalley, which continues downstream the present lake and its surrounding end moraines (Fig. 1, 5 and 6). This moraine ridge is probably of Late Glacial Age.

The inner and innermost moraine ridges including the high terminal moraine damming the lake, represent push moraines consisting of glaciofluvial deposits. Stratified ice-contact drift of the retreat stages (kame terraces) were deformed into push moraines at subsequent advance stages (Fig. 7). Therefore these ridges don't grade downvalley, since they were derived from formerly flat lying kame terraces (Fig. 3 and 7). These ridges are probably of Holocene age.

The hummocky terrain damming the lake and situated inside the high end moraine represents an ice-cored push moraine as we may conclude from the hummocky morphology with hollows and ponds besides the observation of actual collapse features at the exposures (Fig. 4 and 6).

Resting above the marginal push moraines debris cone deposits were accumulated from the valley flanks according to the lake level in the past (Fig. 3 and 6 VI - VIIa).

The actual (recent) retreat stage is characterised by a relative low lake level measured by the high position of subrecent debris cone deposits, which are exposed at certain locations along the moraine dammed lake (Fig. 2, 3 and 4).

The deep and fairly large noche in the terminal moraine ridge damming the lake (Fig. 5) probably indicates a relic-feature of a GLOF event, e.g. from a glacier lake outburst flood probably in the near (historic?) past.

Supporting evidence for a GLOF in the past is provided by a characteristic diamictic valley fill in the glacial trough valley of the Dana Khola some 2.5 km downstream of Thulagi Lake. Here, the river cutting exposes a sedimentary deposit (diamicton) of 6-8 m thickness and is interpreted as debris flow sediment.

REFERENCE

Ives, J.D., 1986: Glacier lake outburst floods and risk engineering in the Himalaya. ICIMOD Occasional Paper No. 5.