RP World History and Cultural Studies
Vol. 3, No. 2 (July – December 2024) pp. 30–33
e-ISSN: 2583-8156

Cite this article: S. Beniwal, Physiognomies and features of paraglacial geomorphic in some deglaciated inner Himalaya regions, *RP World. Hist. Cult. Stud*. **3** (2024) 30–33.

Original Research Article

Physiognomies and features of paraglacial geomorphic in some deglaciated inner Himalaya regions

Sunita Beniwal
Department of Geography, Government P.G. Nehru College, Jhajjar – 124103, Haryana, India
*Corresponding author, E-mail: sunibe1974@gmail.com

ARTICLE HISTORY
Received: 9 March 2024
Revised: 2 July 2024
Accepted: 5 July 2024
Published online: 7 July 2024

KEYWORDS
Paraglacial landform; Geomorphological process; Alakananda valley; Rathang valley; Eastern Himalaya.

ABSTRACT
In the Alpine environments, paraglacial slope formation occurs naturally both during and after deglaciation. In areas of the western and eastern Himalaya during and after deglaciation, paraglacial stress-release acting on glacially steepened rock walls has produced a wide variety of typical landform features of rock fall and talus slope types. These are linked to characteristics of catastrophic slope collapse, deeply buried rock mass deformation, fan development, and progressive slope adjustment with sporadic rock fall activity. The creation of avalanche tracks and melt-water canals in this region also assisted in the simultaneous change of mountain slopes. From a geomorphological perspective, typical features that emerged under the aforementioned circumstances and their evolution on the mountain slopes in these places have been recognized.

1. Introduction

Quaternary geomorphologists have recognised four typical geomorphological processes, including glacial, periglacial, paraglacial, and nival, that occur in frigid mountain environments. Numerous regions in the Arctic and Alpine environments have previously seen an intensive study of glacial, periglacial, and nival processes and characteristics. Only recently, over the past several decades, have Quaternary geomorphologists begun to pay attention to the processes and characteristics associated with paraglaciation.

The word "Paraglacial" was used initially by Ryder [1, 2] for describing how rivers and debris flow modified potentially unstable glacial drift, British Columbia's Canadian Rockies saw deglaciation afterwards. Church and Ryder [3] later conducted extensive research on paraglacial as a distinct geomorphological process, describing it as "a glacially conditioned fluvial process in the cold settings" that characterises this characteristic landscape process. Following that, the conception of paraglacial process as well as the explanation of modification of glacigenetic deposits on hillsides in the Arctic and Alpine regions have frequently included attendant landscape alterations. [4–10]. The disclosure and consequentparaglacialalteration of vertical rock walls is one of the most important geomorphological effects of deglaciation, according to Ballantyne [7], and independent of sediment reworking, it frequently happens in many mountainous places.

Recently, glacier movement in the Inner Himalaya has received little attention in terms of the paraglacial processes and geomorphics, additionally, in certain instances, the newly formed alluvial fans that appear on the uncovered foot slopes ensuinglatest glacier pull-back have been incorrectly endorsed to exclusively fluvial procedures. This study intends to analyse the arrangement of dropping on slopes of the mountains in freshly glaciated Upper Alakananda, Upper Bhagirathi, and Eastern (Sikkim), Rathang valleys in the Western (Garhwal).

2. The Himalaya's tectonically active paraglacial rock-slope modification mechanism

Slope evolution results from both geomorphological and geotectonic processes in the Himalayas, the Alps, and others which are tectonically active mountains. The scale at which one of these two processes predominates determines how much it predominates in a certain area of the terrain. It is now thought that residual strain energy was stored in the rock mass of the valley wall during the Pleistocene era when the valley glaciers were at their thickest. Then, as the valley glaciers started to melt during the deglaciation, the rock tension continued to be released, causing the slopes to deform [7]. The rock body frequently experiences a variety of impacts following deglaciation, including severe fracture and significant slope modification. The type, as well as the extent of the paraglacial acknowledgement, are influenced by variations in lithology as well as structural characteristicssignificantly. A complex geological structure can be seen in this area of the Inner Himalayas, where there is a lot of gneissic and schistose rock folding. In this Himalayan region, the following three kinds of paraglacialgeomorphics and processes have been researched:

2.1. Catastrophic failure of the rock slope and supplementary geomorphics

Failure of disastrous rock slope is a frequent occurrenceamong all highlands. Following glacier retreat, exposed mountain slopes in cold mountain environments tend to exert outward strain, resulting in rock shattering and catastrophic slope failure. The initial change of slopes is thought to have resulted from multiple failures of disastrous rock slope in the introductory phase of the main Alakananda Glacier's ongoing retreat commencing in the early Holocene. The recent discovery of morainic formations in the Upper Alakananda Valley, which is outside of Mana village, lends credence to this theory. But given the enormous amount of debris—shattered blocks mixed with fines—covering the slopes on either side, it is unclear how much of it is paraglacial product and how much is the result of the Himalayan tectonic (seismic) activity. After the glacier was removed from the valley, it appears likely that the large blocks of debris that have collected on the slope's base are the effect of paraglacial activity, and individuallayersof higher portion of slopes exhibit evidence of combined paraglacial, periglacial, as well as tectonic activity. In contrast to those on the foot slopes, which are primarily preserved in relict form as has been deduced from the spot markings of enormous lichens on the boulders, debris found on the hilltop was reported recent in form and believed to be functional in the current.

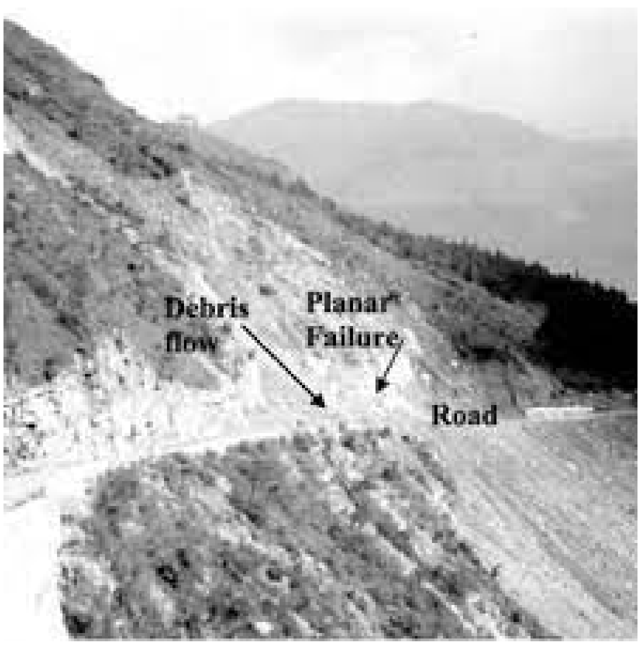

Figure 1. Disastrous rock slope failure induced modified hill slope of Upper Alakananda valley in Garhwal Himalaya.

2.2. Deformation of the rock-slope and related geomorphics

Deformation Rock-slope is the activity of debuttressing a rock slope during the deglaciation. This process and the start of rock-mass creep have a particular link. Several researchers, including Tabor [11], Evens and Clague [12] have explored this process. Bovis [13] conducted extensive research on paraglacial rock-slope deformation in the British Columbian valley of Affliction Glacier. His studies revealed that the slopes supported antiscarps, elongated grabens, collapse pits, and other common features related to rock-slope deformation.

Stress may be released during the dcglacial unloading and debuttressing processes, which are also known as the processes of slow rock-slope deformation and rock-mass creep. Such deformation of the rock slope results in the widespread failure of rock masses. Convex bulging slopes, tension cracks that resemble crevasses, upslope-facing scarps, and ridge-top pits are the primary geomorphics created by the gradual rock-slope deformation process (grabens). There are numerous crevasse-like tension fractures as well as preserved upslope-facing scarps on both sides of the mountain wall that cuts across this valley.

Figure 2. On the south-facing slope of the Kanchenjunga in the Sikkim Himalaya, anti-scarp formation is a result of the slope debuttressing at the edges of the retreating Rathang Glacier.

2.3. Formation of the paraglacial talus-slope and fans

The third conceivable reaction of glacially processed slopes is steepened slopes and paraglacial talus slopes [14]. As paraglacial talus accumulation developed, the valley's cliff walls responded quickly with rock-fall activity. Geomorphologists operating in cold regions said that the enormous amounts of talus created on the foot-slope underneath the walls of the cliff were inconsistent given the rate at which rock falls are currently occurring. They came to the conclusion that, in the past, once the glacier had retreated from the valley, the pace of rock fall had been much higher [15–17].

Alluvial fans and debris cones are distinctive paraglacial accumulations from the Late Pleistocene and Early Holocene eras, but little is known about how they formed on freshly deglaciated forelands [8]. Deglaciated mountain environments are dotted with alluvial fans and paraglacial debris cones. It is believed that some paraglacial debris cones in the Himalayas are from the Late Holocene. During the preceding 200 years, concurrent with glacier retreat, debris-flow-dominated fans have grown in the higher portionof Bhagirathi Valley or Garhwal Himalaya [18].After the glacier ice receded, many cones were shaped in the LangtangHimal of the Himalayas of Nepal, and some of these cones eventually had their toes terminated by further glacier advances [19]. The studied area of the Upper Alakananda Valley is characterised by a series of extensive paraglacial fans. These tend to be of the relict variety and are frequently severely trenched by snow-avalanche trails.

In this region, the large number of fans has concluded to expand and show entrenched fan heads as well as river erosion.

Figure 3. The valley-side slopes of the upper Alakananda valley, which were impacted by Sathapanth glacier retreat, exhibit both the bottom zone of coalescing debris cones and the top slope zone of gullies.

Figure 4. Creating pathways for meltwater near the upper Bhagirathi river valley, on a mountain.

Figure 5. Melt water channels have caused scars on the freshly glaciated mountain slope in Upper Bhagirathi river valley of Garhwal Himalaya.

Figure 6. In the Upper Alakanandariver valley of the Garhwal Himalaya, there is a significant snow-avalanche trajectory on the foothill.

3. Conclusions

Paraglacial slope evolution is the main geomorphological procedure across the recent glaciated mountain range of the Upper Alakananda Valley. The initiating impact of suchprogression was formed inside the unsteadyfoothill cliffs overseeing the floor of a valleyvia pressurerelief of the rock body during and instantly after withdrawal of the glacierfrom the main valley. Beyond the Badrinath pilgrimage, uphill via the Upper Alakananda Valley from Mana village to Satapanth, numerous paraglacially produced geomorphic features, such as talus buildup, fan formation, antiscarps, and convex bulging slopes, have been seen. Since the Late Pleistocene as well as Early Holocene, paraglacial occurrences have gradually ceased, leaving the buildings that were built previously vulnerable to periglacial and fluvial processes and relics. As a result, the slope's evolution has been changing ever since. The rock-fall features deposited near the foot of the slopes, consisting of big blocks and minute fines, and the angular debris intermingled with finer material seen on the upper slopes are illustrative of the slope deposits created by pariglacial as well as by tectonically (seismically) processes.

References

[1] J.M. Ryder, The Stratigraphy and morphology of paraglacial alluvialfans in south central British Columbia, *Canad. J. Earth Sci.* **8** (1971) 279-98.

[2] J.M. Ryder, Some aspects of geomorphometry of paraglacial alluvial fans in the south-central British Columbia, *Canad. J. Earth Sci.* **8** (1971) 1252-1264.

[3] M. Church, M. Ryder, Paraglacial sedimentation: a consideration of fluvial processes considered by glaciations, *Geolog. Soc. Am. Bull.* **83** (1972) 30593071.

[4] L.S. Owen, Mass movement deposits in the Karakoram Mountains: their sedimentary characteristics, recognition and role in Karakoram landform evolution, *Zeitschrift fur Geomorphologie* **35** (1991) 401-424.

[5] C.K. Ballantyne, D.I. Benn, Paraglacial slope adjustment and resedimentation following glacier retreat, Isdalen, Norway, *Arctic Alpine Res.* **26** (1994) 255-269.

[6] C.K. Ballantyne, Paraglacial debris cone deformation on recently-deglaciated terrain, *The Holocene* **5** (1995) 25-33.

[7] C.K. Ballantyne, Paraglacial adjustment of rock slopes: Causes and consequences, *Ind. J. Geog. Envir.* **5** (2000) 1-22.

[8] C.K. Ballantyne, Paraglacial Geomorphology, *Quat. Sci. Rev.* **21** (2002) 1935-2017.

[9] T. Watanabe, L. Dali, T. Shiratwa, Slope denudation and supply of debris to cones Langtang Himal, Central Nepal Himalaya, *Geomorphology* **26** (1998) 185-197.

[10] A.M. Curry, Paraglacial modification of slope form, *Earth Surf. Proc. Landforms* **24** (1999) 1213-1228.

[11] R.W. Tabor, Origin of Ridge-top depressions by large-scale creep in the Olympic mountains, Washington, *Geol. Soc. Am. Bull.* **82** (1971) 1811-1822.

[12] S.G. Evans, U. Clague, Glacier-related hazards and climate change, in The *World at Risk: Natural Hazards and Climate Change*, R. Bras, (Ed.), American Institute of Physics Conference Proceedings **277** (1999) 48-60.

[13] M.J. Bovis, Rock-slope deformation at Afflicton Creek, Southern Coast mountains, British Columbia, *Canad. J. Earth Sci.* **27** (1990) 243-54.

[14] P.C. Augustinus, Rockmass strength and the stability of some glacial valley slopes, *Zeitschri Jtf. Lr. Geomorphologie* **39** (1995) 55-68.

[15] B. Luckman, The geomorphology of the Alberta Rocky Mountains - a review and commentary, *Zeitschrift fur Geomorphologie Supplement Band* **37** (1981) 91-119.

[16] I.S. Gardnar, Alpine mass wasting in contemporary time: some examples from the Canadian Rocky Mountains, in *Space and Time in Geomorphology*, C.E. Thorn (Ed.), Allan and Unwin (1982).

[17] J. Marion, L. Filion, B. Hem, The Holocene development of a debris slope in Subarctic Quebec, Canada, *The Holocene* **5** (1995) 405-419.

[18] L.S. Owen, M. Sharma, Rates and magnitudes of paraglacial fan formation in the Garhwal Himalaya: implications for landscape evolution, *Geomorphology* **26** (1998) 171-184.

[19] T. Watanabe, Timing of the Late Holocene debris supply and glacial fluctuations in the Langtang Himal, central Nepal Himalaya, *Mitteilung der Versuchsanstalt fuer Wasserbau, Hydrologie und Glaziologie der Eidgenossischen Technischen Hochschule Zuerich* **158** (1998) 207-216.

Publisher's Note: Research Plateau Publishers stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.