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Study of Some Debris Avalanches in Garhwal Himalaya, India

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ABSTRACT: This study was carried out in the Alaknanda - Dhauliganga catchment area, located in the north and north-east of Joshimath in the Garhwal Himalaya. The snow fields, cirques and the related glaciers are located above the altitude approximate 4000 meters, whil e the river valley have a mean altitude of around 2000 meters.

The strategic roads viz. Joshimath-Badrinath and Joshimath-Nitipass pass through this area with a number of villages along with their cultivated land are located along the roads. These roads are often blocked on huge debris avalanches not only damage the road, but also the cultivated land and forests.

The geological studies has indicated the presence of a major thrust viz, Main Central Thrust (M.C.T.) in this area, with highly deformed rocks. Most of the zones with frequent debris avalanches do not follow the thrust zones etc.

The glaciers have been studied on the basis of aerial photographs and landset imegeries. It appears although most of the glaciers are slowly receding back, are located in the crest of Badrinath is apparently static and many crevasses etc., are formed and slumpping is taking place. The slumped mass of Ice is pushing the moraines down in the valley and large scale debries avalanches are causes on the Joshimath-Badrinath road.

INTRODUCTION

The study area is located in catchment area of Alaknanda-Dhauliganga rivers. It is situated in north and north-east of Joshimath, bounded by longitude 79°30'-79°45' and latitude 30°30'-30°45' in Chamoli district of Uttar Pradesh, India (Fig.1). The area has a high seismic intensity along with frequent landslides, debries aval-anohes etc., are the regular features happened there. Due to these features, two important strategic roads viz, Joshimath-Badrinath and Joshimath-Nitipass are effected regularly.

The study was taken in order to identify the processes of debris avalanches, landslides. Studies of the position of the glaciers indicate the state of glacial retreat. The retreat in case of the Juma and Tipra glaciers is found to be greater than other glaciers lying on the north-west in area. The western part's glaciers of the area (above the Badrinath) is apparently static and many crevasses etc., are formed. The slumpping are regular feature in this area, pushing the moraines down in the valley slope and large scale debris avalanches are caused on the roads of strategic importance.

Cotter and Brown (1907) were the first to survey some of the glaciers of Kumaon and Garhwal Himalayas. The other workers are Heim and Gansser (1936) Jangpangi and Vohra (1958,62), Gopendra Kumar, Syed Hyder Mehdi and Gyan Prakash (1964).

GEOLOGY

Structure and Rock Types

The greater Himalaya is situated in between two great thrusts viz, the Main Central Thrust (MCT) and the Tethyan Thrust (T.T). This is indicated by the metamorphic rock which are gradually increase in metamorphism northwards and intruded by granite batholiths. The tectonic plane of Main Central Thrust dips at an angle of 45° to 15° towards the North-east. The term Main Central Thrust was first proposed by Heim and Gansser (1936). Valdiya (1980) while redefining the Main Central Thrust proposed another name, farther north and called it the Vaikrita Thrust. The Main Central Thrust is clearly definable on the surface in the mountain slope and deep cut river gorges of Alaknanda. Sinha-Roy(1982) defines the Main Central Thrust as the basal thrust of the crystalline nappe sequence either rooted or detached from the Central Crystalline zone. It could be inferred that activity along the Main Central Thrust started in the Palaeogene (Krishnaswamy, 1981 and Sinha, 1982).

The general trend of strike of the rocks in the area is E-W. Descending to the gorge at Vishnuprayag, where the gneiss is exposed. It is over lain by highly metamorphic mica schist and paragneiss. The succession is overlain by highly metamorphic sedimentary series (Fig.2)

Geomorphology

North ofVishnuprayag the gorge of Alaknanda is not only continuous but also more tremendous. The view from Joshimath to north, Convex Valley sides are tremendous showing no more place for the rivers, as if they had been caused by a fault collapse. It may be assumed that these transverse gorge is also exclusively formed on river erosion.

When river meets to moraines the valley become widens, as from Pandukeshwar. The low gradual terraces are on both flank of the river. The Lateral moraines are following both side along the river. The villages are lies just below the moraine wall near Pandukeshwar.

The topography of a Great Himalaya, which is an enormous curvilinear, arch, is highly rugged with horned peaks, surrected crest of ridges, cirques and hanging wall valley with glaciers causing cascades of gushing icy water through deep canyons(Fig.3). In beginning of this sector, the ridges are rapidly rise then the river and afterwards it run parallel to it. The river is narrower in lower elevation, while it is wider in upper one. Rivers has a very low gradient at higher elevation as in the case of Alaknanda, has a very low gradient of 5.5% from Badrinath to Mana village, while below the Badrinath the gradient is 15% (Heim and Gansser 1936).

Epigenetic gorges are abundent in higher elevation with numerous hanging valley. The terraces of higher elevation are covered by the moranies. The widened valley of Alaknanda is filled with recent mounting slide material and fan deposits. Which came down from both sides covering the older moranies and gravel deposits The glacial striations are well preserved within the rocks. Inter glacial and interstadial lake deposits are also there. (Fig.4,5 and 6).

GLACIERS AND THEIR DEPOSITS

As given in the map (Fig.3), there are two main cirques in this area viz. the Juma and Rajbank. Their cirques shoot out a number of the glaciers, of which the two main glaciers are Tiprabank, originating from Rajbank and the Kagbhusandi, originated from Juma glacier. These glaciers in turn shoot out their glacial streams.

The following table gives the altitudinal position of the glaciers, along with position of snow, the zone of accumulation and ablation (Fig.7).

TABLE I. Altitudinal Zones

Glaciers	Glacial streams	Altitudes in meters	
		zone of accumulation	zone of ablation
Tiprabank	Bhiundar Nadi	4000	3600
Kagbhusandi glacier	Laxman ganga	4100	3360

The morphometric parameters of these glaciers were calculated on the basis of the technique suggested by Prasad (1987), which is based on the general observations that an advancing glaciers has a wider snout, and a relatively larger area than a retreating glaciers. Moreover a retreating glacier will have more rugged appearence viz. higher relief ratio.

The following table gives the values of various glacial morphometric parameters.

TABLE II Glacial Morphometric Parameters

Glacier	Area Index	Relief Ratio	Snout ratio
Tiprabank	0.63	0.72	2.2
Kagbhusandi	0.34	0.84	1.4

In addition to the glacial morphometric parameters, the drainage parameters of the glacial streams were also calculated, which are summarised in the following tables.

TABLE III Drainage Morphometry of Glacial Streams

Drainage	Mean Altitude	Area
Kagbhusandi	3000-4400	0.43-2.39
Laxmanganga	3400-4200	0.69-2.83
Bhuindar	3380-4280	0.54-1.83

TABLE IV Drainage Morphometry of Glacial Streams

Drainage	Shape	Bifurcation Ratio	Drainage Density
Kagbhusandi	0.21-0.52	2-4.1	0.97-3.1
Laxmanganga	0.17-0.66	2.6-4.6	3.3-26.2
Bhuindar	0.47-0.77	2.5-4.5	7.14-15.19

The glacial moraines consisting of Boulder-clay etc., are found deposited in the zone of ablation upto following altitude in the valleys

TABLE V Altitudinal Position of the Moraines

Glacials	Altitudes of moraines	Type of Moraines
Tiprabank	3200	Boulder clay
Kagbusandi	2400	Boulder clay alongwith gravel and sand beds

MASS MOVEMENTS

Various morphometric parameters, alongwith field observations aided by the study of aerial photographs suggests that the zone of ablation is larger in case of the Kagbhusandi glacier which is retreating. The Kagbhusandi and Laxmanganga streams have wider basins with greater bifurcation ratio and drainage density, suggesting relatively greater erosion done by the streams existing in zone of ablation for the Kagbhusandi glacier.

On the otherhand, in case of the Tipra bank glacier the zone of ablation is narrow and mass movements is mainly debris avalanche.

DISCUSSION AND CONCLUSIONS

As already pointed out the zone of ablation in case of the Kagbhusandi glacier is larger than that of Tiprabank. Kagbhusandi glacier shoot out the streams of Home Gadhera and the Kagbhusandi.

The stream profiles of these streams (Fig.7) shows that the zone ablation is only 500 meters thick in case of Home Gadhera, but is 1400 meters thick in case of Kagbhusandi. On the other hand, in case of streams originated from Tiprabank viz, Laxmanganga the zone of ablation is only 200 meters thick.

The profile of Laxmanganga is concave upwards, convex in the middle and again concave downwards but concavity is very feable in the Uppar part. The profile of Home Gadhera is also very similar but the concavity is more in the upper part. Whereas incase of the Kagbhusandi, the profile is convex in the upper part and is concave in the lower part.

The mass movement is generally controlled by the type of the slope profile (Small 1970). The more steaper profile of Kagbhusandi indicates the presence of debris avalanche followed by the debris flow, whereas in case of Laxmanganga and Home Gadhera the mass movement is mainly by debris flow. This fact is supported by the drainage morphometric parameters, which suggest a greater intensity of erosion in case of Kagbhusandi Nadi, than in Laxmanganga.

Therefore, it can be concluded that since the Kagbhusandi glacier is retreating more in comparison to the Tiprabank glacier. The mass movement are in case of rapid debris avalanche here. Because of the debris avalanche the slope are more unstable in the southern part of the area, which contain the ablation for the Kagbhusandi glacier.

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REFERENCES

Cotter, G.DE.P. and J.C. Brown (1907), Note on certain glaciers of Kumaon, India. Record Geological Survey of India. Volume 35, 148-157.

Gansser, A., (1964), Geology of the Himalaya, Interscience Publishers, London.

Gopendra, K., S.H. Mehdi and G.Prakash(1968). Observations of some Glaciers of Kumaon Himalaya, India. Record Geological Survey of India. Volume 106, Part 2:231-239.

Heim, A. and A. Gansser(1939), Central Himalayan Geological observations of Swiss expedition,1936. Reprint Hindustan Publishing Corporation Delhi,India.

Jangpangi, B.S. (1958), Study of some of the Central Himalayan glaciers, Journ. Sc. Ind. Res., Vol.17A, No.12, Supplement: 91-93.

Jangpangi, C.P. Vohra (1962), The retreat of Shunkalpa (Ralam) glaciers in Central Himalaya, Pithoragarh District, U.P., India, Union Geodseique Et Geophysique Internationale, Commission Des Neiges Et Des Glaces, Colleque D'obergurgl, Publication No 58 : 234-238.

Krishnaswamy, V.S. (1981), Status report of the work carried out by Geological Survey of India in the framework of International Geodynamics Project. In H.K.Gupta and F.M. Delany (Editors), Zagros Hindukush Himalaya-Geodynamic evolution. Geodyn. Ser., Am. Geophys. Union, Volume 3_ 169-188.

Nainwal, H.C. M.P.S. Bisht C. Prasad (1987), Studies on mass movement of the Kaliasaur Landslide area district Pauri Garhwal, U.P., India. JOHSARD, Garhwal University Srinagar (Garhwal), India, Volume 9 & 10: 77-81.

Prasad, C.(1987), Studies in morphometry of a glaciated terrain. Proceeding of International Seminar on Geomorphology, Allahabad, India.

Sinha, A.K. (1982), Tectonic framework and Geological evolution of Higher Central Himalaya, D.Sc Thesis, state University Moscow.

Sinha, A.K. (1987), Tectonic Zonation of the Central Himalaya and the crustal evolution of collision and Compressional belts. Tectonophysics,134:59-74.

Sinha-Roy, S.(1982), Himalayan Main Central Thrust and its implication for Himalayan inverted metamorphism. Tectonophysics, 84:197-224.

Small,R.J. (1970), Study of landforms, Cambridge University, London.

Valdiya, K.S.(1980), Geology of the Kumaon Lesser Himalaya Wadia Institute of Himalayan Geology, Dehradun, Iedia.

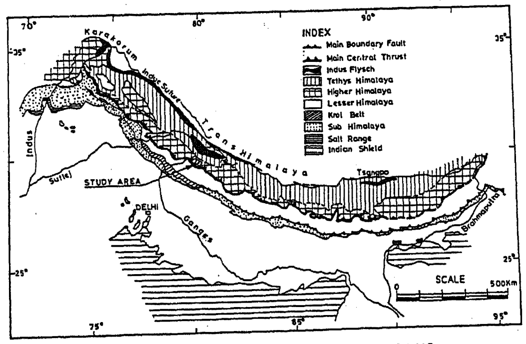

Fig. 1 – STRUCTURAL MAP OF HIMALAYA SHOWING LOCATION OF THE STUDY AREA

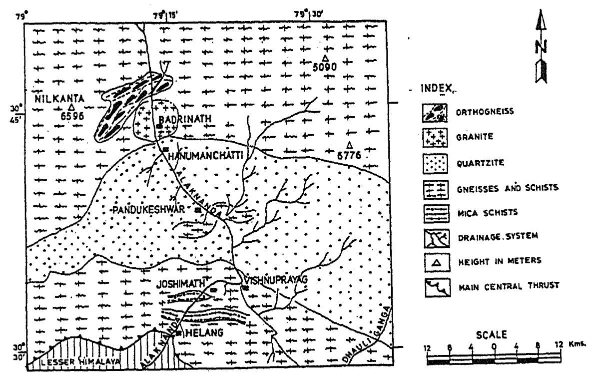

Fig. 2 – GEOLOGICAL MAP OF THE STUDY AREA (MODIFIED AFTER A.K.SINHA 1987)

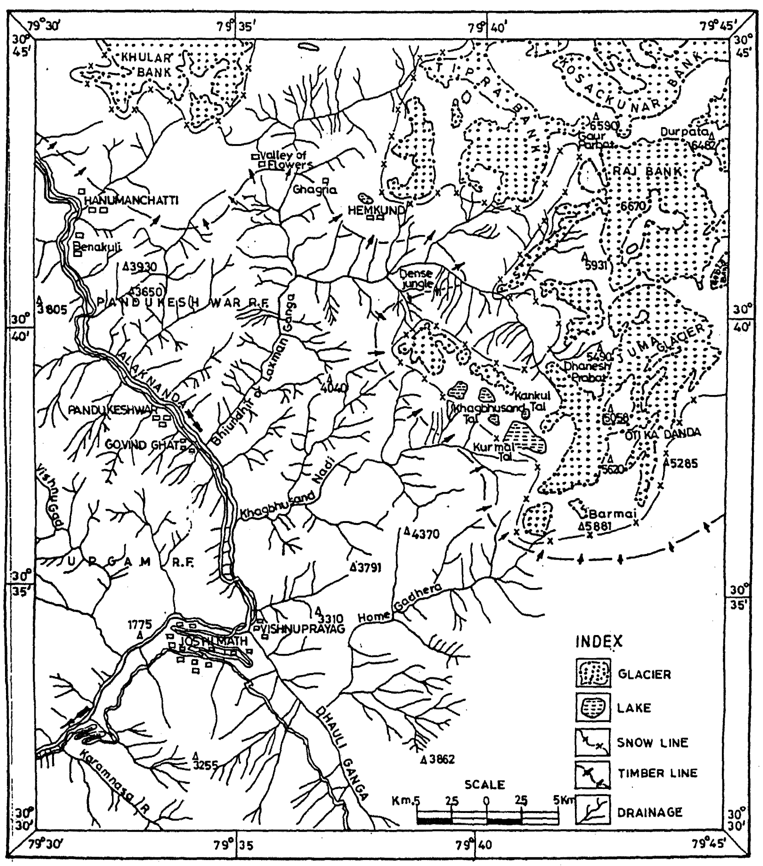

Fig.3 – PHYSIOGRAPHIC MAP OF THE NORTH OF JOSHIMATH GARHWAL HIMALAYA INDIA

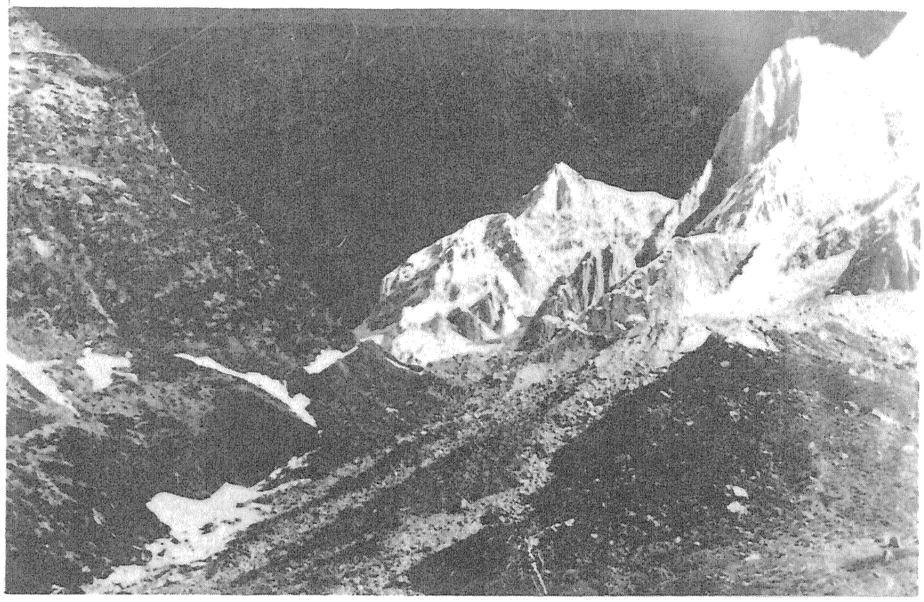

Fig.4 Glacial valley alongwith the Lateral moraines
Garhwal Himalaya, India.

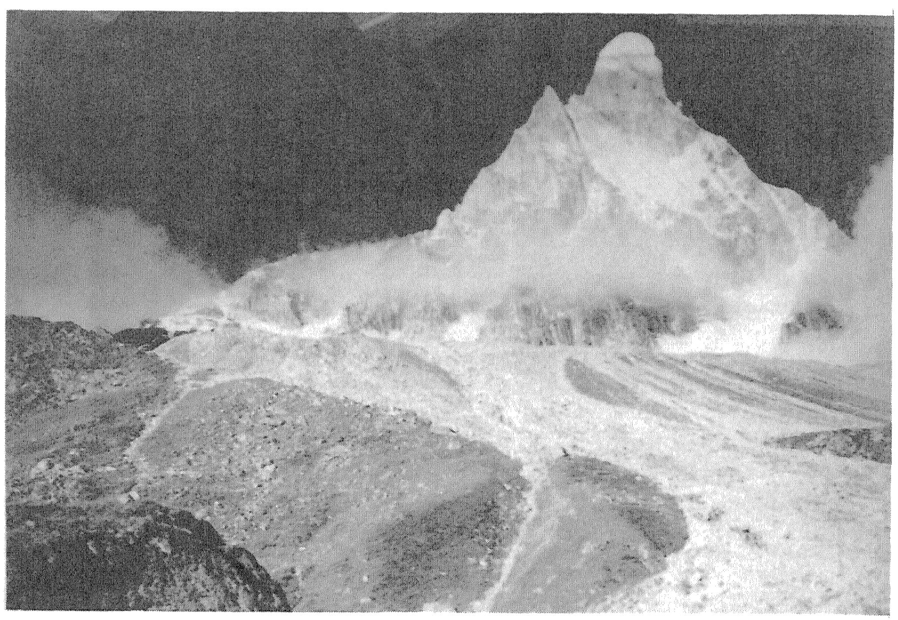

Fig.5 Part of the Cirque and the shooting out glaciers, Garhwal Himalaya
India.

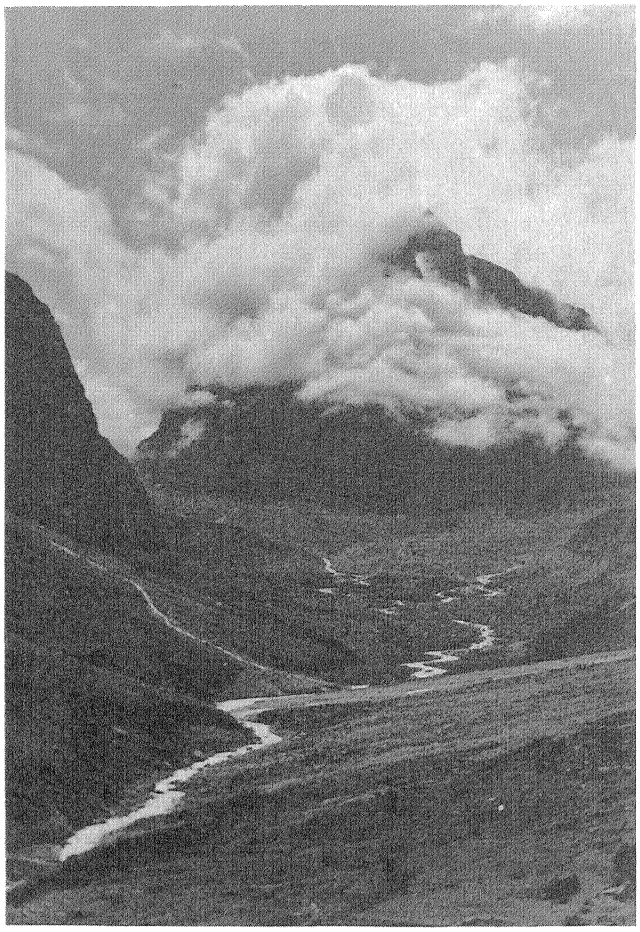

Fig.6 Glaciated Valley, glacial streams in the zone of ablation, Garhwal Himalaya, India.

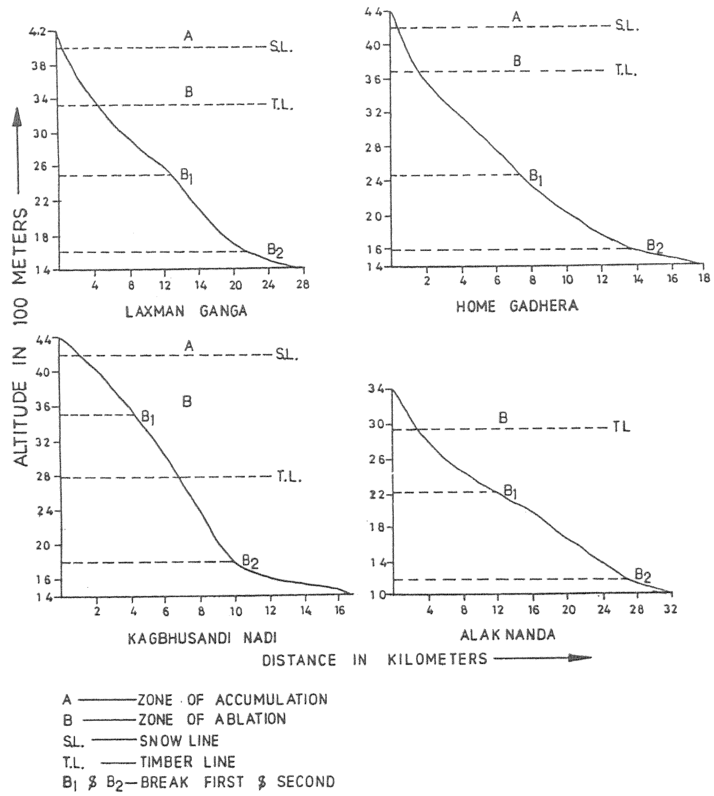

Fig.7 - SLOPE PROFILES OF THE RIVERS