Periglacial Phenomena in Hidden Valley, Mukut Himal*

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Abstract

Periglacial landforms occur in the altitudinal range between the forest line and snow line in Hidden Valley and its southern outer slope. Since most of Hidden Valley is situated above the vegetation limit, sorted patterned ground and solifluction slopes cover vast areas, but vegetated patterned ground, such as earth hummocks and turf-banked terraces, is found only along the streams drained from glaciers. The occurrences of large sorted polygons and solifluction lobes are likely to be associated with the existence of permafrost. The occurrences of large sorted stripes on the supraglacial moraine seems to indicate that the glacier ice is stagnant in this part. The stripe pattern of small sorted stripes observed at 5630 m starts to become clear on gradients of more than 5° and is still clear on gradients of 40°. The rate of mass movement was proportional to the square root of the gradient of the slope and ranged from 0.4 cm/day (150 cm/year) to 0.8 cm/day, greater with one or two digits than those previously reported. Such a high rate seems to be induced by both solifluction and frost creep intensified by soaked and loose states above permafrost table, and by a steep slope angle.

1. Introduction

In contrast to the comprehensive knowledge on periglacial phenomena in Europe, northern Asia and North America, little is known about it in the high mountain regions of the Himalayas and in the Tibetan Plateau. In a semi-arid region at high altitude, such as the Tibetan Plateau, periglacial processes seem to play a significant role in landform evolution, much more than other processes.

For the purpose of understanding the periglacial system in such a semi-arid region at high altitude, preliminary investigations were carried out in Hidden Valley, Mukut Himal from June to September, 1974.

2. Description of the field area

The study site, Hidden Valley, is situated in the Himalayas on the southern fringe of the Tibetan Plateau in a semi-arid climatic environment but still under the effect of the monsoon (Shrestha, Fujii and Nakawo, 1976).

The geomorphology of Hidden Valley consists of gentle and non-vegetated slopes. The valley extending from west to east for about 10 km exhibits a typical U-shape. Vegetation patches are found along the main stream, Rikha Samba, drained from glaciers up to 5100 m but the major part of this valley is free of vegetation (Fig. 1).

The basic climatological data in the mature stage of the monsoon, July to August, obtained at the temporary Weather Station at a height of 5055 m are given in Table 1. In discussing periglacial processes, the most significant climatological data are the large air temperature range, low air

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<td>total evaporation (mm)</td>
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<td>soil temp., 50 cm (°C)</td>
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temperature, low precipitation and high evaporation. The climate of Hidden Valley has been described by Shrestha, Fujii and Nakawo (1976).

Such geomorphological and climatological features as mentioned above seem to provide a suitable environment for the development of periglacial landforms.

The distribution of periglacial landforms is shown in Fig. 1 and the detailed discussion on the comparison of the occurrences of the periglacial landforms in this region with those in Khumbu Himal was given by Iwata, Fujii and Higuchi (1976).

3. Patterned ground

1) Sorted polygons

All of the observed polygons are sorted except for an example of non-sorted one in the old terminal moraine of the Rikha Samba Glacier. Sorted polygons in both large and small scales occur in the flat surface of the valley’s bottom and top of the crest. Polygons are found even on slopes of 4-5° on turf-banked terraces.

Large sorted polygons 1-1.5 m in diameter enclosing smaller polygons develop in the flat site near Dambush Pass (5196 m) and adjacent to a small pond about 1 km east from the Station. Some of the polygons are found in the pond bed. Sorting of materials of smaller forms, 10-20 cm in diameter, develop in the sands of the alluvial plain along Rikha Samba khola.

2) Sorted stripes

Sorted stripes are found on most of the slopes except on rock walls, terrace cliffs and so on. Like sorted polygons, both small and large sorted stripes occur.

The interval of coarse stripes is about 10 cm for small sorted stripes and 1 m for large one. Sorting of large stripes is better than that of smaller forms.

Large sorted stripes generally develop as transient forms from large sorted polygons on the slopes adjacent to such flat places as Dambush Pass and French Col. Large sorted stripes observed near a pond located about 1 km east of the station, however, change to large sorted polygons on gradients of 2-3°. Small sorted stripes occur independently of the existences of sorted polygons.

Large sorted polygons are found on the supraglacial moraine of the glacier located 1.5 km east of the Station. This fact seems to indicate that the glacier ice is stagnant in this part.

The pattern of small sorted stripes (Fig. 2)
observed at 5680 m just beside the Rikha Samba Glacier become clear on gradients of more than 5° and is still clear on gradients of 40°, though the maximum gradient on which sorted striped have been recorded hitherto rarely exceed 30° (Washburn, 1973).

3) Vegetated polygons

Earth hummocks and turf-banked terraces (Fig. 3) are found in this valley as vegetated polygons. Their distribution almost coincides with the distribution of vegetation cover. Earth hummocks occur in wet sites along Rikha Samba and turf-banked terraces are found on gentle slopes near the valley bottom.

Earth hummocks develop in an altitudinal range from 4000 m, 200 m higher than tree line, to 4600 m, near the vegetation limit on the west slope of the Kali Gandaki river, namely, on the east side of Dambush Pass.

Turf-banked terraces are observed near the station with a vegetated front of 15-20 cm in height embanking an area of nonvegetated ground upslope (Fig. 3). The fronts are about 10 m wide in the direction perpendicular to the steepest gradient and are parallel to each other. The bare surface of the terraces is 1.2-1.6 m long in the direction of the slope. Small sorted polygons occur even on gradients of 4-5° on the bare surface of turf-banked terraces.

4) Striated ground

Striated ground, which consists of aligned lumps of fine to coarse sand, separated by narrow channels about 2-3 cm wide and about 10 cm long as reported by Schubert (1973), was observed on the flat and wet ground surface along the streams (Fig. 4).

The orientations of the striae in the ground were measured and plotted by a short solid line in Fig. 1. The striae generally predominated in the direction of NE-SW, but are slightly different from place to place. Near Dambush Pass, they were oriented from W-E to WNW-ESE on the left bank of the Rikha Samba Glacier, showing a direction similar to that of cloud movement.

The orientation near the Station was N75 E on July 17 and the prevailing wind directions measured at the Station at 0540 NST (Nepal Standard Time) by eye measurement were from W to WSW for the previous ten days when minimum air temperature recorded was below 0°C. Even such insufficient data seem to follow Schubert’s (1973) observation; the formation of needle ice...
in the ground reflects the direction of the freezing wind, forming striae oriented in that direction.

4. Periglacial mass movements

1) Solifluction slopes

In Hidden Valley, solifluction slopes cover vast areas. The most widespread effect of solifluction is to produce extensive low angle slopes, partly erosional and partly depositional. It seems to be clear that the predominance of solifluction leads to the characteristic landscape of Hidden Valley; it might have played a significant role in the slope evolution of pre-existing glaciated valley after the receding of glaciers.

Solifluction slopes develop on gentle slopes in the altitudinal range from 5050 m to 5500 m. The dimensions of the solifluction lobes on the slope in south of the Station are 3-5 m long in the direction of the steepest gradient and about 2 m wide. The ground temperature measured on this slope implied the existence of permafrost (Fujii and Higuchi, 1976). As the thickness of active layer of permafrost was less than 2 m, the mass movement layer should be less than 2 m thick.

Since the altitudinal distribution of solifluction slopes corresponds to that of permafrost (Fujii and Higuchi, 1976), the occurrences of solifluction slopes are considered to be associated with permafrost.

Fig. 5 shows typical solifluction lobes which were found outside the lateral moraine of the glacier located 2.5 km east of the Station. The dimensions, however, are considerably bigger than that mentioned above.

Fig. 5. Solifluction lobe (large) developed outside the lateral moraine of the glacier located 2.5 km east of the Weather Station.

2) Measurement of mass movement

Measurements of mass movement were carried out on a slope with developed small sorted stripes at 5680 m near the Rikha Samba Glacier. The targets of painted tabular stone were set in a line to be at a right angle to the slope direction. They were measured on August 29, 47 days after setting.

The results are shown in Fig. 6. They moved in proportion to the square root of the slope angle. The rate of surface movement on a 30° gradient ranged 0.4 cm/day (150 cm/year) to 0.8 cm/day (300 cm/year), greater by one or two digits than that previously reported by Washburn (1967) and others.

![Fig. 6. The relationship between the rate of surface movement and the slope angle measured at 5680 m near the Rikha Samba Glacier.](image)

The ground temperature measured on this slope on August 29 was 1.1°C and 0.6°C at depths of 50 cm and 79 cm respectively and the thickness of the active layer, therefore, is expected to be 110 cm. The active layer was soaked and very loose.

Such a high rate of mass movement will be explained by the intensified movement by both solifluction and frost creep in soaked and loose active layer above the premafrost table, and by the steep slope angle.

5. Altitudinal distribution of periglacial landforms

Fig. 7 shows the altitudinal distribution of periglacial landforms observed above 4850 m in Hidden Valley and below 4600 m on the east slope of Dambush Pass. Almost all of the observations were carried out in Hidden Valley.

Periglacial landforms occur in the altitudinal range between tree line and the snow line. Tree growth and snow cover are, therefore, the most significant factors for defining the lower and upper limits of the altitudinal distribution of periglacial landforms. These factors prevent the
development of periglacial processes such as frost sorting, frost creep, and so on.

Earth hummocks appear in the lowest part of the distribution of periglacial landforms though sorted lobes (solifluction lobes) and large sorted polygons occur in the highest part of the distribution of periglacial landforms. The sorted lobes and large sorted polygons appear to be associated with the existence of permafrost.

References


